33d Congress, 2d Session. | SENATE. | Ex. Doc. No. 78.

REPORTS

OF

EXPLORATIONS AND SURVEYS,

TO

ASCERTAIN THE MOST PRACTICABLE AND ECONOMICAL ROUTE FOR A RAILROAD

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

MADE UNDER THE DIRECTION OF THE SECRETARY OF WAR, IN

1853-6,

ACCORDING TO ACTS OF CONGRESS OF MARCH 3, 1853, MAY 31, 1854, AND AUGUST 5, 1854.

VOLUME VII.

WASHINGTON:
BEVERLEY TUCKER, PRINTER.
1857.

IN SENATE—February 24, 1855.

Resolved, That there be printed, for the use of the Senate, ten thousand copies of the several reports of surveys for a railroad to the Pacific, made under the direction of the Secretary of War; and also of the report of F. W. Lander, civil engineer, of a survey of a railroad route from Puget's Sound, by Fort Hall and the Great Salt lake, to the Mississippi river; and the report of John C. Frémont, of a route for a railroad from the head-waters of the Arkansas river into the State of California; together with the maps and plates accompanying said reports, necessary to illustrate the same; and that five hundred copies be printed for the use of the Secretary of War, and fifty copies for each of the commanding officers engaged in said service.

Attest: ASBURY DICKINS, *Secretary.*

THIRTY-SECOND CONGRESS, SECOND SESSION—Chapter 98.

Sect. 10. *And be it further enacted,* That the Secretary of War be, and he is hereby authorized, under the direction of the President of the United States, to employ such portion of the Corps of Topographical Engineers, and such other persons as he may deem necessary, to make such explorations and surveys as he may deem advisable, to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean, and that the sum of one hundred and fifty thousand dollars, or so much thereof as may be necessary, be, and the same is hereby, appropriated out of any money in the treasury not otherwise appropriated, to defray the expense of such explorations and surveys.

Approved March 3, 1853.

THIRTY-THIRD CONGRESS, FIRST SESSION—Chapter 60.

Appropriation: For deficiencies for the railroad surveys between the Mississippi river and the Pacific ocean, forty thousand dollars.

Approved May 31, 1854.

THIRTY-THIRD CONGRESS, FIRST SESSION—Chapter 267.

Appropriation: For continuing the explorations and surveys to ascertain the best route for a railway to the Pacific, and for completing the reports of surveys already made, the sum of one hundred and fifty thousand dollars.

Approved August 5, 1854.

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REPORT

OF

EXPLORATIONS FOR RAILROAD ROUTES

FROM

SAN FRANCISCO BAY TO LOS ANGELES, CALIFORNIA, WEST OF THE COAST RANGE,

AND FROM

THE PIMAS VILLAGES ON THE GILA TO THE RIO GRANDE, NEAR THE 32D PARALLEL OF NORTH LATITUDE,

BY

LIEUTENANT JOHN G. PARKE,
CORPS OF TOPOGRAPHICAL ENGINEERS,

ASSISTED BY

ALBERT H. CAMPBELL,
CIVIL ENGINEER.

1854–5.

LETTER TO THE SECRETARY OF WAR.

WASHINGTON, *February* 9, 1857.

SIR: I have the honor to transmit, herewith, the report of explorations and surveys made for Pacific railroad purposes, in pursuance of your instructions. The report embraces the operations of the party in the field, and results obtained; and is accompanied by maps and profiles of the route surveyed, exhibiting the topography of the districts through which they are located, and a continuous profile of the route by the 32d parallel, showing therein the data, as obtained from the present survey.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Lieutenant Corps of Topographical Engineers.

Hon. JEFFERSON DAVIS,
Secretary of War.

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INTRODUCTION.

INSTRUCTIONS FROM THE WAR DEPARTMENT.

WAR DEPARTMENT, *October* 2, 1854.

SIR: The following duties are assigned to you, under the appropriation for continuing explorations and surveys, to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean.

1st. To make such explorations and surveys as will determine the practicability of a railroad from the Bay of San Francisco to the plains of Los Angeles by a route west of the Coast Range.

2d. To determine whether the valley of the Mojave river joins that of the Colorado, and will afford a practicable route for a railroad; and to explore the line recommended for examination by Lieut. Whipple, from Soda lake, Mojave river, to the Colorado river, by the Chem-e-hue-vas plain or valley.

3d. To make the additional examinations and surveys, recommended in your report, upon the route from the Pimas villages to the Rio Grande.

The geological examinations and surveys over this portion of the route are to be made with an especial view to obtaining an ample supply of water, for railroad purposes, by artesian wells, or by other means, if that prove to be improbable.

It is unnecessary to enter into details as to the nature of the surveys required, and of the information to be collected. They will be such as to furnish all the important elements in the solution of the question of practicability and economy in location, construction, working, and support of a railroad communication through the region of country passed over.

The surveys in the mountain passes will be sufficiently careful and minute to determine with precision their practicability or impracticability.

The geological information is considered to be especially valuable, not only as determining the character of the country, the nature of the difficulties to be overcome, and the quality, position, and extent of the building materials to be found, but in ascertaining the probability of supplies of water in arid regions, at suitable distances for railroad purposes, and for irrigation, where this is essential to agriculture. In these arid regions the collection of soils becomes of additional interest.

Your attention will be directed to the botany and natural history of the country, and to such other objects tending to illustrate its present and future condition and resources, to which the attention of the parties heretofore organized has been called, so far as they have a practical bearing upon the question of building and supporting a railroad.

A comparison of profiles, over the same lines, made by the barometer and spirit level, on the surveys of Lieutenant Williamson, promises to yield some interesting information upon barometric levelling; additional means of comparison are desirable.

To execute these duties you are authorized to employ the following assistants, viz: A geologist, civil engineer, draughtsman, meteorologist and computer, at the rates proposed by you; they will receive, in addition to their compensation, the actual cost of transportation to and from the field ; to employ such hands, teamsters, &c., as are necessary; to purchase the instruments named in your requisition, also camp equipage, wagons, mules, harness, &c., should the quartermaster's department not be able to furnish the means of transportation to you upon the conditions specified in the order to that department. The commanding general of the Pacific division will be directed to assign an escort of infantry to accompany the expedition from Los Angeles, California, to Fort Fillmore, New Mexico, to instruct the commanding officer of the escort to furnish you such aid and assistance as will tend to facilitate your operations, and to designate an officer of the army to perform the duties of quartermaster and commissary to the expedition.

The quartermaster's department will be directed to furnish you with mules, wagons, and equipments, and such other public property as may be needed for the use of the expedition, which will be returned to that department upon the completion of the field duties, payment being made for such mules as may have been lost, or as may then be found unfit for use, and of other public property lost or seriously damaged.

The commissary department will furnish you with such provisions and stores as you may need for the use of the expedition, to be paid for out of the appropriation for the survey, at cost, at the place of delivery.

The ordnance department will furnish arms, &c., and the medical department medicines, &c., for the parties, upon your requisition.

The sum of $39,000 is set apart from the appropriation for the expenses of the survey entrusted to you.

With your assistants, you will proceed without delay to San Francisco, and organize your party there or at Benicia, as may be most convenient.

The best route by which to connect the waters of the Bay of San Francisco with the valley of the Rio Salinas will probably be by the Rio Pajaro to its mouth, and thence along the coast to the mouth of the Salinas. Ascending the valley of the Salinas to San Miguel or Santa Margarita, near the head-waters of the Salinas, you will then make a thorough examination of the valleys of the various affluents of that stream, and survey such as promise to afford practicable grades to the plain of Los Angeles, through the mountain masses of the Coast Range which come down to the shore at Point Concepcion.

The examinations and surveys must be sufficiently extensive and thorough to exhaust the subject.

Should this connection prove impracticable, you will ascertain the practicability of passing from the valley of the Salinas, near its source, to the coast, and along the coast to the plain of Los Angeles.

The department desires to be informed, at the earliest possible day, of the result of these examinations and surveys.

This duty being completed, and the connection made with the lines of survey of Lieutenant Whipple or Lieutenant Williamson, you will proceed to the Mojave river, near Soda lake, and ascertain whether a continuous valley from this lake to the Colorado exists, and affords a practicable route for a railroad. You will also, if practicable, explore the line recommended for examination by Lieutenant Whipple from Soda lake to the Colorado by the Chem-e-hue-vas plain or valley.

You will then proceed to the Gila river, and ascertaining carefully the practicability of a road between the Pimas villages and the mouth of the San Pedro, you will make the examinations and surveys recommended in your report upon the route surveyed by you between the Gila and the Rio Grande.

Over this ground the geological examination and surveys will be particularly minute, because it is especially important here to determine the practicability of obtaining a supply of water ample for the uses of a railroad, either by artesian wells or by other modes.

These duties being completed, should any further examinations or surveys be assigned to you, instructions will be sent to Fort Fillmore. Should no further field duties be required of you, you will discharge your party, dispose of your outfit to the best advantage, and proceed, with your assistants, to this place and make out your report.

Very respectfully, your obedient servant,

JEFFERSON DAVIS,
Secretary of War.

Lieutenant John G. Parke,
United States Topographical Engineers, Washington, D. C.

PART I.

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WAR DEPARTMENT.

ROUTES IN CALIFORNIA TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS, AND ROUTE NEAR THE THIRTY-SECOND PARALLEL, BETWEEN THE RIO GRANDE AND PIMAS VILLAGES, EXPLORED BY LIEUT. JOHN G. PARKE, CORPS OF TOPOGRAPHICAL ENGINEERS, IN 1854 AND 1855.

GENERAL REPORT.

WASHINGTON, D. C.
1857.

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* From original sketches by A. H. Campbell, Esq.

GUADALUPE LARGO & SAN LUIS HARBOR

No. 1.

REPORT OF EXPLORATIONS FROM SAN FRANCISCO BAY TO LOS ANGELES.

GENERAL REMARKS.

