Preliminary Report

of the

GEOLOGY OF THE JULIAN REGION, CALIFORNIA

Thesis by

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FIELD WORK AND ACKNOWLEDGEMENTS

The present paper is a result of field studies carried on in the Julian region during the summer and early fall of 1932. Considerable time was spent in plane table surveying to establish a control for aeroplane pictures used in part to map the geology and locate some of the mine openings. A portion of the Ramona and Cuyamaca sheets of the U.S.G.S. topographic atlas enlarged 5 times from a scale of 1" = 2 mi. (approximately) to a scale of 1" = 2000', was used to map certain areas, notably along the western edge of the main schist belt. The accompanying map is a compilation of data plotted on an engineer's base map prepared by Allen and Rowe, Inc., of San Diego. The hypsography is from portions of the U.S.G.S. Ramona and Cuyamaca Quadrangle, amended by the writer, who has also revised or added certain culture date. (N.B. This is not the appended map.)

Where so many persons, as at Julian and in San Diego, have cheerfully and in most cases unreservedly given of their time and information to the investigation, the selection of a few for individual mention is difficult. Mr. Fred Farmer and Mr. Sidney Dodge of Julian gave freely their time and knowledge and the former was instrumental in having transportation facilities placed at the disposal of the writer. Mr. Howard Williams and Mr. Lou Smith of Julian assisted in plane table surveying and Mr. Arthur Blanc, owner of the Julian Union Garage, extended many favors. Appreciative acknowledgement is made to the firm of Allen and Rowe, civil engineers of San Diego, for permission to reproduce part of their copyrighted Engineers Map of the Julian-Cuyamaca District, and I am especially indebted to Mr. R. Robinson Rowe of that firm for professional and personal courtesies. Mr. Ernest Childs, San Diego County Surveyor, and his capable office staff rendered valuable assistance. The aeroplane pictures used in the study were copied from a collection in the files of the County Surveyor's office. The work was made possible by a grant of funds from the California State

Division of Mines and a coöperative grant from the San Diego Board of Supervisors, the larger part of the latter having been retained by Mr. J. E. Morrison who assisted in the field for three weeks. To Mr. Rene Engel, Dr. Ian Campbell, Professor F. L. Ransome, and Professor J. P. Buwalda, of the Balch Graduate School of the Geological Sciences in the California Institute, I am particularly indebted for helpful suggestions and illuminating criticism.

GEOGRAPHY AND ACCESSIBILITY

Systematic treatment of the physiography will be given in a chapter under that heading.

To the mountainous belt extending 300 miles southeast of an irregular line formed by San Gorgonio Pass and the Santa Ana River in about the latitude of Los Angeles, through San Diego County into Lower California, the name Peninsular Range has been given. In San Diego County the range attains by step-like ascents from the coastal belt elevations exceeding 5000', and, in the central east-west segment of the county, a width of about 50 miles is reached.

120 miles southwest of Los Angeles, 40 miles northwest of San Diego, a little to the east of the geographical center of San Diego County, and along and near the crest of the Peninsular Range as developed in this vicinity, elongate patches of metamorphic rocks, mostly mica schist and quartzite, lying in eruptive masses of granitic and gabbroic rocks, form the geologic base for what has been variously called the Cuyamaca region, the Julian-Cuyamaca district, and the Julian region or district. In this report the term Julian district is used to include, somewhat arbitrarily, the southern part of Volcan Mountain, the northern and eastern slopes of the Cuyamaca massif, the rolling uplands lying between and about these eminences, Banner and Chariot canyons, and the unnamed irregular submountainous peaks east and south of Chariot canyon. The boundaries thus defined are not conterminous with either the original Julian Mining district or the later

formed Julian Consolidated Mining district. For that portion of the rolling upland lying between the upper San Diego River canyon and Santa Ysabel valley on the west, Volcan Mountain on the northeast, Banner and Chariot canyons on the east, and Cedar Creek canyon on the south, the name Julian Mesa has been proposed (Sauer). While there are obvious objections to the use of mesa in application to a land form which has very slight resemblance to a tableland, the writer accepts and uses the term Julian Mesa, as defined, for lack of a better one.

The sinuous 15-mile long northwest trending Volcan Mountain, arcuate in vertical section with blunt ends, reaches a summit elevation of 5570' in its middle part, about 5 miles north of Julian. To the south the same distance the first Cuyamaca, North Peak, rises to 6028', followed by Middle Peak, 5800', and Cuyamaca Peak, 6515', highest in San Diego County. Almost due east of the last named peak is Stonewall Peak, 5600', which bounds Cuyamaca valley on the south.

Several land grants are partly in or near the Julian district; San F elipe on the northwest, Cuyamaca to the south, and Santa Ysabel on the northeast. The Cuyamaca land grant has recently passed by purchase into governmental hands. A large Indian reservation, Santa Ysabel, lies just outside the northern boundary, and two small Indian reservations, Cosmit and Inaja, are a short distance southeast of the western limit of the district.

The largest town in the region is Julian (elevation 4219') which had in 1932 a permanent population of 150, and several general stores, a meat market, service stations, well-equipped garages, a hotel, a grammar school, and a union high school. On the Julian Mesa are many summer resorts, of which Kentwood-in-the-Pines, Pine Hills, and Whispering Pines are the more important. Power, telephone, and bus lines from San Diego terminate at Julian. The town of Banner (elevation 2717'), once a thriving mining and milling center of several hundred people, was partially destroyed in the flood of 1916 and almost completely washed out in the flood of 1926, and now contains only a few inhabitants.

An improved concrete road connects Julian with San Diego, 61 miles distant. A paved highway from Ramona to Escondido, completed in the fall of 1932, connects with the so-called Inland Route from Los Angeles to San Diego; the opening of this road links Julian with Los Angeles by an all-paved direct route. An improved road runs from Julian eastward by way of Banner canyon to Banner and to the Imperial valley; construction on sections of this road was in progress in 1932. Although the road in Banner canyon is sometimes very difficult to traverse in wet weather, it is seldom impassable to light automobiles. The old Julian-Banner road along the steep western scarp of Banner canyon, which gives access to many of the mines, has fallen into disuse and, while now almost impassable, it could readily be put into shape for automobile travel. A narrow road, soon to be widened, straightened, and paved, connects Julian with Lake Cuyamaca and Descanso.

A radiating network of secondary roads connects Julian with San Felipe valley, Henshaw Dam, Chariot canyon, Rattlesnake valley, Pine Hills, Mesa Grande, and the base of Volcan Mountain. Mining operations have caused to be built numerous roads or trails which are, or easily could be made, passable to automobile traffic.

CLIMATE AND VEGETATION

The climate in the Julian region varies considerably from place to place and may be said to depend upon the altitude and the relation of the place to the nearby massifs, Volcan Mountain and the Cuyamaca Peaks. On the broad open upland country called by Sauer(32) the Julian Mesa the climate is temperate, precipitation averages about 30" per year or less (U.S.G.S. W.S.P.446-7). Most of the rainfall comes in the winter months, January being a notable month for storms accompanied by high precipitation. The precipitation on the Cuyamaca Peaks and on Volcan Mountain is between 35 and 45" per year average and the temperatures reached on these peaks are much less than those prevailing on the neighboring lower country. East and west of Julian the rainfall diminishes, the decrease being gradual to the west, sharp and sudden to the east so that at Banner, three miles east of Julian, the rainfall is estimated to average 12" per year, while in the lower part of San Felipe valley it is under 10" per year. Thunderstorms occur during the summer months, although a season may pass wholly without one.

The vegetation is a well-harmonized expression of the rainfall control and the vegetational zones between the humid climate prevailing about Julian and the arid climate found in southern San Felipe valley are sharply marked. Open stands of oak, pine, and cedar, with fringing clumps of manzanita, developed on the Julian Mesa and on the nearby peaks, give way to the east to thickets of chaparral, which in turn are supplanted by sage brush, thinning to the eastward. In the arid-sloped canyon bottoms sufficient moisture is present in places to support tree growth. Pear and apple orchards are successfully cultivated in the broad valley bottoms and on the slopes of the low hills of the Julian Mesa.