Having secured the services of the assistants authorized, and procured the instruments necessary for the prosecution of the field duties, the party sailed from New York in the mail steamer of the 5th of October, and arrived in San Francisco on the 1st of the following month. To organize and furnish the party with the required stores, camp equipage, and transportation, detained us until the 20th of November, when we started from Benicia, crossing the Straits of Carquinez to Martinez, and proceeding thence by the wagon road to the Pueblo of San José at the southern end of the Bay of San Francisco, where we entered upon the field of survey for determining the practicability of locating a line of railroad from the Bay of San Francisco to Los Angeles, lying wholly west of the Coast Range.

From San José, the initial point of the survey, we followed along the Santa Clara valley to a tributary of the Pajaro, and thence down the valley of this stream to near the mission of San Juan Bautista. From this point the examination of the Pajaro was continued down to its opening upon the Bay of Monterey. Lines were also run over the hills, west of the mission, which separate the valley of the Pajaro from the plains of the Salinas. Having made this connexion we moved to the Rio Salinas, and ascended it to a point about nineteen miles above the mission of Soledad, where the party was divided, one taking the wagon road over the hills on the left bank of the river, *via* San Antonio, while a small party with pack mules continued up the valley, and joined the main party at the mission of San Miguel. Thence we followed the road to the rancho of Santa Margarita, where a depot camp was established, from which various explorations were extended and surveys made.

Our first object was to trace the Salinas to its source; this being done, and an apparently practicable connexion found between its left fork and the Cuyama plain, which is on the direct line towards the San Fernando and Los Angeles plains, a compass and level survey was there made, so that a complete chain of observations for profiles might be established, should the final link be found practicable. While this was being accomplished, a reconnoissance was made up the Estrella, the right fork of the Salinas, debouching at San Miguel. It was found that this fork had a course nearly parallel to the Salinas, and *headed* further to the south, and opposite to the Cuyama plain, from which its valley is separated by a single divide, giving but one summit to be crossed instead of three, as are encountered on the first line of survey. This new summit and approaches were surveyed, establishing the connexion between the Salinas plain and the Cuyama, *via* the Estrella and Panza ranchos. In addition to the main explorations, simultaneous side trips were made in order to develop more fully the topography and geology of the country. These duties occupied the party thirty days, throughout which time meteorological observations were taken at the permanent or depot camp.

These being completed a survey was made through the San Luis Pass, which leads across the ridge of the Santa Lucia mountains, from the rancho of Santa Margarita to the mission of San Luis Obispo, on the ocean slope of the mountain. The survey was afterwards pushed down to the beach at the mouth of Arroyo Grande.

In the mean time our camp was moved over to San Luis Obispo, and thence to Beebe's rancho, near the Corral de Piedras creek. Thence we moved by the wagon road (*via* Napoma rancho) across the Guadalupe Largo to the mission of Santa Inez, from which point explorations were made connecting the valley of Santa Inez with the Guadalupe Largo by three lines.

Camp was then moved to the Gaviote Pass, it being the only known practicable wagon route through the Santa Inez mountain. This ridge is a decided obstacle, and the only way of surmounting or avoiding it is by the Gaviote Pass, which leads directly from Santa Inez mission across to the beach, or by turning the mountain and following the shore line by Points Arguello and Concepcion. A survey was, therefore, made of the Pass.

Finding, on completing this survey, that our provisions were becoming exhausted, it was determined to continue on to Santa Barbara, and there encamp, replenish our supply, and then return with pack mules to make the necessary examinations for determining the practicability of the shore route. In this manner a second line was explored from the valley of Santa Inez, at the mission La Purissima, around to the mouth of the Gaviote Pass.

A topographical examination was made at the same time by another party, under Mr. A. H. Campbell, across the San Marcus Pass (the bridle path, or pack-route across the Santa Inez mountains,) and the sources of the Santa Inez river.

This examination proved to be one of the most important ones made, by furnishing the *key* to the whole system of the Coast Range. Mr. Campbell, having paid much attention to the *geological dynamics* of this entire region, soon perceived a relation of parallelism between the various geological axes which would subserve valuably to a correct understanding of the topography. He accordingly made a careful survey of these axes in the cañon of the Rio Santa Maria and the *Muerto Macho* cañon, along the base of the Sierra de Napoma and Sierra San Rafael, and at other points, and by his survey across San Marcus Pass and to the sources of the Santa Inez river was enabled to connect these several serpentine axes throughout long distances, and thereby unlock this whole system, and demonstrate the erroneousness of classification, both geological and topographical, with reference to these mountains, as proposed by W. P. Blake, geologist, and adopted by others. A reference to the accompanying map and report of Dr. Antisell will show these parallel axes and the importance of Mr. Campbell's discovery in a geological point of view.

From Santa Barbara we continued down the coast to the mission of San Buenaventura. Ascending the mission valley a few miles, we located a camp and started on a trip across the mountain, intending thus to reach the Cuyama plain. In this enterprise we utterly failed, notwithstanding three attempts were made. The difficulties of rugged and precipitously walled cañons, and the deep snows of the summits, forced us to return. Topographical examinations were made of the country surrounding our camp. We then moved to the Santa Clara valley with the wagons, *via* San Buenaventura, a party at the same time crossing the intervening low ridge. On the parties joining, the valley of the Santa Clara was ascended to the rancho of San Francisquito, and camp was located near the road leading from Los Angeles to the Tulare valley. At this point a party was organized and started for the Cuyama plain, passing through the Cañada de las Uvas into the Tulare valley, and thence across the low hills to the north of Santa Emilia mountain. Reaching the plain, our object was to find a practicable connexion between it and that of Los Angeles, and complete the line already extended thus far from the Salinas. To do this, we traced the Rio Santa Maria to its source, and encountered a divide between it and a tributary of the Santa Clara, with rugged, difficult, most forbidding and impracticable approaches, precluding all idea of locating a line of railway along this route. Leaving this divide, we followed down an open and inviting valley; but its character, however, now changed to that of the cañon, and finally became impassable. Rather than retrace our steps, we clambered up the left wall, and with great difficulty got out upon a more open country; here we soon fell into our trail from San Francisquito to the Cañada de las Uvas; having thus completely encircled the Santa Emilia mountain, and satisfied ourselves of the utter impracticability of the mountain route, we wended our way back to the depot camp, having been absent fourteen days, and experienced, during that time, more hardships and difficulties, from ruggedness of country, snow, and rain, than we had before met with. Leaving San Francisquito, we followed down the Santa Clara, making such side explorations for topography as time and occasion permitted, until we reached the coast road to Los Angeles, and proceeded thence to the rancho Triompho, making examinations and surveys on both sides of the road *via* the ranchos Semi and Conejo. From Triompho we proceeded to Los Angeles, and thus completed the first division of the work entrusted to our charge, occupying the party four months from the 20th November, 1854, (the date of our entering the field.)

At the mouth of the Cajon Pass, near the Mormon settlement of San Bernardino, we were joined, on April 3, by the escort under the command of Lieut. Wm. A. Winder, 3d regiment artillery. Leaving the main body at this point under his charge, we then started through the Pass with a small party for the Mohave river, which we traced down to the Soda Lake. Skirting this lake, we found (as did Capt. Whipple and Lieut. Williamson) no outlet to the Colorado river.

Between Soda Lake and the Colorado river lies a strip of desert country, upon which the only known watering places are those along the route of Capt. Whipple. To traverse this line was, of course, unnecessary, and from previous experience in districts of country of similar character, I deemed it too hazardous, and in fact an unwarranted risk to attempt to traverse the Chemehueves plain, when, from all the information I could gather from trappers as well as Indians, there was not a drop of water for over a stretch of *one hundred and ten miles.*

Returning from the Mohave river, I proceeded to San Francisco *via* Los Angeles and San Pedro, to procure funds and replace broken instruments, whilst the party proceeded to San Diego, there to reorganize and refit for our Gila trip. Lieut. G. T. Andrews, 3d regiment artillery, here relieved Lieut. Winder in charge of the escort.

I arrived in San Diego on 23d May, and everything being in readiness, we started on the 26th, following the wagon road to Fort Yuma, and thence up the Gila to the Pimas villages. Owing to the excessive heat on the desert and along the Gila, the entire distance from Carrizo Creek was performed at night. At the Pimas villages the party was divided, one taking the wagons *via* Tucson to the crossing of the San Pedro, while the other, with pack mules, continued up the Gila to the mouth of the San Pedro, thence up this stream to the wagon road, where the parties again joined. From this point an exploration was made of the ridge on the right bank of the stream, and to the north of our camp. On the return of this party we proceeded to the Playa de las Pimas, and camped at the springs on its northwestern margin. Here we again diverged, one party taking the road through the Puerto del Dado, while the other proceeded through the opening between the Chiricahui range and Mount Graham. Uniting in the Vallé del Sauz, the country in advance was reconnoitred with reference to obtaining water, under the Peloncillo (Sugar Loaf) ridge immediately to the east of us. Receiving a favorable account, we moved next morning to this point, determining at the same time the barometric altitude of the gap south of camp.

From the Peloncillo camp we continued eastward, following the trail of the Boundary Commission, crossing a *playa* turning the north end of the Pyramid ridge, crossing a second *playa* and ascending the foot slopes of the extreme southern spurs of the Burro mountains, and reached the southern emigrant road, (Cooke's.) We then entered the arroyo, or cañon, leading from the Ojo de Inez, and ascending it a mile or two to Las Peñasquitas, encamped at some water holes or natural cisterns in the bed rock of the lateral cañons; proceeded thence to the Ojo de la Vaca, Rio Mimbres, and Cooke's spring, making at the same time lateral examinations to obtain barometric readings at stations on lower ground to the south, and of course more favorable than that passed over by the wagon road. Thence to the Rio Grande, at Fort Fillmore, we followed the usual wagon road, diverging, however, near the edge of the *mesa*, and descending to the river bottom by a smooth and easy slope, and avoiding the rough cañon heretofore encountered north of El Picacho, the examinations of 1854 being most satisfactory, and also impossible to be improved upon.

The observations taken during this examination and survey embraced not only those necessary to determine the practicability of constructing a railroad through the country traversed, but also, so far as means and time would permit, those required to make a topographical sketch of the country along and adjacent to the proposed line. These embraced, therefore, astronomical and barometrical observations, in connexion with odometer and prismatic compass surveys in the valley and plain districts, and also compass and chain and level surveys in the mountain passes.

Section 1. EXTENT OF SAN FRANCISCO AND LOS ANGELES DIVISION.

Exploration for railroad purposes in a country whose detailed topography is so little known as is that of the great west, involves the necessity in nearly every instance of primary reconnoissance to develope the topographical features of the district, that the parent mountain chains and radiating spurs with the interlocking rivers and tributaries may be accurately mapped, and thus afford definite data with regard to the gaps and depressions in the several watersheds or divides, and their lines of easiest ascent and descent. This necessity we found to be particularly the case in the California division of our work, where we had reason to expect greater accuracy in existing maps, the country along and adjacent to our line of examination being for a long period occupied, but by a population who knew, as a general thing, little of their own country beyond their ranchos and lines of communication to the neighboring towns. Our operations were, therefore, confined in the first place in collecting materials for an accurate mapping of the country, and then to determine the question of practicable location of a railroad through its various valleys and mountain passes from San Francisco to Los Angeles. The explorations and surveys, together with the various side explorations, extend throughout the diagonal of the area bounded by the parallels 34° and 37° 30′ and the meridian 119°, 123°, and have resulted in the location of a practicable route from San Francisco to Los Angeles, lying wholly to the west of the watershed of the Coast Range, and following in the main what is known as the coast road.

SECTION 2. COAST RANGE.

By referring to the map of southern California, it will be perceived that there are two main mountain masses, the Sierra Nevada and Coast Range, separated by an extensive plain, the San Joaquin and Tulare. The crests of their serpentine watersheds gradually converge towards the Tejon, where there is an impinging of the two masses to such a degree as to completely envelope the plain, throwing around it formidable barriers to egress toward the desert on one side and the ocean slope on the other. Beyond, and to the south of the Tejon, but one mass or chain will be observed trending off to the peninsula of Lower California, dividing the waters flowing directly to the coast from those of the Colorado Basin. The ranges are marked and decided in their several features and characteristics, the former being made up of a solid and dense mass of ridges and spurs, presenting but few depressions or openings to the desert or Great Basin; while the Coast Range is composed of a series of distinct ridges, with intervening valleys and plains, rendering the whole district very inviting to the agriculturist, and affording the artist every variety of study, from the smooth plain with its lowing herds, to the rugged mountain with its walled cañons.

No little confusion has of late arisen in regard to the application of the term *Coast Range*, but this may, in my opinion, be greatly corrected by giving the term its widest acceptation, and applying it to the whole system of ridges lying west of the San Joaquin and Tulare valleys. Each ridge has been, in turn, called the Coast Range, depending on the position of the observer, whether in the interior or on the ocean; but by using it as a general term to include the whole, and giving to each ridge its local name, no difficulty will be experienced in studying the topography and geology of that very interesting region.

The ridges are five, and, proceeding from the eastward, they will be distinguished in what follows as—1st, the Monte Diablo mountains; 2d, the Santa Cruz and Gavilan mountains; 3d, the Salinas mountains and San José mountains; 4th, the Santa Lucia mountains; and 5th, the Santa Inez. The axes of the several ridges are parallel, with the apparent exception of the Santa Inez, and this has been found, after a close geological investigation, to follow the same law, although from the mass there appears to be a fan-like order about the ranges, which is really the case when the crests of the several watersheds are considered in connexion with the form and slope of the intervening valleys. Following the coast line from the south, this fan-like arrangement of the ridges resembles more an *echelon* order, where each ridge, in turn, presents its full front to the ocean for some distance, and then gives way to the one immediately behind it, each becoming thus, in fact, a coast ridge; and this feature no doubt has contributed much to the confusion before noted. The Monte Diablo mountains form the western boundary of the San Joaquin valley, and extend from near the head of the Bay of San Francisco to opposite the Tulare lake. The most prominent feature of this ridge is the Monte Diablo, a heavy and massive peak with rounded profile, and a summit elevation of about four thousand feet, giving it great prominence as a landmark. Further to the south there are other peaks, Pachecho and Santa Ana; and in the vicinity of the peaks are found passes leading through from the Bay of San Francisco, San José plain, and Santa Clara valley, to the great interior basin of the San Joaquin. To the west of this ridge lies that of the Santa Cruz and Gavilan mountains, forming in their extent the western boundary of the San José plain and Santa Clara valley, and separating the southern arm of the Bay of San Francisco from the ocean, becoming, in its prolongation to the north, the barrier through which the waters of this bay find egress by the Golden Gate.

To the south of the Golden Gate this ridge is again broken through by a stream—the Pajaro—which, draining a portion of the Santa Clara plain, wends its way to Monterey Bay, dividing the ridge into the Santa Cruz and Gavilan mountains. The Gavilan mountains take their name from its most notable peak, which looms up a sharp cone, indicating the turning point of the Pajaro, and giving a landmark quite as prominent and unmistakable as Monte Diablo. These mountains trend off on the prolongation of the Santa Cruz mountains, forming the boundary between the Santa Clara and the great Salinas plains; and by gradually widening and impinging upon the Monte Diablo mountains, the axes of the two are apparently lost, but embraced within an elevated district lying to the west of the Tulare lake and close under the Santa Emilia mountains of the Tejon.

Proceeding westward from the Gavilan mountains, we find the third ridge extending from the Bay of Monterey off to the southeast even beyond where the two preceding appear to terminate. The axis of this ridge is broken through by the Salinas river, dividing it into the two masses—the Salinas mountains on the north, and the San José mountain on the south. The Salinas mountains are irregular and much broken, and are separated from the Gavilan by an extensive plain sloping northward to the Bay of Monterey. Ascending this plain, it is narrowed down to a valley which partakes somewhat of the character of a cañon, where the stream, by a slight change in direction, is found to cross the axis of the ridge. Here there is a breaking up and apparent termination of this ridge, but it will be perceived that it is reproduced in the San José ridge beyond, which becomes in its extent rugged and precipitous, having an extensive elevation of about four thousand feet. To the west of the San José, and separated from it by the valleys at the headwaters of the main Salinas, lies the fourth ridge, (the Santa Lucia,) which abuts on the ocean in the vicinity of Punta Gorda and trends off, occupying, in its course and by its adjuncts, the most conspicuous position among its neighbors, preserving its direction and identity to a greater extent than all preceding, and becoming really the main axis of the chain stretching off to the peninsula of Lower California, forming, below the junction of the Sierra Nevada and Coast Range, the boundary between districts, one as sterile and inhospitable as the other is beautiful and inviting. It is, however, much broken, and bears in its course different local names. It not only forms the western limit to the valleys of the upper Salinas, but plays the same part with reference to another plain and valley lying beyond and in the prolongation of the Salinas plain. This new plain is called the Cuyama, and is separated from the head of the Salinas by low transverse divides which unite the two bounding ridges. The Cuyama plain is drained by the Rio Santa Maria, which, heading in the Santa Emilia mountain, meanders off to the northwest, and breaks through this intervening ridge by a narrow, tortuous, and exceedingly rugged cañon to the plain lying between it and the coast, the Guadalupe Largo. That portion of this ridge to the north of the cañon is divided longitudinally by the Wasna creek into two ridges, one of which is called the Napoma Ridge, and the other the Santa Lucia. To the south of this cañon, and opposite the Cuyama plain, the ridge is again divided longitudinally by a tributary of the Santa Maria into the Cuyama mountains and San Rafael mountains—the former being the boundary of the plain from which the name is derived, and the latter forming the eastern limit of the Santa Inez valley. These two ridges unite beyond, near the sources of the Santa Inez and San Buenaventura rivers, and then the mass bears the name of Santa Cruz.

The fifth ridge, Santa Inez mountains, is, as before remarked, apparently unlike the preceding in the feature of parallelism, which they all possess in a great degree throughout their whole

extent. From Points Arguello and Concepcion this ridge trends off to the east, impinging upon the preceding ones, and terminates abruptly at the valley of the Rio San Buenaventura. For seventy-two miles to the east of Point Concepcion the shore line follows closely the direction of this ridge, the foot hills sloping down to a grassy terrace which bluffs down step-like from 60 to 100 feet to the alternating rock and sand beach. Opposite Santa Barbara these mountains take the name of that town. Below this point there is a gradual divergence of the shore line and the main ridge, and a secondary and minor ridge intervening, continues to San Buenaventura, with its precipitous faces sloping down to the water's edge; so that the traveller is forced for a few miles to take the beach, and to conform his motions to those of the tide. Besides these principal mountains, there are others of secondary importance, and these retain generally the same feature of parallelism, although apparently trending more to the east. They give the country in many places a rolling, and in others a terraced appearance. Of the latter ridges, the most important are the Sierras de la Santa Susana and de la Monica, lying between the Santa Clara and Los Angeles plains.

Section 3. VALLEYS AND PLAINS.