During the early years of the settlement of the region timber was cut from surrounding stands of trees, on Volcan Mountain especially, and sawed for local structural and mining use. Decaying stumps, often several feet in diameter, now blanketed by scrub growth, attest to these early logging operations. In recent years all structural timber for mining and other purposes has been trucked into the district from tidewater at San Diego, although considerable wood is cut for fuel to supply local needs and for shipment to the coast cities of San Diego County.

HISTORY

Toward the close of 1869 a party of ex-Confederate soldiers drifted into the vicinity of what is now the Julian district. Driven from their homes in Georgia by the economic collapse of the South during Reconstruction, Mike and Webb Julian, James and D. D. Bailey, had prospected in Montana and Arizona with little success. Placer mining on a small scale was by this time no longer profitable in these states, all the rich ground accessible without the expenditure of capital was worked out, and a general exodus to more remote districts took place. In November, 1869, these men and others organized the Julian or the Cuyamaca mining district and during December worked placers on Coleman Creek near Wynola in a small way, apparently attempting meanwhile to trace the origin of the float gold. I t is reported that on February 22, 1870, a boy in search of firewood in a small ravine north of Julian found gold under the roots of a blown-down tree on what was called, after the date of its discovery, the George Washington claim. The Van Wirt, about a half mile northeast of town, was located the same day. The first town, T ent City, was laid out in the small valley east of Julian on the Volcan road.

C. C. Parry(29), W. P. Blake(3), Thomas Antisell(2), and J. S. Newberry(26) made geological and topographical reconnaissances across the mountains from San Diego to the Colorado Desert in the decade 1849-1859. Most of these exploratory parties followed the now-little-traveled route: San Diego-San Pasqual-Santa Ysabel-Warners-San Felipe-Vallecito-Carrizo Creek, and the Colorado Desert. C. C. Parry, however, in the fall of 1849 followed a route now taken in part by the improved highway from San Diego to Julian and the Imperial valley. Of his observations made while traveling down Banner canyon to join the main road in San Felipe valley, Parry records "the geological formation exhibited along the eastern slope (along the west wall of Banner canyon) of the mountain range at this point shows a very sensible change, and in place of the usual forms of feldspathic or quartz granite we meet a more prevalent character of micaceous granite, in which the scales of mica are frequently of large size, and very confusedly intermixed. With this also occur mica and talcose slates, traversed by quartz veins. At this point, then, we have an approach to the gold formation, and in the section of country thus limited, exist the fairest prospects of mineral discoveries." Over twenty years after Parry made this note gold was found in these quartz veins.

Up to August 30, 1870, 54 claims had been recorded in the Julian mining district by M. S. Julian, Recorder. These included the Owens, High Peak, Eagle, Van Wirt, Hayden, George Washington, Shamrock (not the present claim), San Diego, and others.

The discovery of the mines in the Banner district did not come, as one might suppose, from prospectors working southeastward from Julian along the strike of the veins. In August, 1870, a party of men from Julian while looking for wild grapes in southern San Felipe canyon, as Chariot canyon was then called, found the vein named from one of its discoverers, the Redman. Both the vein, 3' wide, and the sands of the nearby creek were rich in gold. In a few days after this discovery the steep and chaparral-covered slopes of Banner and Chariot canyons were alive with prospectors and the Ready Relief, Hubbard, Kentuck, Madden, Antelope, Chaparral, and many other claims were located. Two of the most important mines in the belt were among the last to be discovered, the Helvetia, about a mile east of Julian, was found late in 1870, and the Golden Chariot, two miles south of Banner, was discovered in February, 1871.

During the early and vigorous epoch of mining activity, which brought at its peak 700 people to Julian and 300 to Banner, these towns constituted the center of separate mining districts. In 1881 the two districts were consolidated into one and the boundaries of the newly formed Julian Consolidated mining district were made to also embrace several unimportant districts, including the Desert mining district, some miles southeast of Banner and containing the Oriflamme Mine, and the Indian mining district, a short distance northwest of Julian. Later nearby discoveries, like the Gold King and Gold Queen, the Ranchita and Elevado, were grouped in the Julian district.

The absence of capital in the period 1870-1874 has been explained as a consequence of a suit brought in 1870 by the owners of the Cuyamaca grant who attempted to float their boundaries to include the Julian district. The Land Department finally decided in July, 1874, in favor of the miners. Another cause for the scarcity of foreign capital at the same time has been assigned to the prejudice existing during this period in northern and middle California against the "lower" country or southern California.

Production reached a maximum in the Julian and Banner districts in 1872 and declined very rapidly thereafter. The greatest annual production, that of 1872, was probably slightly in excess of $500,000. The production estimates include the returns from the Stonewall Mine, which although not a part of the Julian mining district at any time during its history, is reported in the meager literature with the mines of the Julian belt and is described in this report. In 1876 the Golden Chariot closed down, and according to the report of R. W. Raymond(36) for 1875 most of the mills were idle and none of the mining operations had proved permanently profitable.

T he discovery of the Gold Queen and Gold King mines four miles southeast of Julian in 1888 almost twenty years after the main discoveries infused new vigor to prospecting and development and the building from San Diego to Foster of the Cuyamaca Railroad, under construction in 1888, probably also helped to stimulate mining activity so that in 1889 work was resumed on many of the Julian mines and some rich ore discovered. In 1890 many of the mines were taken over by more or less strongly financed companies and although it is probable no large amount of gold was produced by them, their exploratory work, coupled with the system of leasing inaugurated about this time, and the general industrial condition of the nation resulted in considerable gold production during the nineties. In 1891 the first claim map of the district was compiled by D. D. Bailey, J. E. Chamberlin, and W. A. Sickler; a revision of this map was made in 1896. In 1894 20 mines were operating in the Julian district and some time in the following year the Ranchita and Elevada mines were discovered. The Stonewall after attaining a depth of 600' and a production record of $2,000,000 closed down in 1893 and has never been reopened. The Owens Mine, abandoned in 1889, was unwatered and reconditioned at considerable expense in 1890-91, but this attempt at reopening failed; in 1896 operations had been resumed and some good gold-bearing quartz was found.

In the first two decades of the twentieth century almost no substantial mining ventures were under way in the Julian district. A small amount of ore was found in 1910 on the southwest slope of Granite Mountain in what was called the Granite Mountain Mine. During 1913-14 attempts were made to work the Golden Chariot. In March, 1923, the Golden Chariot Mine was taken over by the Golden Chariot Mining Corporation and a formidable program of exploration was laid out. In the latter part of the year the Ready Relief and contiguous mines were consolidated and considerable prospecting is reported to have been done in the next few years. A number of smaller mines were being worked in this same period. The total amount of gold produced by the mining operations in the years 1923-1932 is not known but it is not regarded as being notable. In the fall of 1932, after an alleged expenditure of $300,000 with only a small return in gold production, most of the surface plant of the Golden Chariot Mine was dismantled and removed from the property.

During the writer's visit in the summer of 1932 scarcely any mining work was being done. The moratorium on mining claim assessment work for the year ending July 1, 1932, and the expected continuation of this moratorium for the next year, virtually stopped all development work.

PRODUCTION

The gold production during the early years of greatest mining activity, from 1870 to 1876, can only be inferred. For the early production no records are available which are even approximately based on statistical information.

The following figures represent estimates founded on fragmentary sources:

1870---$150,000		
1871--- 175,000		
1872--- 490,000		10,000 tons of ore crushed
1873--- 500,000		10,500 tons of ore crushed
1874--- 190,000		
1875--- 100,000 or less		
1876--- 100,000 or less		

Mr. Chester Gunn of San Diego, California, estimated the total production for 1869-1880 at over $2,500,000. As an indication of how the estimated amount of total production increased by passage of time, the Julian Sentinel in 1889 reported the total production of all mines at well over five million dollars, despite the small amount produced in the eighties.