Proceeding from Martinez, (on the Straits of Carquinez, opposite Benicia,) we traversed in order the following plains and valleys:

Between Monte Diablo and a secondary ridge, forming the eastern boundary of the Bay of San Francisco, lies the beautiful and inviting valley of San Ramon, extending inward about ten miles, where it opens out into a plain, headed by the foot hills and spurs of the two bounding ridges which unite beyond. This valley has an average width of two miles, and is drained by a stream, Arroyo de los Nueces, flowing into the Suisun Bay. The waters of Livermore's plain at its head form a stream, the Alameda, which breaks through the secondary ridge on the west and empties into the Bay of San Francisco, near its southern end. The divide between these two streams is not marked by a decided or distinct ridge, but is found on a smooth plain surface, where, without the aid of instruments, it would be difficult, if not impossible, to trace it. This feature is not confined to this locality alone; it was observed also in the Santa Clara valley, in the divide between the drainage towards San Francisco and Monterey Bays. On either side of the southern arm of the Bay of San Francisco are smooth plains or meadows, sloping from the bases of the bounding ridges gently down to the water's edge. These plains unite and surround the head of the bay, giving at San José a total width of eight miles, and thence extend in an unbroken valley between the Monte Diablo ridge and Santa Cruz mountains to a distance of over sixty miles on a prolongation of the axis of the bay. This entire valley is known by the general name of Santa Clara, whilst that portion enveloping the head of the bay retains the name of the *pueblo* or town, San José. From the mountains on either side there are several small streams flowing down towards the bay, but the valley proper is drained by the Coyote and Guadalupe creeks, flowing into the Bay of San Francisco, and the Pajaro and its tributaries into that of Monterey. Between the headwaters of the streams of these two bays is the divide similar to the one before mentioned. Beyond this, the main tributary of the Pajaro has its source, at the head of the valley to the south of the Pacheco and Santa Ana peaks. This stream breaks through towards the coast, receiving the drainage from a second plain or valley, that of the San Juan Bautista, lying at the base of the Gavilan.

The Pajaro, by a narrow valley, pierces the ridge, or rather flows between the terminal spurs of the Santa Cruz mountains on the north, and of the Gavilan mountains on the south. When through the main spurs, the valley gradually widens, becoming in its course a smooth, broad bottom, extending to the margin of the bay, and unites with the bottom lands of the lower Salinas.

The most prominent of the several valleys is that of the Rio Salinas. This valley, at its mouth, has a width of about nine miles, and extends sixty miles inland, between the Salinas and the Gavilan mountains. The lower portions of this valley are decidedly of a prairie or plain character, and are thus styled. They are quite like the lands along the lower Pajaro, flat and monotonous. Ascending the stream, the valley narrows, and losing its continuity, breaks up into tributary or lateral valleys. Of the lateral valleys, those which came under our observation are the Estrella, Santa Margarita, Rinconada, and San José. The Estrella heads to the east of the San José ridge, and is separated from the Tulare valley by a district of low, broken, and bold hills, the terminal spurs of the Monte Diablo and Gavilan masses. This valley has an average width of over eight miles, and unites with the Salinas at San Miguel, having a meandering course of forty miles. The Santa Margarita and Rinconada are lateral valleys, uniting with the Salinas on its left bank. These valleys are somewhat basin-shaped, and receive the drainage from the eastern face of the Santa Lucia range for a space of twelve miles, and all uniting in these basins, flow off easterly to the bed of the Salinas.

San José is above and to the southeast of Santa Margarita, and may be called the head valley of the Salinas. It partakes, also, somewhat of the basin character, but of limited area. Here are gathered the waters of the Santa Lucia and San José mountains, the sources of the Salinas, forming a single stream, which, breaking through the rim of the basin, flows off through a tortuous cañon, assuming in its progress all the different phases of valley features, which finally resolve themselves into those of the plain below. Beyond San José, and separated from it by twenty-three miles of rough country, transverse divides, stretching between the two longitudinal ridges, lies the Cuyama plain, on the prolongation of the axis of the San José and Santa Margarita valleys. This plain is about forty-five miles long, and has an average width of two miles. It heads near the Santa Emelia mountain, and slopes off to the northwest, being drained by the Rio Santa Maria, which meanders through its length, and reaching a barrier at its northern end turns abruptly oceanward, and breaks through the Santa Lucia ridge by a narrow and rough cañon. The head of the Estrella valley lies immediately on the east of the lower portion of this plain, and is separated from it by a low divide.

Still further to the east is found another remarkable feature, the Estero, a broad, smooth plain, destitute of timber and shrubbery, cut off from the Estrella and Cuyama, and also from the Tulare valleys, by low ridges. From a distance, this plain had the appearance of a basin, having a broad and shallow lagoon near its centre, whose waters were evaporated during the dry season, but, nevertheless, it has a drainage towards the Tulare valley.

Crossing from Santa Margarita to San Luis Obispo, we enter upon the plain of the mission, extending from the base of the ridge to a low range of sandstone hills and bluffs, separating it from the beach, through which the waters of this plain flow off by a narrow valley to the ocean, at the port of San Luis. This plain was smooth and meadow-like, but of limited extent. Between the plain of San Luis Obispo and the valley of Santa Inez are found several minor valleys, whose streams break out from the San Lucia mountains and flow directly to the ocean. Of these, the most important is the Guadalupe Largo, a plain which stretches from the base of the ridge, in delta form, to the beach, and contains about eighty square miles. The Santa Inez valley heads in the angle embraced by the Santa Inez and San Rafael mountains, and is drained by a stream which trends off in a westerly direction close under the former mountain. In its course this stream flows through a gorge for about twelve miles, separating the main valley into the upper or Santa Inez valley, and the lower or La Purisima, from the mission there located. These valleys have a combined length of fifty miles and an average width of four miles, and are bounded on the north by terraces sloping back to low spurs jutting out from the mountains to the coast. The valleys and side slopes of the mountains and terraces are dotted with clumps of oaks, and the streams fringed with a growth of willow and cotton-wood. Leaving the Santa Inez, no valley is found until arriving at the mission of Santa Buenaventura, which is situated at the mouth of the valley of the same name, near the beach. This we crossed at right angles, but found, by side explorations, that it extends inland, and turning the east end of the Santa Inez mountain, heading with the Santa Inez river, receives the waters of the ocean slope of a lofty ridge, the extension of the Santa Lucia which separates this valley from the head of the Cuyama plain.

Leaving the San Buenaventura, we enter upon the Santa Clara plain, which takes its name from the stream draining it. This plain extends from the beach, where its width is twenty miles, inland for forty miles, gradually narrowing as it is ascended, and contains nearly two hundred square miles. It heads in the New or Williamson's Pass, and in a range of mountains behind the mission of San Fernando, and is joined in its course by several tributary valleys. It is separated from the San Fernando plain by the Santa Susana mountains, within which, however, lies a small valley, the Semi, apparently completely cut off from the plain on either side, but is a tributary of the Santa Clara, and from its location and extent affords an easy connecting link between the two plains. The San Fernando has an area of eighty-five square miles, bounded on the north by a high ridge or main axis of the Coast Range, on the west by Santa Susana, and separated from the ocean by a low rolling ridge, which extends for thirty miles to Los Angeles, where the stream which receives all the waters of the plain and surrounding slopes turns the ridge and bears off to the ocean at San Pedro. Between Los Angeles and the coast, and adjacent to the stream above noted, there is spread out another smooth extent of prairie or meadow country containing about ——— square miles, the Los Angeles plain proper. To the east, and at the base of the mountains is found the mission of San Gabriel, located upon the foot slopes of the mountain range, and overlooking another large plain, bearing the name of the mission. These are simply local names and are all embodied under the general name of Los Angeles plains, embracing the champaign district lying at the base of the mountains between the missions of San Fernando and San Gabriel, and extending off to the shore line. But it must not be understood as one unbroken and continuous prairie surface. It is beautifully diversified with smooth knolls and low rolling ridges, with an occasional clump of oaks near the base of the mountains.

SECTION 4. WATER COURSES.

The Coast Range between the Bay of San Francisco and the plains of Los Angeles is drained by numerous small streams, which break from the cañons and gorges, clear limpid mountain brooks, whose waters become turbid and sluggish as they meander through the lower valleys and plains, and are often entirely absorbed by the sands of their beds. In the mountainous districts these streams have narrow valleys and gorges while flowing parallel with the geological axis. But when these axes are crossed or ridges pierced the valleys become contracted, till finally the stream is hemmed in by lofty walls of rock approaching verticality, and flows over a bed of huge boulders, rendering the passage of these cañons always difficult, and often impracticable. As soon as these streams debouch upon the plain districts their features undergo a thorough change. The bed gradually widens until the water-way or channel often occupies even less than one-fourth of the entire width. The boulders of the cañons pass through the several gradations of cobble stone, pebbles, gravel, and sand, which becomes finally so light and shifting that the channel is continually changing, assuming a zigzag course through its bed. The current becomes sluggish, the waters turbid, the volume diminishes, and in many instances entirely lost for many months of the year in the absorbing sands of their beds.

These streams are, however, all insignificant when compared with the water courses of the Mississippi basin and Atlantic slope, and with our standard they are not worthy to be called rivers. But, nevertheless, the largest are thus known and so called. The most important are the Pajaro, Salinas, Santa Inez, San Buenaventura, and Santa Clara. The Salinas drains the largest area of country, and has a length of one hundred and fifty-two miles. The Santa Clara is about one hundred and fourteen miles long.

These streams are all readily forded, excepting during a brief period of the rainy season when there is more or less danger in crossing, owing to the quicksandy nature of the beds.

These beds have a depth of from four to twenty feet below the valley bottom, and are bounded by vertical walls of soil, when exposed to the undermining action of the stream.

Section 5. SOIL.

The soil of the valleys and plains, over which our line traverses, is a very rich alluvial loam, extending in many places to great depths. With proper cultivation and attention, these grounds will yield crops equal to any in the world. This rich soil is not confined entirely to the plains and valley bottoms, for we find the wild oats frequently covering the foot hills, and even stretching up the mountain slopes. Besides the wild oats, there is found a great variety of grasses, which have afforded the sole pasturage to the herds of countless cattle and horses that have roamed here untrammelled for an half a century, the pride of the princely padre and patriarchal ranchero.

These grasses are chiefly annuals, and are reproduced by nature, who carries on through her agents, the seasons and winds, all the duties of the ploughman, the seedsman, and harvestman. During the long drought of the summer months, the grasses and oats become perfectly cured hay, while the seeds ripen and fall to the ground, which, by this very drought is prepared to receive them, being cracked and fissured in all directions. The winds scatter and sow, and thus the seeds remain in these cracks perfectly preserved until the first rain of the following season, which, playing the part of the harrow, crumbles the soil and covers the seed, which soon germinates and leaps forth a new crop. There is also a great variety of flowers intermingled with these grasses, whose brilliant colors, contrasted with the rich verdure, give these plains an Eden-like aspect in the early spring months, rendering the country then as beautiful and inviting as it is bare and forbidding just prior to the rainy season. The great difference in the aspect of the country has given rise to the many contradictory accounts given of its fertility and agricultural capacities.

The country west of the crest of the Coast Range extending from San Francisco to San Diego was, in the year 1800, under the control of the Spanish priests, who had at that time founded sixteen mission establishments. Here were collected the Indians of the mountains, and these, under the good management of the padres, erected spacious churches, immense suits of apartments, and long rows of quarters. Luxuries soon followed the comforts, these establishments soon became princely in their extent, the cattle and horses were counted by thousands. This excited the cupidity of the government of Mexico, and in 1833, a decree was published depriving the padres of all temporal control, and giving it to commissioners. The Indians dispersed, the padres gradually retired, and from that date these mission establishments went into decay. Now they are wrecks, monuments of their pristine splendor, masses of crumbling walls, with here and there occasional evidences of design and good taste in the arrangements of parts and construction. The churches are generally in good preservation, the bells of some are still hanging. But adobe walls soon melt before the southeasters of the rainy season.

By degrees these mission lands were passing into the hands of private individuals, a state of things going on up to the time of the occupancy of this country by our troops, when the few that were left were taken possession of in the name of the general government. Claims and counter claims are now set up by individuals for this property, and while they are being adjudicated the *squatter* locates and establishes his pre-emption. The buildings are applied to various uses; a church is converted into a barrack; the padres' apartments are used for stores, smith shops, and stables, and even, in one instance, by a retail liquor vender. Cattle and pigs roam at large in the orchards where once flourished the grape, fig, olive, peach, and pear, pomegranate, and orange. The agricultural capacities of this country are unsurpassed in the world. Its hills and mountain slopes afford rich pasturage. Its valleys and plains yield enormous crops of cereals and vegetables, whilst the fruits of our Atlantic board, together with many of those of more tropical latitudes find here a most genial soil and climate.

According to the State census of 1852, there were in the countries along our route:

	Horses and mules.	Horned cattle.	Grain.—Bushels.	Cultivated acres.
Santa Clara	4,980	23,767	670,697	19,066
Monterey	2,857	55,959	23,292	3,117
San Luis Obispo	1,232	27,914	6,006	2,538
Santa Barbara	3,110	52,379	7,679	699
Los Angeles	13,266	115,083	53,289	5,587

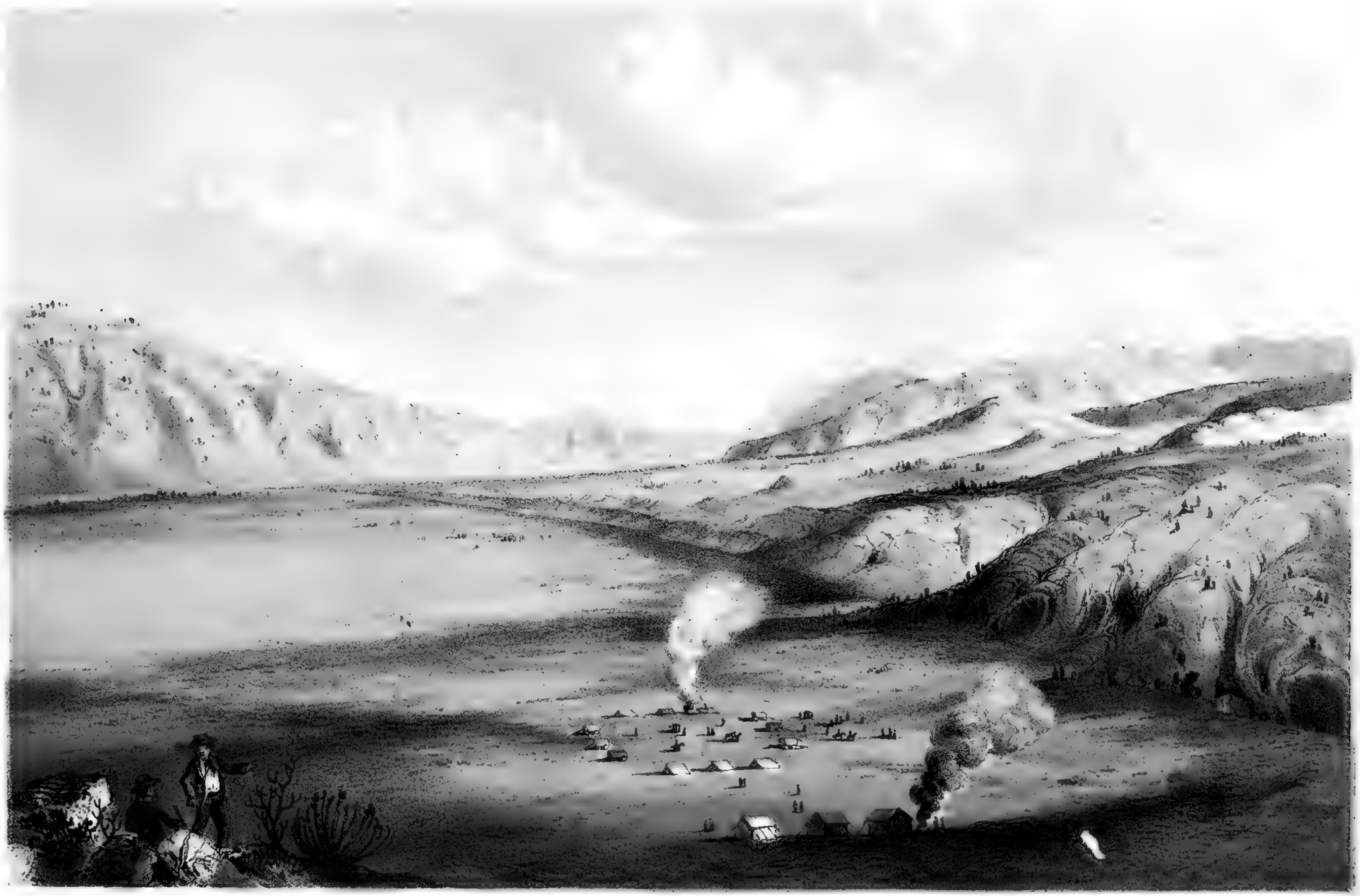
In 1854, Santa Clara had 29,000 acres under cultivation, only one-tenth of her area of valley land, and yielded 1,060,000 bushels of grain, besides vegetable products. Much attention is paid to the cultivation of wheat and barley about San José, on the Pajaro, lower Salinas, and in the vicinity of Los Angeles. The Mormons of San Bernardino county have been very successful in their farming operations. Very heavy crops of corn are raised near the mission of San Gabriel, in a district known as El Monté, a low bottom lying along the San Gabriel river.

Section 6. CLIMATE.

The climate of the district along the route proposed is varied, owing to the localities, whether exposed to the immediate influences of the ocean moisture or in a measure shut out from these, by intervening ridges, which, by their altitudes and direction, with reference to the prevailing winds, affect materially the amount of moisture deposited and the degree of temperature experienced. The seasons are two, the "rainy" and "dry." The former occupies seldom over three or four months, and corresponds with our winter, and the latter embraces the remaining months of the year. Working parties can be in the field throughout the entire year, and their work will not be impeded by snows or frost. For the working and running of road after completion, the climate and seasons are highly favorable.

Section 7. TIMBER.

The country immediately along the line of survey is sparse of timber. The varieties are limited, and localities few. Sycamore, cotton-wood, and small willows are found fringing the watercourses. Upon the plains and side slopes of valleys are found oaks in occasional clumps, and isolated trees, giving to the landscape the appearance of an old settled country where the woodman's axe has spared just a sufficiency for the purposes of fuel, and shade for the grazing herds. The wood is very brash, and, excepting the pine of the mountains, is unfit to be used in construction. The red wood is found in the Santa Cruz mountain, and the long leafed pine on the Gavilan ridge and mountains back of Monterey. In the vicinity of Santa Margarita, near the head of the Salinas, the pine is abundant, also in the mountains at the head of the Santa Maria to the south of the Cuyama plain. This latter locality is, however, difficult of access. Besides these the supply is very limited. In the vicinity of Santa Barbara the mountain slopes are generally bare of trees, oaks and sycamores only are found in the protected gorges and valleys. Tradition states that the timber used in the construction of the mission of Santa Barbara was drawn from the San Rafael mountains, northeast of Santa Inez, at least forty miles distant. Travelling in the mountain districts of California is rendered very trying by the frequency with which one encounters patches of dense masses of shrubbery known as the *chemizal.* This term is applied to that growth covering whole mountain slopes and summits, and is made up of many varieties of shrubs, chiefly dwarfish oak, *manzanita,* and a shrub called red wood. It seldom exceeds ten feet in height, and from the toughness of the wood and density of the growth it is often impracticable to penetrate these thickets without free use of the axe.



WARNERS PASS FROM SAN FELIPE

ADAPTATION OF COUNTRY TO THE CONSTRUCTION OF A RAILROAD.

First Division.—*From San José to Rio Pajaro*—the ground is particularly favorable for the construction of a railroad, there being no obstacles to long tangents and light curves, with easy grades to the summit, which, being itself a broad plain, required but little earth work save suitable ditching and ballasting. From the summit the same character of country prevails to the Pajaro.

The length of this division is 39.25 miles.

Maximum grade required, 18 feet per mile.