In a publication issued by the San Diego Chamber of Mines in 1927 entitled "San D iego County Mines & Minerals" the total gold production of the Julian belt since 1880 is stated to be approximately $7,500,000, an amount about equal to the published production records of the State Mineralogist for San Diego County for the same period. The records of the State Mineralogist prior to 1907 include the gold production of what is now Imperial County, which was a part of San Diego County until that time, and, while there is no way of correctly allocating the production emanating from the Julian belt, the whole amount cannot be credited to the Julian mines.

The total production of all mines in the Julian-Banner-Cuyamaca region is believed to be between $4,000,000 and $5,000,000. The estimated production for individual important mines tabulated in appropriate order of rank

Stonewall	$2,000,000
Golden Chariot	700,000
Ready Relief	500,000
Helvetia	450,000
Owens	450,000

Blue Hill or Gardiner	$200,000
North Hubbard	200,000
Banchita	150,000

The Antelope, Chaparral, Cincinnati, Eagle, Elevado, High Peak, Kentuck S, Madden, Redman, San Diego, Van Wirt, Warlock, and Washington probably produced between $25,000 and $50,000 each.

The Cable, Chieftan, Eldorado, Ella, Fraction, Gold King, Gold Queen, Granite Mountain, Hidden Treasure, Homestake, Neptune, North Star, Oriflamme, Padlock, Ruby, South Hubbard, and Tom Scott are believed to have produced less than $25,000 each.

LITERATURE

Previous detailed geologic study of the Julian region is confined to an investigation, mainly petrographic, by F. S. Hudson, who gave the gold bearing quartz veins, however, only a passing examination. Carl S auer has written his views on the genesis of the land forms as developed in this and the neighboring vicinity to the north. The papers listed below contain information on the Julian region and the Peninsular Range, or have a bearing on the interpretation of the geologic phenomena found therein.

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METAMORPHIC ROCKS

General Statement

Isolated bodies of metamorphic rocks of sedimentary origin have been reported from many places in the Peninsular Range. They occur generally as roof pendants or flanking bodies having the same general strike as the northwest trend of the range, the smaller masses are found in part as screens between two different intrusives; all have steep dips. Apparently the bodies lying within the batholith of the range owe their preservation to downfaulting or downfolding, and not, as has been held, to their alleged occupancy of present day valleys, because they are found both in valleys and along the summits of the present day topography. The dominant tectonic lines of the range bear northwest and almost all of the structural units of the range--granitic intrusions, bodies of slates and schists, major pegmatite dikes, sedimentary beds of Cretaceous and Tertiary age--are related to these lines. The reflection of this northwest tectogeny in physiographic development is striking and will be discussed under physiography.

JULIAN SCHIST

Local Distribution

Numerous bodies of schist are found in the Julian region; the largest, most continuous, and economically most important schistose mass is an elongated, curving body which extends without a break from northeast of Wynola to the vicinity of Rattlesnake Valley, somewhat over twelve miles. The width of this body varies from a maximum of a mile and a half just southeast of Julian to about a half mile near the trail from the Gold Queen mine into Chariot canyon; the average width is a mile. Several other schist patches have been mapped but unless otherwise specifically stated the main mass above defined will be meant when referring to the main Julian schist body. Of the other mapped masses, an important one extends almost due north four miles from the base of Stonewall Peak to the vicinity of

Harrison Park. The caved and abandoned workings of the once productive Stonewall Mine are located in the lobate end of this body of schist, which like many of the schist bodies in the vicinity of Pine Hills, occurs as a screen between the Cuyamaca Basic Intrusive and the Stonewall quartz diorite. There are many small bodies of schistose rock southwest and northeast of the main Julian schist which are not sufficiently large to have warranted field mapping.

Fissile Quartz-Mica Schist

The main constituent of the Julian schist body is a fissile, quartz, muscovite, biotite schist in which the schistosity is developed parallel to the bedding of the sediments, as evidenced by the lithologic variation across the schistosity and by the agreement in attitude between the layers of quartzite and the schistosity. Because of the ease with which the mica schist disintegrates and weathers, the writer has been unable to collect fresh specimens of the fissile mica schist on the Julian Mesa, most of these collected being the harder, gnarled variety richer in quartz than the average rock. There is evidence, which is more distinct nearer the eastern boundary, for the presence of a double schistosity, the second and less pronounced consisting of large flakes of biotite or muscovite oriented at an angle to the primary schistosity. From the association of andalusite on the same secondary surfaces it is thought they are related to contact metamorphism, presumably incident to the quartz diorite intrusion. Much of the mica in the schist, both muscovite and biotite, has been hydrothermally altered, especially in the vicinity of the quartz veins. Iron oxide (magnetite) resulting from this breakdown forms minute specks on both the hydromica and on the associated quartz, sometimes in amounts visible megascopically. A rock of frequent occurrence, which because of its resistance to disintegration is often found in creek bottoms, especially in Chariot canyon, is a fine grained fissile mica schist in which the quartz is present as small lenses or knots, giving the rock a hummocky appearance.

JULIAN SCHIST

To this rock the name eye schist is applied.

Quartzite

A rock of wide distribution in the Julian schist, especially in the western half of the main body is a dense, more or less impure, quartzite. There are practically all gradations from an almost pure blue or gray quartzite to a rock which may be called a micaceous quartzite. Biotite or muscovite, or both, are found in greater or less amounts in all the quartzite examined microscopically, along with numerous specks of magnetite, which are found, however, only in some quartz individuals and not in others. One of the most persistent beds of quartzite extends continuously from the gap east of Lake Cuyamaca northward for two miles, forming a portion of the main drainage divide; another well exposed bed occupies a considerable area on the small flat east of Heckelman's in section 23, T13S, R4E. The ridge forming the main divide southeast of Julian has a backbone of quartzite which can be traced from almost a mile. Included in these quartzite beds and in the schist and contact metamorphic rocks are short, blunt-ended lenses of quartzite and an unique quartzose rock, the latter consisting of four-fifths quartz and one-fifth pyroxene, hornblende, and plagioclase. A field determination of this pyroxene, quartz rock would unhesitatingly classify it as a normal quartzite. Quartzite forms the footwall or hanging wall of some of the gold quartz veins, but it is not believed to have a causal relation to them. An opening on the Cincinnati Belle, for example, shows an impure quartzite hanging wall and a quartz-injected mica schist footwall.

Actinolite Schist

Intercalated with the schist series and along the western contact-metamorphosed border are lenses of actinolite schist. A specimen of actinolite schist from Hill 5000 on the boundary between sections 22 and 23, T13S, R4E, consists almost entirely of green actinolite in a medium grained, fibrously interlaced mass, which weathers white or slightly reddish, indicating that in composition the material approaches more nearly tremolite. A coarse grained actinolite schist from Aul's Ridge in the southeast quarter of section 5, T13S, R4E, is made up of long fibered actinolite, with notable amounts of quartz, minor quantities of plagioclase, apatite, and sillimanite.

Coarse Schists and Paragneiss

Along the western border of the Julian schist body is a zone of coarse schists and paragneisses which varies in thickness from several hundred yards to over a half mile. The gap east of Lake Cuyamaca along the road leading into Rattlesnake valley is an excellent place to study these metamorphosed rocks. Immediately at the contact between the schist series and the quartz diorite is a layer of dense, hard quartzite which makes off into the schist to the north as though broken or bent by the intrusive action. Farther in the schist series are layers of paragneiss showing elongated masses interpreted as flattened pebbles. The major part of the contact zone is a hard, resistant coarse schist made up of biotite, quartz, feldspar, muscovite in layers slightly bent and not at all fissile. Throughout the zone are lit-par-lit injections of granite and pegmatitic material.