Probable cost of graduation and superstructure, $1,177,500.

Cost per mile, $30,000.

Second Division.—*From Rio Pajaro to the Salinas.*—This division extends from the point of reaching the Pajaro river, down its valley to near its debouch into the Bay of Monterey, thence around the foot hills of Mount Gavilan to the open plains of the Salinas. The graduation upon this division will not be very heavy, the terraced character of the banks of this stream presenting nearly throughout the entire division most favorable slopes and natural beds for the location of a railroad. There will, however, be required several bridges of a medium class, *i. e.*, from 50 to 150 feet, single span, and one first class bridge across the Pajaro, two miles above the Rancho de las Aromas, where the line crosses from the right to the left bank of the stream. To bridge the stream at this point will require three spans of 100 feet each; there is a natural abutment on one side. Between the Pajaro and the plains there will also be required several small bridges across the sloughs into which the ravines from the Gavilan foot hills empty themselves. Very little rock cutting will be required upon this division.

Length of second division, 20.75 miles.

Maximum grade required, 11 feet per mile.

Probable cost of graduation and superstructure, $1,141,250.

Cost per mile, $55,000.

Third Division.—*Salinas Plains.*—This division is 45.50 miles in extent, traversing that immense area known as the Salinas plains, and is peculiarly favorable for the location of a railroad, requiring but slightly undulating grades to conform to the wave-like character which is peculiar to all these plains, with but little earth work. Traversing this plain for nearly forty miles, the line impinges upon the river Salinas a few miles above the old mission of Soledad, thence following the meandering of the river to the mouth of the San Lorenzo, (a tributary of the Salinas, heading towards the Tulare plain, and forms what is known as the San Lorenzo Pass to that plain.) Within the first ten miles several bridges across sloughs will be necessary.

The length of this division is 45.50 miles.

Maximum grade required, 6.5 feet per mile.

Probable cost of graduation and superstructure, $1,365,000.

Cost per mile, $30,000.

Fourth Division.—*From San Lorenzo creek to the Atascadero.*—This division, extending from the mouth of the San Lorenzo, pursues the meanderings of the stream to about six miles above, where a suitable place offering, it crosses to the left bank and continues nearly the entire distance to the mouth of the Atascadero creek, in the valley of the river. At several points where a shortening of distance would be accomplished, and where the terraces abut down upon the bed of the stream, a slight increase of grade above the average ascent of the river bottom will secure a favorable location along the edge of the first terrace, which, for many miles, presents the appearance of a natural embankment. The general character of the work upon this division varies from that of either preceding division. The river having a more contracted valley than below, the number of lateral ravines and streams are greater, requiring a greater amount of masonry and earth work. The graduation, however, will be comparatively easy, for the cuts and fills will nearly balance each other, and a large majority of the lateral ravines will require but small culverts or percolating drains, and many of them none at all. There will be five first class bridges required across the San Lorenzo, the Salinas, the San Antonio, the Nacimiento, and Pasa Robles creek. The materials for the construction of the piers and abutments of these bridges are at hand at the respective places, though not of a first rate character. Several smaller works of this character will also be necessary at several points throughout the division. The line pursuing, for the most part, the windings of the valley, is throughout a curved line; but it is believed, from careful observation, and measurement where practicable, that no curve of less than 4° will be required; nor, indeed, throughout the entire distance, from San José to Los Angeles, will a radius of less than 1,000 feet be necessary.

The length of this division is 71.50 miles.

Maximum grade required, 70 feet per mile.

Probable cost of graduation and superstructure, $3,575,000.

Cost per mile, $50,000.

Fifth Division.—*From Santa Margarita valley to the mouth of Arroyo Grande.*—This division comprises, perhaps, the most difficult and costly portion of the route, from the boldness of the work required to overcome its difficulties; it contains the celebrated San Luis Pass through the (Coast Range) Santa Lucia mountains, and is the only passable point of these mountains between the Bay of Monterey and its southeastern extremity. The wagon road occupies this pass.* The height of the summit is 1,556.5 feet above the level of the sea. The height of Santa Margarita valley is 978 feet, and the San Louis plain about an average height of 300 feet. The point of tunnelling is two hundred feet below the summit, and at the foot of the *cuesta* or sharp divide which lies between the disjointed mountains. To reach this point the line is projected on the slopes of the hills on the west of Santa Margarita, and ascends with an uniform grade of eighty feet per mile. This ascent will not be attended with any excessive cost of graduation, the side slopes of the mountain being remarkably tenable, there being no gorges to fill, or wide valleys to span, and presenting favorable cross sections for side cutting and embankments. The tunnel, three-fourths of a mile in length, is through serpentine and sandstone rock, and can be advantageously worked from both sides. In the construction of a road through this pass, should this tunnel be considered too formidable a work, there is no obstacle to passing this mountain, without cutting, by a system of heavy grades, similar to those which have been worked so successfully for several years across the Blue Ridge at Rockfish Gap, where the traffic and travel of a great part of the valley of Virginia has been carried over this mountain, over a grade of 275 feet per mile. To accomplish the passage of the San Luis summit, there will be required a much less rate of gradient, probably not over 200 feet per mile. On the west side of the *cuesta* the San Luis creek heads, and descends rapidly to the plain through a wide valley, flanked on either side by rib-like spurs from the mountain, which have a slope of about 30°, the alternating ravines being, except in one instance, shallow; four and one-half miles below there is a lateral ravine, heading with a stream which flows through the plain to the ocean, called Corral de Piédras creek, in a summit 1,191 feet above tide, and in the prolongation of the valley from the *cuesta*. A glance

* A line of levels was run through this pass from Santa Margarita valley to the mouth of Arroyo Grande, but upon plotting them they were found to have irreconcilable errors in them; and as it would have involved a great loss of time to run a second series to check these errors, it was not deemed advisable to do so. A longer series of barometric observations than we were able to take, in connexion with these levels, would have been necessary to institute comparisons between these several modes of determining elevations.

at the map will convey a better idea of the topography of this point than an elaborately written description. The descent of the stream is too great to locate a line through, or near the town of San Luis Obispo; it is, therefore, necessary to project the line along the slopes of the mountain upon the left bank of the creek, through this second summit, to the small divide between Arroyo Grande and Corral de Piédras creek; thence down the right bank of Arroyo Grande to near its debouch into the sea. From the summit a descending grade of one hundred feet per mile for five miles will be required; thence an ascending grade of one hundred feet per mile for three miles, to the second or *serpentine* summit, and from this second summit a descending grade of one hundred feet per mile to Arroyo Grande; thence along the slopes of the right bank of Arroyo Grande to near its debouch, with a descending grade of seventy-two feet per mile.

This entire division is a bold one, and the cost of graduation will be great on account of the rocky character of the side slopes, in some instances *serpentine*, and the deep cuts and fills required to keep up an uniform and practicable grade.

The length of this division is 24.5 miles.
Maximum grade required 100 feet per mile.

Probable cost of graduation and superstructure	$2,450,000
Cost of 3,960 feet of tunnelling, at $125 per foot	495,000
Total cost of division (including tunnel)	2,945,000

Cost per mile, exclusive of tunnel, $100,000

SIXTH DIVISION.—*From the mouth of Arroyo Grande to the Rio de Tres Alamos.*—Turning the point of the low rolling hills and terraces which lie between the Arroyo Grande and the Santa Maria, the line enters and traverses the Guadalupe Largo, an extensive triangular plain, which was probably an arm of the sea at a recent geological period, defiles through the low system of hills extending from Point Sal southeastward, attains a summit elevation of 637 feet above the sea; thence by a light grade down the slopes of the right bank of the Tres Alamos to the rancho of Jesus Maria. The work upon this division across the Largo to the Todos Santos summit is remarkably light. From the summit to Jesus Maria the slopes of the hill, are smooth and of easy occupation, and of comparatively easy graduation. Bridges of the first class across Arroyo Grande, the Santa Maria, and Tres Alamos, will be required. There will probably be very little, if any rock cutting upon this portion of the line.

The length of the division is 32.50 miles.
Maximum grade required 63.2 feet per mile.
Probable cost of graduation and superstructure $975,000
Cost per mile $30,000

SEVENTH DIVISION.—*From Tres Alamos creek to the mouth of Gaviote creek.*—From Tres Alamos two routes present themselves, each of which have their peculiar advantages: the former in point of distance and directness, the latter in point of grade and probable cheapness. The former route lies over the terraced plain which forms the tongue of land between the Tres Alamos and the Santa Inez river, up the right bank of the latter to the mouth of Sal si Puedes creek, two miles above the mission of La Purisima; thence up the valley of Sal si Puedes to a summit elevation of about 700 feet above the sea; thence down a valley which is tributary to the Gaviote Pass at the Rancho del Santa Cruz, and from this point to the mouth of Gaviote Pass and creek. The earth work upon this division, in many places, will not be heavy, but will be great in quantity, particularly up the valley of the Rio de Santa Inez and the Sal si Puedes creek as far as the rancho of that name, and from the summit to the ocean the location is a most bold one, requiring heavy work in earth and rock (sandstone) and masonry, to keep up the grade. To do this it will be necessary to construct a lofty though short structure across the Gaviote creek, where it defiles between two jutting cliffs, and continue along the slopes of the mountains, and curving around to the ocean slope by a heavy cut through the salient spur at the mouth of the creek. This portion of the line is imposing, and partakes somewhat of the character of the San Louis Pass. Two bridges of the first class will be required upon this section—one across the Santa Inez river, and one across the Gaviote creek—together with several smaller structures and culverts and drains.

The length of this division is 33.50 miles.
Maximum grade required 100 feet per mile.
Probable cost of graduation and superstructure $2,680,000.
Cost per mile $80,000.

Seventh Division *a.—Second Route from Tres Alamos to the Gaviote creek.*—This route continues down the Alamos to the coast, thence via Points Purisima, Arguello, and Concepcion, along the terraced coast. The distance by this route is thirteen and three quarter miles longer, but it is probable that the difference of cost will not be very great. The general character of this shore line is identical with that of the eighth division. In passing from the mouth of the Santa Inez to Point Concepcion, the west end of the Santa Inez range of mountains is turned. This mountain range has an almost equilateral cross section, having no long spurs upon either side, which renders it an immense prism, extending to the valley of the Rio San Buenaventura, where it terminates. Its ocean slope is terminated by a long line of terraces, which are distinctly marked, evidencing a gradual elevation of the land, and are covered to a greater or less depth with a fine soil. These terraces are formed of the upturned strata, which alternately dip seaward and landward several times between Point Concepcion and San Buenaventura, and are cut into innumerable lateral ravines, which will require bridging, or to be filled up, with culverts to pass the water in rainy seasons. To construct an economical line along this shore, comparatively heavy grades will have to be resorted to, to avoid deep rock cutting and high embankments. It is highly probable that upon a more minute examination of the ground it will be found advisable to locate the line partially along the shore, a few feet removed from high tide. Such a location would be cheaper of construction than one midway between the mountains and the sea, thereby avoiding much deep cutting and filling, and bridging also. Upon this route a bridge across the mouth of the Santa Inez river and one across Gaviote creek will be necessary, besides numerous smaller structures, and culverts across the ravines which cut through the terraced shore in many places.

The length of this division is 47.25 miles.
Maximum grade required 60 feet per mile.
Probable cost of graduation and superstructure $2,835,000.
Cost per mile $60,000.

Eighth Division.—*From the mouth of Gaviote creek to San Buenaventura.*—This division lies for nearly the whole distance near the coast over the terrace. Two or three miles below Carpinteria, at El Rincon, this peculiar character disappears, and the bluffs of a small range of hills, spurs or outliers of the Santa Inez mountains, impinge immediately upon the sea to within a short distance of the valley of San Buenaventura. The traveller at this point is compelled to regulate his movements by those of the tide, and is often obliged to wait for hours to make the passage in safety. From the Gaviote to Santa Barbara the average height of the terrace, along the present wagon road, is about 110 feet, and is intersected by innumerable ravines and creeks, which, heading in the mountains and descending with rapid slope, have during rainy seasons cut out for themselves deep beds with precipitous banks; Arroyo Hondo and Cañada del Corral are the most notable of these ravines, as having cut deeper beds, having wider valleys, and requiring heavy structures to pass them. This is, indeed, the character of the entire coast, from the mouth of the Rio Santa Inez to El Rincon, as before stated; and from the numerous ravines to be crossed, and the earthwork necessary to maintain light undulating grades, will render this portion of the route more expensive of construction than would at first appear. The heaviest portions of this work, however, are between Gaviote creek and Hill's creek (rancho.) From this point to El Rincon there is a low line of hills situated near the beach, and the route lies within these, through a system of *saddle-backs*, which will admit of comparatively easy occupation. There is no obstacle, however, to the line being located nearer to the beach on the low terrace, between Santa Barbara and Carpinteria, as the sea appears to make no encroachment upon the land. From the short distance between the numerous ravines, and the rolling character of the slopes in many places, it is difficult to determine the maximum gradient here necessary, without a detailed survey with chain and level. From a careful inspection of the entire distance, and a study of the barometric heights attained, it is believed that no grade exceeding sixty feet per mile will be required over this undulating terrace. From El Rincon to San Buenaventura the location is of a novel character, requiring for thirteen miles a sea-wall, or something of the nature of a *rip-rap*, to protect the road bed from being undermined and swept away by the sea. There does not appear to be any evidence of a rapid encroachment of the tide upon these slopes, which are principally clay and sandstones, for the waters sweep to and fro over the upturned edges of the strata, which incline nearly vertically, first to the seaward and then to the landward, and are hard, compact sandstones. A road bed around this point can be easily constructed at an elevation of about thirty feet above high water, by depositing large masses of stone, which are accessible, along the foot of the bluffs at, or near, high water mark, and then excavate a road bed by side-cutting above, and *dumping* the material over to form a bank protected from the action of the waves by the rocky *rip-rap*.

The length of this division is 58.50 miles.

Maximum grade required, 60 feet per mile.

Probable cost of graduation and superstructure, $3,510,000.

Cost per mile, $60,000.

NINTH DIVISION.—*From San Buenaventura to Los Angeles via Semi Pass.*—From San Buenaventura to Santa Clara river the plain is nearly level, and requires no work save the preparation of the road bed by excavations thrown out from side ditches. From the Santa Clara to Semi creek, about ten miles, the excavations will be very light, the surface of the ground being nearly level; from the latter point to the base of the Pass the line is located upon the rolling slope on the right bank of the stream, where the excavations and embankment will nearly equalize each other, and probably not exceed twenty feet in depth, with an ascending grade of thirty-two feet per mile, to the level of the San Fernando plain, thence through the sharp summit by a tunnel 600 feet below the crest. The length of this tunnel is about 3,960 feet, through soft sandstones, scarcely requiring blasting. From the eastern entrance to this tunnel to Los Angeles a smooth plain presents itself with no obstacles, similar in character to the San José, the Salinas, Guadalupe, and Santa Clara plains, requiring, like these, but little earthwork to prepare a road bed; a small culvert across the San Buenaventura and a bridge of about two spans of 150 feet each, across the Santa Clara, besides several smaller culverts, are all that is required upon this portion of the route.

The length of this division is 70 miles.

Maximum grade required, 63 feet per mile.

Probable cost of construction and superstructure, $2,100,000.

Cost per mile, $30,000.

Recapitulation.		Miles.	Amount.
Cost of 1st division		39.25	$1,177,500
Cost of 2d division		20.75	1,141,250
Cost of 3d division		45.50	1,365,000
Cost of 4th division		71.50	3,575,000
Cost of 5th division		24.50	2,945,000
Cost of 6th division		32.50	975,000
Cost of 7th division		33.50	2,680,000
(*) (7 *a*)		(47.25)	(2,835,000)
Cost of 8th division		58.50	3,510,000
Cost of 9th division		70.00	2,100,000
Total cost of		396.00	19,468,750
Average cost per mile	$49,163 00		
Add for equipment			1,200,000
Total cost			20,668,750
Average cost per mile, including equipment	52,194 00		

(*) Division 7 *a* being 13.75 miles longer than division 7, at $60,000 per mile = $2,835,000, or $155,000 more than division 7, which gives for total cost of 409.25 miles, $19,623,750, exclusive of equipment.

It should be borne in mind that the above estimates are not based upon as minute and careful a survey as it is customary to make for the purpose of determining the actual cost of a railway, and are therefore to be considered as mere approximations, where a very liberal allowance for each element which enters into them has been made. The basis upon which this estimate is made up may be briefly stated, as follows:

The amount of manual and animal labor required to finish the road in four years (of working days) is taken to be equivalent to 3,833 men, at $2 50 per diem, which gives (*a*) about	$12,000,000
The superstructure, including rails, ties, chairs, and ballasting, when necessary, at $8,000 per mile, for 400 miles	3,200,000
(*b*) Bridging and masonry, including cost, haulage, and preparation of materials...	2,700,000
Water stations and depots	1,200,000
Contingencies	368,750
Total	19,468,750
Add for first equipment	1,200,000
Total cost	20,668,750

It is believed that when a more stable state of things exists in California, a greater mass of population will be found along the route; the immense districts of excellent agricultural and pastural lands through which it passes will be occupied and improved; the avenues to every branch of human industry which the country is capable of maintaining will be thrown open to competition; the prices of manual labor be reduced to a reasonable rate in consequence, and the cost of construction of so important and extensive a work be materially lessened.

(*a*) By the employment of Mexicans, Indians and Coolies, in large numbers, this item will be lessened.

(*b*) This item is probably in excess.

VIEW ON THE GILA BELOW [illegible]

No. 2.

REPORT OF EXPLORATIONS FROM PIMAS VILLAGES TO RIO GRANDE.

CENTRAL SECTION 32D PARALLEL ROUTE.

SECTION 1. GENERAL DESCRIPTION OF ROUTE.

THE central section extends from Mesilla, on the Rio Grande, to the Pimas villages on the Gila, and comprises that district of country recently acquired from Mexico by the Gadsden treaty. The practicability of constructing a railroad through this section was demonstrated by the data obtained during an examination made by me in February and March, 1854. But, owing to the limited means placed at my disposal, that examination was necessarily partial and hurried. Still a practicable route was then determined and reported upon, and at the same time lines were indicated for further explorations, by following which, it was presumed that obstacles encountered on portions of the main line would be avoided, and great advantages be gained in regard to the supply of water.

The line of survey of 1854 commenced at the Pimas villages, on the Rio Gila, and pursued a southeasterly course for about seventy miles to Tucson, where an easterly course was assumed and pursued until we struck the Rio Grande at Mesilla, opposite Fort Fillmore. Of this district the most remarkable feature is the extended, elevated plain lying between the Rio Grande on the east, and the San Pedro, a tributary of the Gila, on the west. This plain is made up of a series of smooth slopes, converging to several central depressions or basins, and is studded with precipitous and rugged ridges and peaks, rising abruptly from the prairie land in picturesque confusion, without any apparent order or system. These ridges and peaks, the "Lost Mountains" of the great west, are not, however, without order or system in their arrangement, but, on the contrary, have a decided and marked parallelism in the trend and direction of the axes, which have a general northwesterly and southeasterly course. They are, on the one hand, the terminal spurs, or representatives, of that portion of the Rocky Mountain system which forms the western boundary of the Rio Grande valley of New Mexico, and on the other hand, the inceptions or initials of the great Sierra Madre of Mexico. These two mountain chains, with this intervening plain, form the divide between the waters of the Gulfs of Mexico and California, and become in their prolongation the back bone or main watershed of the continent, one of the great obstacles in the location and construction of the railroad to the Pacific. Owing to the wonderful smoothness of this plain, and absence of continuous ridges and watercourses, it is impracticable to trace, without detailed and very extended surveys, the exact divide or connecting link joining the axes of the mountain masses.