Origin

From the (1) presence of beds of quartzite paralleling the primary schistosity, (2) the lithologic variation normal to the primary schistosity indicative of sedimentary bedding, and (3) the mineralogic composition, a sedimentary origin is ascribed to the Julian schist. Many weathered outcrops of the less metamorphosed fissile schist resemble thin bedded sediments more than weathered crystalline schists. It is believed that the Julian schist series represents the product of regional and contact metamorphism of relatively pure quartz sandstones, clayey sandstones, and shales. Hudson(19) interpreted the layers of amphibolite and actinolite schist intercalated in the schist series as products of metamorphism of andesitic and basaltic lavas. This may be the case with the layers of actinolite and amphibolite schists actually within the schist series, but for the actinolite rock occurring at the contact a contact metamorphic origin is suggested.

Age of the Julian Schist

The only direct evidence found up to the present time in the Julian region which may lead to an inference as to the age of the Julian schist series is a fossil found by the late Mr. D. D. Bailey of Julian in a small area of metamorphic rock that lies in the granite about a mile southeast of Banner. Hudson(19), who reports the discovery of this find and the description of the fossil, states that Dr. J. P. Smith in an oral examination pronounced it "a slender ammonite that is without much doubt Triassic." No additional paleontologic information can be supplied by the present writer. The other basis for tentatively allocating the time of sedimentation of the rocks now represented in part by the Julian schist to a more or less definite place in the geologic time scale is the correlation with similar rocks and their intrusive accompaniments in the Peninsular Range and the Sierra Nevada.

Comparison and Correlation

The principal exposure of pre-batholithic (pre-Sierran disturbance of Schuchert, or pre-Cordilleran revolution of J. P. Smith) meta-sedimentary of the Peninsular Range rocks occurs in the Santa Ana Mountains. The determination of the age of these rocks, dominantly slates, offers the best known approach to the dating of the period of folding and batholithic intrusion which apparently affected at about the same time the rocks now represented by the Julian schists.

Hudson(19) has reviewed the literature pertaining to the paleontologic and lithologic age determination of the Santa Ana meta-sedimentary rocks. The summary of the results seems to be that the Santa Ana slates are Triassic in age, although all paleontologic studies reviewed by Hudson appear to be based on scant and geographically-uncertain fossil collections. B. N. Moore (unpublished manuscript) worked on the rocks of the Santa Ana Mountains during 1926-30. Much light on the structural details of the Santa Ana slates was thrown by Moore's studies, but since he did not find any fossils in the slates his work did not help to strengthen the age determination of the slate series. Rene Engel, of the California Institute of Technology, has been recently engaged in a study of the Santa Ana Mountains and has found additional fossil material in the slate series of this most northwesterly division of the Peninsular Range. We may expect from him, therefore, a critical review of the past geologic work and a description of the recent investigation to appear soon in the literature. Suffice to say here that Engel (oral communication) on the basis of fossil content believes the slates of the Santa Ana Mountains to be upper Triassic in age.

Three investigators, Fairbanks(8), Merrill(24), and Hudson(19), have examined the metamorphic rocks of the Julian region and published their views of the comparative features with similar rocks in the Santa Ana Mountains and in the Sierra Nevada. Fairbanks correlated the metamorphic rocks of the Santa Ana Mountains, in which he found fossils, determined by the National Museum as Carboniferous, with the metamorphic rocks of San Diego County. Merrill, on the basis of structural position and lithologic characters, suggested that the Julian schists were probably equivalent to the Calaveras group described in the Mother Lode Folio of the U. S. Geological Survey. Adolph Knopf(39, p.10) states that "the Calaveras formation, as that term is used in the gold-belt folios, includes all rocks older than the Mariposa slate, except the amphibolite schist that has been separately mapped. It is considered to be mainly of Carboniferous age, but it may include some Triassic rocks and some older than Carboniferous." It should be inserted here that W. C. Mendenhall(41) believed the slates of the Santa Ana Mountains resembled the Mariposa slates of central California, with the qualification that the Mariposa rocks are more extensively altered. Quoting Knopf again (p.14) "the age of the Mariposa rocks has been specially studied by Hyatt, Diller and Stanton, and Smith. They agree that the Mariposa is of late, 'though not latest,' Jurassic age. Smith, indeed, refers it to an early Upper Jurassic age. The evidence from fossil plants harmonizes closely with this conclusion. Knowlton was inclined to regard the Mariposa slate as of Middle Jurassic age." In brief Merrill correlated the Julian schist with the Calaveras formation of Central California, Fairbanks correlated the Santa Ana slates with the Julian schists, and Mendenhall thought the Santa Ana slates resembled the Mariposa slates.

Hudson in addition to bringing forth the lone fossil discovery in the Julian schist established two approaches to a possible correlation between the Santa Ana slates and the Julian schist: (1) "The beds of the Santa Ana Mountains, as described by Mendenhall, would, if subjected to further metamorphism, yield schists like those at Julian(19,p.190)." (2) Hudson examined metamorphic rocks in Railroad canyon, north of Elsinore in Riverside County, which were referred by Mendenhall on the basis of their lithologic similarity with rocks of the Santa Ana Mountains, and found intercalated within this series of dark slates and gray quartzites, gray cherts interbedded with green shale. Lenses of fine-grained quartz-rhodonite-rhodochrosite rock are found lying parallel to the bedding within the chert layers. Similar occurrences of manganese minerals in chert lenses inclosed in small masses of metamorphic rocks were found by Hudson a short distance northeast of Deer Park, and between Campo and Jacumba, in San Diego County. The inclosing metamorphic rocks are quartz-mica schist similar to the Julian schist. If the Railroad canyon rocks are the correlatives of the Santa Ana slates, and if the Deer Park and other similar rocks are the correlatives of the Julian schist, then the peculiar association of manganese-bearing chert is indicative of some relation between the Santa Ana slates and the Julian schist.

I have examined the slates in the Santa Ana Mountains outcropping in Silverado canyon. The materials that make up most of the slates is much like that which probably constituted the Julian schist before the development of the Schist minerals. There is, however, nothing distinctive about a series of sedimentary rocks consisting dominantly of shales with interbedded sandstones and I do not feel that a resemblance between the Santa Ana slates and the Julian schist based on general lithology can be much more than confirmatory evidence for their correlation.

It is my conclusion that the age of the Julian schist is still uncertain, especially as regards the lower or older limit. It is probably not older than the Carboniferous. The upper limit is somewhat more sharp. No instances of Cretaceous granitic rocks are known to the writer in California and in lower California and in the Santa Ana Mountains. Cretaceous rocks rest on the eroded surfaces of great batholithic masses, which are presumably the correlatives of the quartz diorite and granodiorite that intrude the Julian schist, so that the period of sedimentation of the Julian meta-sedimentary rocks must have been pre-Cretaceous. A more definite statement of the age of the Julian schist than that they are late Paleozoic and/or early Mesozoic does not seem warranted by the facts. The writer hopes by diligent search to find within the Julian schist additional fossil material.

IGNEOUS ROCKS

Peninsular Range Rocks

The dominant petrographic type exposed in the Peninsular Range is a coarse grained intrusive rock which varies in composition from gabbro to granite. Surficially the outcrops of these rocks or their metamorphic equivalents greatly exceed all others, as may be seen from a mere reconnaissance through the mountains, and this general conclusion is testified to by the few maps which have been published or made available on the area. (Preliminary Geologic Map of San Diego County, A. J. Ellis, U. S. Geological Survey Water Supply Paper 446, 1919; Geologic Map of the San Jacinto Quadrangle, D. M. Fraser, 27th Dept. State Mineralogist, 1931; A Geological Reconnaissance of Two Tunnel Lines from the Imperial Valley to the San Diego Region, F. L. Ransome, Rept. No. 542, Metropolitan Water District of Southern California.) Rene Engel(43) reported that in the portion of the Santa Ana Mountains and Elsinore Mountains (next mountains southeast of the Santa Ana Mountains) examined by him the assemblage of metamorphics of igneous effusive and sedimentary origin are intruded by diorite and various hypabyssal rocks, which are in turn intruded by granitic rocks, the latter occupying a large portion of the area. A. O. Woodford believes (personal communication, 1932) as a result of reconnaissance observations that the dominant rock of the San Pedro Martir Mountains in Baja California is probably a quartz-biotite-hornblende-diorite. W. J. Miller(25) has recently (1933) given the results of petrologic studies on the rocks found along a section from La Mesa, San Diego County, to Coyote Wells, Imperial County, in which the principal formations are found to be a metasedimentary schist and a volcanic series; an extensive diorite series, varying from acidic quartz diorite to olivine gabbro-diorite; a late Jurassic granodiorite which definitely cuts the diorite series, some Tertiary sediments; and late Tertiary or early Quaternary volcanics. Ransome(31) found mainly diorite, granodiorite, and gneiss having the composition of a granite to granodiorite. In the

San Jacinto quadrangle Fraser(12) has shown the dominant rock to be a typical granite with a marginal gneissoid phase. E. S. Larsen states (personal communication, 1933) his work in the San Luis Rey quadrangle and in parts of the Elsinore and Ramona quadrangles reveals the earliest granitic intrusion to be a norite or gabbro mostly pyroxenic, but in part carrying much hornblende. This gabbro was followed by several quartz-diorites and finally by granodiorites. The average rock of the batholith (of southern California) according to Larsen is probably a quartz-diorite.

Granodiorite and Related Rocks

To the coarse grained acidic intrusive rock which outcrops along the western border of the Julian schist body Hudson(19) has applied the name Stonewall quartz diorite from the good exposure on Stonewall Peak. A thin section of a specimen of this rock collected on Stonewall Peak shows plagioclase (oligoclase), quartz, orthoclase, and biotite in textural relations forming apparently a combination of mortar and pseudo-cataclastic texture (G. H. Anderson-1). Myrmekitic replacements are developed on the orthoclase individuals and similar material has been deposited in the interstices between the feldspar and quartz. Megascopically the corresponding hand specimen exhibits a moderate stage of foliation, curving plates of biotite arranged in discontinuous layers alternate with layers of flattened feldspar and quartz. The writer's determination of this rock indicates that in places at least it should be classed as a granodiorite and herein it will be so called for convenience in discussion. Other sections are made up almost solely of acid plagioclase and quartz, with minor amounts of biotite, and are hence representative of a quartz diorite. Such a specimen was collected from the southeastern slope of Volcan Mountain near the end of the Volcan Road in Sec. 19, T12S, R4E. In a number of slides examined, notably one from a specimen collected in a road cut in Sec. 12, T12S, R3E, on the Pine Hills road, a feldspar, considerably altered and pseudo-cataclastically replaced, agrees with the criteria for distinguishing orthoclase, except that it gives a positive sign. The determination of this mineral is of considerable importance in classifying the rock as a granodiorite or quartz diorite, but such determination must await further study. The mineral may possibly be isorthoclase. Much of the quartz diorite and granodiorite is foliated and the character of this foliation depends directly on the nearness to schistose bodies. Along the immediate contact with such bodies the foliation in the granodiorite is sharp, the layers are thin and have the same general trend as those of the contiguous schist. Away from the contact the folia in the granodiorite increase in thickness and decrease in sharpness, indicating that the gneissosity developed in the igneous rock is either due to flowage in a viscous magma around a solid mass, or to pressure crystallization of the viscous, partially frozen granodioritic magma under hydrostatic pressure against the solid schist body, or to both. The present writer believes that pressure crystallization (piezocrystallization) has been more important than flowage in developing the gneissosity. The granodiorite is in intrusive contact with most of the schist bodies. Igneous injections in the schist, the development of contact metamorphic minerals in the schist, the presence of unoriented xenoliths of schist in the granodiorite mass, the gradual change from a non-injected quartz-mica schist to injected schist and gneissic granodiorite to massive granodiorite - all point to intrusive relations. On the east side of the Julian schist body faulting has taken place between the granodiorite and schist, indicated in the Golden Chariot Mine and in Quayle Bros. Contact mine in Sec. 3, T13S, R4E, just south of Banner. In both cases the faulting is apparently of the reverse type, the east member, granodiorite, has apparently moved upward with reference to the schist on the west along a steep eastward dipping fault plane, with the development of gouge, brecciation, and sheared quartz bodies. In most other places along the eastern schist-granodiorite contact normal intrusive relations prevail.

Age and General Structure

The granodiorite is younger than the schist and apparently older than the Cuyamaca Basic Intrusive, as the latter rock cuts across the structures of both the schist and the granodiorite and at the contact between granodiorite and the basic intrusive the grain size of the basic rock increases away from the contact. The writer is as yet, however, only incompletely convinced of the relative age of the intrusive rocks and hopes to establish more clearly the criteria applicable to the problem by more field work. The schist is considered here to be late Paleozoic to lower Mesozoic in age. In a number of places in California Cretaceous rocks rest upon the eroded surfaces of batholithic granite masses and no instances of post-Cretaceous granites are known to the writer in California. The age of the granodiorite and associated rocks is here inferred to be upper Mesozoic, probably related to the post-Mariposa intrusion of the Sierra Nevada batholith. From the presence of contact metamorphic minerals in several places along a cross-section through the Julian schist body it is believed the contacts between granodiorite and schist dip at a low angle and that the schist mass has a wedge shaped cross section of no great depth. The widespread occurrence of rocks throughout the Peninsular Range similar to the granodiorite outcropping here leads to the conclusion we are dealing with intrusion on a batholithic scale; the individual members, however, have no great continuity, are usually elongated north and south, and in this area at least, are separated by rocks of other categories.

Cuyamaca Basic Intrusive

To the relatively coarse grained plutonic rocks outcropping in the Cuyamaca peaks and surrounding territory, Hudson(19) has applied the name Cuyamaca Basic Intrusive, and this writer follows such terminology. These rocks have been so well described by Hudson that nothing will be nowadded to his description, particularly as they are not apparently related to the gold veins which are the principal reason for making this study. In summary they are medium to fine grained basic rocks containing basic plagioclase, pyroxene (hypersthene or augite), hornblende, small amounts of pyrrhotite, along with certain other minor minerals. The presence of the well-nigh ubiquitous pyrrhotite, which is also concentrated in medium-sized masses within the gabbroic rocks along with sufficient nickel and copper to have warranted some prospecting for those metals, led to the thorough investigation by Hudson on the origin of the nickeliferous pyrrhotite.

The Cuyamaca Basic Intrusive has been interpreted by Hudson(19) as being later than the granodiorite on the basis of its (1) transecting structures in the schists and granodiorite, (2) massive character, (3) relation to dikes and plugs of gabbro and norite which cut the granodiorite and schist. The evidence seems good, yet the writer has collected gabbroic rocks at a considerable distance (Sec. 29, T12S, R4E) from the main basic mass. E. S. Larsen (personal communication) found, in the area mapped by him in the San Luis Rey, Elsinore, and Ramona quadrangles, the earliest intrusion to be norite and gabbro and says "it is (a) widely distributed (rock) but (occurs) in most part in relatively small masses." It may well be that the dikes and plugs of norite and gabbro are not directly related to the Cuyamaca Basic Intrusive and hence cannot be used as a criterion of age relation.

Assuming the Cuyamaca Basic Intrusive to be later than the granodiorite, it is probably genetically connected with the same period of intrusion as the more acid rocks and perhaps is late Jurassic in age. From its form and attitude of bounding walls it may be classified as a chonolith (Daly-6), in which the intrusion took place rather quietly (Lahee-21), probably toward the waning end of a period of orogeny in which vigorous compressional deformation, intrusion, and broad uplift were brought to a more gentle close with the development of spaces under less compression, of which the chambers occupied by the Cuyamaca Basic Intrusive and the Rattlesnake granite may be examples.

Rattlesnake Granite

A true granite, consisting of very coarse-grained orthoclase, quartz and muscovite, outcrops near the southeastern limits of the map. The present writer has nothing to add to the petrographic description of this rock named by Hudson from the valley in which it outcrops. The formation has no apparent relation to the gold-bearing quartz veins and has not appreciably metamorphosed the schist which it has intruded.

Aplite

An aplite dike, broken in the middle, averaging 10' in width and 2 miles in length is found within the schist series, conformable with the schistosity, in the eastern part of the Cuyamaca Grant, the road to Rattlesnake Valley passes over its northern end. The strike is slightly west of north at its northern end and the dip steeply east. The dike stands out sharply from the encasing schistose rocks. Minor offshoots strike off to the northeast and disappear in the schist. Microscopically the aplite is made up of phenocrysts of quarts and plagioclase in a fine grained groundmass of quartz and muscovite. Megascopically the rock is sugary in texture, possesses a rude foliation, is white in color except where slightly iron-stained.

Pegmatite Veins

Pegmatite veins cut all the crystalline rocks in the Julian region and in places, as along the old Banner road, form large irregular shaped masses. Most of the pegmatites may be classified as "simple", following the classification proposed by K. K. Landes(38), their further classification depends upon the mineral composition. The several examples determined by the writer were "simple granite pegmatites," containing essentially orthoclase, quartz, and muscovite. A specimen from Racetrack Hill, the small eminences east of the Julian Union High School and south of the main road to Banner, has the foregoing composition, with additional clumps of quartz and tourmaline. As there is no evidence of albitization such specimen is representative of the "simple" type. A nother specimen is from a dike a few inches wide, in which the center is composed of quartz and large black tourmaline crystals and the walls are made up principally of light blue orthoclase with some quartz.

In general the pegmatites in the schist conform to the structure thereof, the larger pegmatites in the granodiorite have the same general trend at the foliation, but many pegmatite bodies are found without apparent structural control.

As might be expected if the gold-bearing quartz veins are viewed as genetically connected to magmatic intrusion, a relation exists between the pegmatites and the quartz veins, the latter being here viewed as lower temperature events than the pegmatites in the same general post-consolidation phenomena of the granodiorite. Some of the pegmatites have been prospected and occasionally contain up to $2 per ton of gold. Transition from barren quartz veins to pegmatite veins have been noted.

Quartz veins

The gold-bearing quartz veins will be discussed under the section on ore deposits. The other type of quartz vein, the "bull" quartz of the miner, occurs extensively in the schist and granodiorite; it may be regarded as a pegmatite in which quartz has been the only mineral deposited. The relation between barren quartz and gold-bearing quartz will be discussed under the heading of ore deposits.

RECENT ROCKS

In many of the depressions throughout the region recent unconsolidated alluvium has been deposited. In the open valley to the north of North Peak one of the branches of Cedar Creek has cut deeply into this alluvium and cliffs 20' or more in height have been cut. Exposed in these cliffs are rudely stratified, poorly sorted layers of angular and subangular fragments, which in the upper two-thirds have been weathered to a dark brown soil. A few feet from the top are lenses of boulders at a concordant level. Intercalated in the alluvium is a bed of dark, carbonaceous material, apparently the result of the burial of vegetal material. This last feature is seen throughout the area in a number of the stream cuts. The cause for stream cutting in the alluvium will be considered in the section on physiography.

The recent deposits in San Felipe valley have been interpreted by Ellis(7) as lascustrine in origin. The writer examined the outcrops exposed in the valley and could find no evidence to support a theory of lake deposition. T he layers exposed in the middle of the valley are poorly delimited and the materials in them are crudely sorted. The lithology differs on two sides of the stream and the beds frequently lens out downstream. In mechanical composition the layers vary from coarse pebbles and boulders in a finer-grained matrix, to fine sands and fine sandy muds. In the upper part of the valley scarcely any stratification can be seen in the exposures of alluvium in stream cuts. In the lower part of San Felipe valley the alluvium has not been significantly trenched by streaming and the fans issuing from the steep eastern side of Volcan Mountain merge gradually with the alluvium of the valley. An interesting remnant of fanglomerate outcrops in the center of the valley a short distance west of the ranch buildings.

It is believed that the alluvium of San Felipe valley is, like the other alluvium in the area, fluviatile in origin, the result of inwash from the surrounding higher lands. I t does not differ greatly from fanglomerate except in the greater amount of water handling and sorting to which it has been subjected.

STRUCTURE

General Statement

On a large scale the structure of the rocks as inferred from the exposures in the Julian region is comparatively simple. The ultimate mechanics of these structures—folding and development of schistosity in originally sedimentary rocks, intrusion of large masses of granitic to gabbroic magmas, the exhalation of large quantities of quartz and pegmatitic material from some of the more acid magmas, the uplift by complex and repeated grossfaltung and/or block faulting of all these rocks from a deep position in the earth's crust to such an estate that they were gradually worn down by ordinary erosional processes to a surface of low relief, the faulting and break-up of this surface with the consequences of deep canyon cutting, and the bending of the strata of the schist toward the direction of relief—are moot questions in geology, the answers to which are still to be attained. Only such speculation covering the ultimate causes will be included here as seems immediately pertinent to the discussion.

Disregarding the events and geologic status of the region prior to sedimentation of the materials now represented by remnant metamorphic patches, of which the Julian schist body is the most prominent in this area, the dominant agency operating in the Julian region has been compression; regional, hydrostatic intrusive, and gravitative. The effects of each of these three types of compression will be discussed with reference to the (1) the nearly structureless Cuyamaca Basic Intrusive and Rattlesnake granite, (2) the some-places foliated granodiorite, (3) the strongly foliated Julian schist, (4) the region as a whole.

Cuyamaca Basic Intrusive and Rattlesnake Granite

As pointed out in the sections on the Cuyamaca Basic Intrusive and Rattlesnake granite, it is believed, from the lack of flowage or pressure cyrstallization effects and from the inferred shape of their magmatic chambers, that they occupied openings conditioned by waning orogeny that permitted places of less compression into which magma was hydrostatically pressed in such a way that the top of the magma chamber was as large or larger than the bottom. These places of less compression may be associated with once-existing fault zones related to the regional tectonic lines. As most of the outcrops of basic rocks are covered by heavy soil and tree growth, gravitative action in the form of landsliding has not been important and from their massive character it may be deduced that such action is probably the only one possible from pure gravitative compression. The Rattlesnake granite has been too little studied to permit making further comments.

Granodiorite

It has already been stated and the relevant reason given for the belief that the granodiorite owes its close-spaced foliation to flowage in a viscous magma and/or pressure crystallization. Much rock of the approximate composition of the granodiorite has been observed throughout this area and in other places in the Peninsular Range which would be classed as a granodiorite gneiss, the structure of which must have originated in regional metamorphism. Gravitative effects result in the formation of numerous landslides in the granodiorite, both on steep and gentle slopes, but the debris produced is so short-lived that no large masses of landslide breccia were observed.

Julian Schist

It seems likely that the primary schistosity as developed parallel to the sedimentary bedding has resulted from the regional compression of initially flat-lying sediments. Tight folding probably took place before the transformation of the sedimentary minerals into the schistose minerals, biotite and muscovite, and before the recrystallization of the quartz. Either the folds were isoclinal, to account for the sedimentary-schistose parallelism, or we are dealing with a single limb of metamorphosed sedimentary series in which the folds, if not isoclinal, were on a sufficiently large scale not to cause development of schistosity at an angle to the sedimentary bedding. The latter explanation is improbable. The present writer does not follow Hudson(19) in his interpretation of southwest dips in the schist series as being indicative of extension of these dips in depth, but explains this reversal of dip by another method.

The intrusive pressure, presumably acting hydrostatically, caused the development of a secondary foliation in the schist, in which plates made up of flakes of biotite or muscovite curve off from the primary schistosity and lie at an angle to it. Some of these flakes of biotite are large in size and are intimately associated with long, slender prisms of andalusite, an association which strengthens the postulate of contact metamorphic origin.

Dips in the main schist mass are predominantly toward the northeast, except on steep, eastward facing slopes, where southwest dips have been observed. The writer believes that these southwest dips are due to pressure of overburden which has caused the folia to bend, like the leaves of a book, toward the area of relief of pressure engendered by removal of material along Banner canyon and Chariot canyon. In some places (Blue Hill Mine) this bending has proceeded to the point where the folia lie almost horizontal, and in a number of the mine crosscut tunnels run southwest in the schist series, gradual change from much-bent to little-bent folia is well seen, no reversal of southwest dipping was seen in any of these tunnels, however. On some of the more gentle slopes along the Banner scarp dips to the southwest were steeper, this was especially the case where a thick bed of quartzite determined or was associated with the gentler slope. Upon this interpretation the effect of gravitative compression on the main schist mass has been notable in determining the surficial appearance of the schist and the evaluation of its invluence seems necessary in arriving at a correct view of the structure in depth. Before drawing strudture sections I wish to check this deduction by further field observations.

Region as a Whole

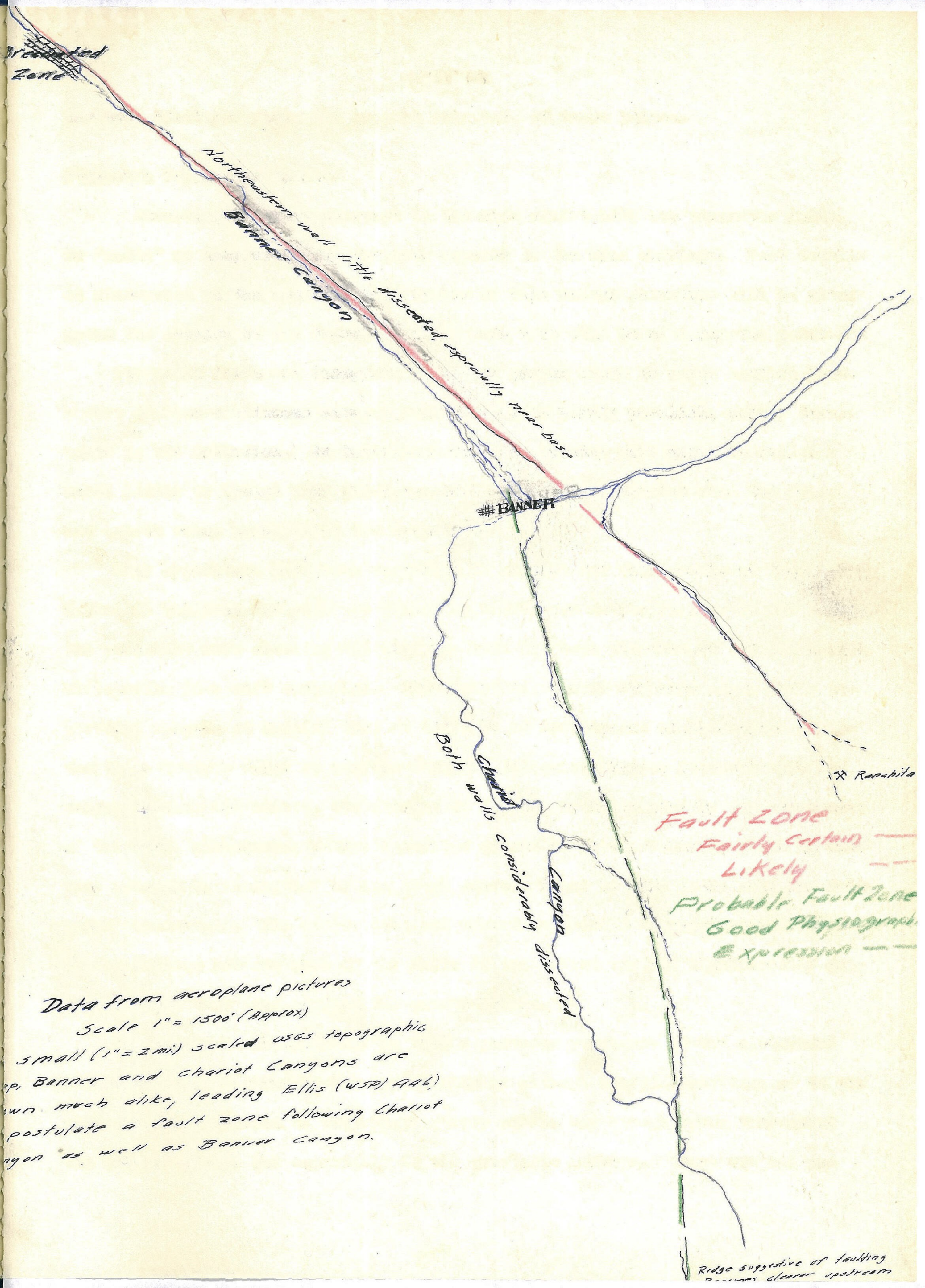
T he effect of intrusive and gravitative compression has been sufficiently treated under the various formational headings. The effect of regional compression will be here briefly treated.

The writer is tentatively of the opinion that the major part of the uplift accomplished prior to and concomitant with the development of the surface of low relief now found on the Julian Mesa and on the summit of Volcan Mountain was in the nature of very broad arching or grossfaltung following a period of intense deformation with consequent metamorphism of the sedimentary cover and intrusion on a batholithic scale. Whether the compression stresses caused the intrusion, were caused by it, or were complementary to it are speculations beyond the logical inference of the writer. That compressive stresses existed during intrusion which were oriented normal to the modern tectonic lines is inferred from the northwest elongation of the igneous bodies.

The principal regional structure susceptible to reasonable proof are the faults in the area. On the Fault Map of California(33) Banner canyon is occupied by a "probably active fault, uncertainly located." The straightness of this canyon and of its fault prolongation to the southeast past the Ranchita Mine and down Rodriquez canyon; the asymmetry of the canyon walls on the two sides of Banner creek--the east side being little dissected, the west side much dissected; the physiographic extension of this same line northward to areas of well located dead or active faulting; the correlation between the surface of low relief found on top of Volcan Mountain with that of the Julian Mesa; and the suspected presence of sag ponds now dry along the fault zone, point unmistakably to comparatively recent faulting along Banner canyon and to the northwest and southeast. The physiographic evidence is greatly strengthened by gouge and brecciation in the granodiorite exposed in road cuts on the Foster grade near the head of Banner canyon. An estimate of the amount of throw based on the differences in altitude between the two surfaces thought to be wrenched apart by faulting is about 1000'.

Ellis(7) believed that Green valley and Chariot canyon constitute with the eastern base of Volcan Mountain a line of topographic expression suggesting faulting. An aplite dike crosses the upper part of Green valley without offset. Chariot canyon on the U. S. Geological Survey topographic sheet is shown straight and simple in outline, which on closer inspection is not the case. The attached sketch gives some idea of the differences in outline between Chariot canyon and Banner canyon and illustrates why an extension of the simple Banner scarp base cannot be prolonged into Chariot canyon. A physiographic line suggestive of faulting follows in a general way the road to the Golden Chariot Mine, and while on the sketch a probable fault zone is indicated as following this line, it should be regarded merely as a suggestion. The writer has no additional information on the other postulated major faults in or near the area depicted on the Fault Map of California(33)--two dead faults, well located, on each side of San Felipe valley, and two probable dead faults, one following Dye canyon (a western tributary of the upper part of the San Diego River) and striking almost due north along the boundary between R2E and R3E as far as San Jose valley, one following Santa Ysabel Creek to the southwestern base of Volcan Mountain. The steep eastern north-striking boundary of Santa Ysabel valley may well be the remnant of a much eroded fault scarp, and this physiographic evidence may be extrapolated southwesterly to account for the course of the upper part of the San Diego River.

Minor faults occur within the schist series, with displacements of a few inches or feet. Faulting along the eastern contact of the schist and granodiorite


Brecciated
Zone
Northeastern wall little dissected, especially near base
Banner Canyon
BANNER
Both walls considerably dissected
Chariot
Canyon
Ranchita
Fault Zone
Fairly certain
Likely
Probable Fault Zone
Good Physiograph
Expression
Data from aeroplane pictures
Scale 1" = 1500' (Approx)
small (1" = 2 mi) scaled USGS topographic
p, Banner and Chariot Canyons are
wn much alike, leading Ellis (WSP) 446)
postulate a fault zone following Chariot
nyon as well as Banner Canyon.
Ridge suggestive of faulting
clearer upstream

has been discussed under the contact relations of these bodies.

Ptygmatic Folding or "Rolls"

Structures of great interest in the main schist body are ptygmatic folds, or "rolls" as they are known wherever exposed in the mine workings. More detailed statements on the specific occurrences of this unique structure will be given under the section on ore deposits, those made here will be of a general nature.

Ptygmatic folds are irregular layers of quartz which in cross section form a more or less continuous sinuous band which lies partly parallel, partly transverse to the foliation. An individual fold constitutes what might be called a small saddle or trough reef (Lindgren-22). Directly associated with the folds are quartz veins paralleling the foliation.

Many hypotheses have been suggested to account for these folds or "rolls." Hanks(15) believed the vein was formed by solfataric action in plastic mud before the mountains were elevated and that the vein has been plicated by its own weight while still in a soft condition. Fairbanks(10), one of the most acute early observers, records an opinion that at the time of development of the second schistosity, a feature which he was the first to recognize, zigzag fissures were developed across the strata, the courses of which were determined by the competence of the beds; circulating waters deposited quartz in these fissures, which in time were rounded by absorption of the rough edges. There is much to be said for Fairbanks' hypothesis. The writer does not regard as tenable an hypothesis of post-quartz folding because most of the folia in the schist are not significantly disturbed where they abut against the quartz "rolls."

The writer has been unable to find a previous reference to the widespread nature of minor folding in the schist with or without quartz deposition or to the widespread development of individual quartz saddle and trough reefs throughout the schist series, but especially in the quartzite members. These are all apparently related to the same forces which produced the more spectacular "rolls" in the Ready Relief and other nearby mines, and should be explained in the same manner. Neither has the writer found on record the rather obvious fact that the axes of folds in the same rock are oriented in different directions, for example at the North Hubbard an outcrop shows ptygmatic folding in which the axial planes of the folds strike west of north and fold axes are inferred to be vertical; within the mine the fold axial planes have a similar strike but the axes are approximately horizontal or plunge northwest. Dr. Ian Campbell (oral communication) has found in the Archean of the Grand Canyon ptygmatic folding in a single outcrop in which there are three categories of fold axes, two parallel and with axial planes at right angles, and a third perpendicular to the first two. Based on this fact and on the absence of megascopic granulation in the quartz, Dr. Campbell tentatively favors an hypothesis of origin due to replacement. The writer advances the opinion that the "rolls" have been formed as the result of fissure filling and replacement along loci determined by diastrophic movement before quartz deposition. Further, I lean to the view that since the folds are especially well developed in richly siliceous rocks, it is possible some of the quartz has been provided locally, either by solution and redeposition in situ or by solution of downward projecting siliceous layers and redeposition higher up in the same or nearby beds.

Physiography and Historical Geology are not treated in the preliminary report for lack of time.

ORE DEPOSITS

General Statement

Lindgren(9) has given a summary of the features of the gold production of North America, some of his remarks are quoted herewith: "Practically all the gold out-put of North America is derived from fissure-veins or from deposits which possess close relationship to fissure-veins.....The deposits in fissure-veins are believed to have been formed chiefly by ascending hot waters.....testimony indicates that the gold is rather brought up from lower levels than derived from rocks near the surface. Gold-bearing fissure-veins or equivalent deposits occur in practically all kinds of rocks known on the continent;....A critical examination will reveal the fact that many vein-systems are massed about the contacts of intrusive masses, which consolidated far below the original surface of the earth at the time of igneous activity, and which have been exposed by subsequent erosion. Under favorable conditions it can often be proved, and in other cases established with probability, that the upper part of the vein has been removed by the same erosion which laid bare the intruded rock masses. In other words the top of the vein has been removed, the root remains. It seems plausible that in these cases the igneous intrusion was one, perhaps the principal, of the genetic causes. Dynamic action producing fissures in and about the intrusives is another genetic cause. The age of these veins must in general be considerable, for the great erosion involved has usually required a long time-interval.....The most important gold-belt in North America extends along the Pacific coast. It is throughout characterized by quartzose ores with free gold and auriferous sulphides. A great erosion has taken place since the veins were formed; and here,.....we have to deal with the lower parts of veins, the upper parts having generally been removed in many places to the extent of thousands of feet."

"Beginning in Lower California, Mexico, a hundred miles or more south of the boundary line, this great belt continues through San Diego, Los Angeles, and Kern counties; through the central part of California, where it is developed in great strength; then on to Northern California, southwestern and northeastern Oregon and Idaho." Northward it is exposed in a number of places as far north as the Klondike region, where it bends westward and follows the Yukon to the western end of the continent at Nome, on the Seward Peninsula.

From the foregoing it should not be considered that the gold-bearing quartz veins in San Diego county are the extension or continuation in southern California of the Mother Lode system of gold-bearing veins of central California; rather the view should be taken that all the Mesozoic gold-bearing veins of California are genetically related to upper Mesozoic batholithic intrusions that were injected along a zone paralleling and in the case of southern California south of the latitude of Los Angeles, bordering directly upon the Pacific Ocean. The roots of these batholiths, now exposed by deep erosion, testify to the enormous igneous activity initiated in southern California toward the end of the Triassic.

The gold bearing quartz veins of the Julian district are unique in many respects and differ from the veins of the Mother Lode system. The significant features respecting the Julian veins are

1. Richness, quartz yielding several dollars to the pound was in the early days of the camp no rarity and most of the profitable ore assayed more than $50 a ton.

2. Structure: no very strong veins continuous either in depth or strike have been discovered. The zone of mineralization is fairly continuous but individual ore bodies; small fissure veins, lenses arranged en echelon, and "rolls" of quartz, have no great continuity. The opinion that there are four continuous, traceable veins in the district is erroneous.

3. The mineralogy indicates a higher temperature of formation than that under which the Mother Lode system veins were deposited. The conditions of deposition

probably compared to the hypothermal environment of Lindgren. This view is predicated on the presence of pyrrhotite, arsenopyrite, and tourmaline in the veins along with pyrite, albite, and glassy, semi-transparent quartz. Large flakes of muscovite and brown biotite are found on the walls of some of the quartz bodies, apparently directly associated with the ore. The very scant amount of sulphide mineralization is noteworthy.

4. Secondary enrichment; this has been denied by some observers, but the writer must tentatively offer the opinion that the gold in the Julian veins has been, at least in part, affected by chemical processes since deposition. This opinion is founded on the (a) proximity of the possible source of salt, (b) the unusually rich concentrations of gold near the surface, (c) the lack of sizeable placer deposits which normally might be expected to result from the disintegration of rich, coarse-gold veins, (d) the known relation between the present surface and purity of gold mined, thus the mines on the Julian Mesa produced gold 800-900 fine, the mines related to the young canyons about Banner yielded gold which averaged between 600 and 750 fine.

5. Reversal of dip going from east to west, interpreted by this writer as being due to bending of the folia toward the points of relief caused by canyon cutting. No hypothesis as to the vertical extent of this bending can be formulated at present.

6. From the mineralogic and physiographic evidence the quartz bodies may be expected to extend, although not continuously, some distance below any depth reached by mining operations.

7. Most of the quartz bodies apparently did not have at the time of deposition well defined walls, that is, the quartz was not deposited in a fault fissure having definite walls. The postulated depth of deposition is in itself contrary to the idea of strong, continuous fissuring. It appears that wherever more or

less definite slickensided walls exist, they are the result of post-mineral deformation. The problem of the mode of formation of some of the banded quartz ore seems to the writer to be identical with the problem of lit-par-lit injection. Tentatively, the writer believes that deposition and replacement along zones conditioned by dynamic movements offers the best explanation. An alternative and likely explanation is the injection under pressure along the foliation at a time when the heat of intrusion had rendered the metamorphic rock pasty or viscous.