By the survey of 1854, the greatest elevation to be encountered in traversing this plain was about 5,000 feet, and by additional data, obtained during the spring of 1855, this has been reduced, so that this table land affords a route of transit from the waters of the Atlantic to those of the Pacific, at an elevation not exceeding 4,600 feet, the lowest yet determined between the parallels thirty-two and forty-nine. In considering the question of crossing from the waters of the Atlantic to the Pacific, the valleys of the Rio Grande and Rio Gila and tributaries occupy prominent positions. Now, as it is perfectly practicable to reach this plain from any point of the Rio Grande valley between Frontera, about seven miles above El Paso, and Mesilla, the main question reduces itself to determining the most easterly point in the valley of the Gila to which it is practicable to construct a continuous road by ascending its valley, and then to connect this point with the Rio Grande valley by the shortest and most favorable route.

The well known cañons of the Upper Gila, and rugged character of the mountains along its right bank, put a limit to the ascent of its valley, and also to the project of encountering the obstacles of the country on the north. As before stated, the route surveyed in 1854 enters this valley at the Pimas villages, but as this line crossed the San Pedro about seventy miles above its junction with the Gila, and traversed a long plain destitute of water, it was determined to test the practicability of a route avoiding this dry stretch by following the valleys of the San Pedro and the Gila. This examination was highly satisfactory, as were also those made on other portions of the line; and it will be seen that these have resulted in vast and important improvements upon the line of survey of 1854, not the least of which is the avoiding of the Puerto del Dado of the Chiricahui mountains. This ridge can be turned at its northern end by passing through a break or gap between it and Mount Graham. This is the lowest summit between the Valle de Sauz and the Playa de los Pimas, being 580 feet lower than that of the Puerto del Dado, and more than 225 feet lower than the Dome Pass of Gray.

I would suggest that it be called THE RAILROAD PASS. These surveys were both commenced at the Pimas villages, the western terminus of the section, and pushed eastward to the Rio Grande; but as this is reversing the direction that is naturally taken, when the question of the Pacific railroad is being investigated, I will commence at the eastern terminus, and take up each subdivision in order.

1st. From the Rio Grande to the Valle del Sauz. 2d. From Valle del Sauz to the mouth of San Pedro. 3d. From the mouth of San Pedro to the Pimas villages.

SECTION 2.

FIRST DIVISION.—*From Rio Grande to Valle del Sauz.*—This division embraces the divide between the waters of the Atlantic and the Pacific. Its characteristic features are the broad, flat plains, bounded by gently swelling divides and smooth slopes, extending back to the bases of the ridges and peaks, which, from their peculiar and striking profiles, form pleasing and prominent landmarks, recognizable often from points one hundred miles distant. These plains are smooth and unbroken by deep washes, and bare of timber, but yield a growth of rich grass, varieties of cactus, artemisia, larrea, and occasionally a dwarfish mesquite, with yucca and Spanish bayonet. Owing to their great extent, frequent and beautiful illustrations of *mirage* are witnessed.

Of the mountains, the most prominent are the Picacho de los Mimbres, Copper Mine and Burro mountains, on the north of the line, terminal spurs of the Rocky Mountains, whose foot-hills give out and are lost in the broad plains.

On the south we have the Florida mountains—a distinct, lofty, prominent, and compact ridge, apparently on the prolongation of the axis of the Picacho de los Mimbres, but completely cut off from it by an open gap of eight miles. Beyond this mountain mass are several distinct peaks, and

VALLEY OF THE GILA & SIERRA DE LAS ESTRELLAS FROM THE MARICOPA WELLS also a low chain of conical hills, Pyramid ridge, which is turned at its northern end by this line of survey. Near the western limit of this division is found a continuous ridge of uniform masses and sharp peaks, the most prominent of which has been styled El Peloncillo (sugar-loaf.) This ridge forms the divide between the waters of the basin district from those of the Valle del Sauz, which flow towards the Gila. Besides these several prominent features, there are others less striking and secondary in their character. The Picacho of Mesilla, a sharp, conical peak, situated on the margin of the *mesa*, a short distance above the town of the same name. To the west of this, and north of the line, are several low terraces, whose surfaces are generally covered with a flow of basaltic lava ; but, when this has been removed, they are broken up into rounded knobs. These knobs are found completely isolated on the plain south of the wagon road and beyond the Mimbres. The plain or table land may be subdivided into three districts, viz : 1st, the Cooke's Spring valley or basin, the portion lying east of the Picacho de los Mimbres and the Florida mountains ; 2d, the valley or basin of the Rio Mimbres, lying immediately west of these mountains ; and 3d, the Pyramid Ridge basin. These valleys or basins are broad and shallow, with scarcely traceable ridge lines, and receive their drainage from the areas extending from the Rio Grande divide to the Peloncillo ridge. The valleys are parallel to the trend of the mountains, and have a gentle slope southwards, probably centering in the Lake Guzman basin, and give to the line which traverses them at right angles an undulating profile.

The Pyramid Ridge basin is made up of a system of dry lakes, (*playas*,) heading or enveloping the northern end of the ridge, and bounded by broad and gentle slopes extending back to the bases of the surrounding mountains. The supply of water through this district is limited, there being but three sources immediately on the present wagon road : Cooke's spring, at the eastern base of the Picacho de los Mimbres ; the Rio Mimbres, a clear, rippling trout-brook, coming from the Copper Mine mountains, and losing its waters in the plain to the west of the Picacho ; the Ojo de la Vacca, a spring rising in the plain about seventeen miles further to the west. Besides these sources there are three other springs, but of minor importance : Neide's spring, about fourteen miles to the southeast of Cooke's spring, at the point of the bluff terrace ; Agua Fria, a short distance to the southeast from the Ojo de la Vacca ; and the Ojo de Inez, a spring rising in a cañon of the Burro mountains, about six miles to the north of the wagon road.

Taking the central section in connexion with the eastern section of the 32d parallel route, its initial point on the Rio Grande will be taken to correspond with the terminal point of that survey—Molino, two miles above El Paso. Molino is situated on the left bank of the Rio Grande, at the foot or opening of the gorge between the terminal spurs of the Organ and Mulera mountains, occupied by the Rio Grande for seven miles, extending up to Frontera, the southern limit of an area of bottom land lying along the river, of which that portion on the right bank bears the name of Mesilla Valley.

In this gorge there are many favorable localities for bridging the river ; but, in order to have both abutments upon our own soil, it will be necessary to ascend the river about half a mile above the initial point of our new southern boundary with Mexico.

Between this point and Frontera, the foot slopes of the mountains on both sides bluff down in many places to the water's edge, presenting advantages for bridging nowhere found between Frontera and Doña Ana. The selection of a site will depend upon a detailed survey of the approaches and the line to be pursued on leaving the crossing. Starting from the bridge, the location of a road will depend solely upon the consideration of the supply of water to be had along this line. From Frontera to Mesilla, the bottom land is bounded on the west by a continuous *mesa* or terrace, which must be ascended by our line, whether it leaves the river at either of the above mentioned points, or any intermediate one, the difficulties in each case being about the same. But looking westward of the Rio Grande, along and in the vicinity of this proposed line, for sources whence a constant and sufficient supply of water can be drawn for the uses of a railroad, we find the first of any note to be the Rio Mimbres, a mountain brook heading in the rugged region to the northeast of the Copper Mines, and flowing off to the south through cañons and valleys which finally open out to the broad plain, where the waters of this stream gradually disappear, and are finally entirely absorbed. This being the most available source of water west of the Rio Grande, our line of road should leave the valley of the latter at that point which gives the shortest interval between it and that point on the plain where the waters of the Mimbres may be made available by conduits or otherwise. In this view of the case, the road should, on crossing the river below Frontera, follow up its valley to near Mesilla, and then make the ascent to the surface of the terrace, where almost an air-line may be located directly to the bed of the Mimbres. Looking, also, to the general question of uniting the waters of the Rio Grande with those of the Gila by the shortest practicable route, it will be seen, by referring to the map, that the line just located fills that condition, its course bearing directly for the Railroad Pass due west.

In the valley bottom we will have an ascending grade of one foot per mile for thirty-six miles, requiring but little earth work, the soil being generally sandy. In many places there will be encountered a light, loose loam, where ballasting will be necessary; the loam becoming light and miry during the seasons of rain.

Our line now turns westward, and the first question is to ascend the *mesa* or terrace. This will require comparatively heavy work for a few miles. There are two terraces before reaching the summit of the plateau of the Sierra Madre: one averaging about forty feet above the alluvial bottom of the Rio Grande, west of La Mesilla; the other, about one and a half miles further west, rises about two hundred and fifty feet above the former, or about four hundred and seven feet above the crossing near Fort Fillmore. This latter steppe sweeps round to the south, and is merged gradually into a plain until it loses almost entirely its terraced character, forming, as it were, an immense amphitheatre, for to the southwest of Fort Fillmore it again assumes the escarped character. By the combined results of the surveys of 1854 and 1855 the summit between the Monument basin and the valley of the Rio Grande has an elevation of six hundred and sixty-two feet above the river, and from this summit the ground slopes about two hundred and eighty-two feet per mile down to the edge of the plateau. To reach the plateau of the Sierra Madre, commencing at a point in the vicinity of San Tomas, and thirty-seven miles above El Molino, we ascend the first terrace by a grade of twenty feet per mile for four miles; thence to the edge of the plateau five and-one half miles, at the rate of sixty feet per mile; and from this point to the summit, about nine miles, with a grade conforming to the slope of the plain, 28.2 feet per mile.

From this summit to the terminus of the first division, in the Valle de Sauz, a distance of one hundred and thirty-eight and one-half miles, the profile is undulating throughout, and made up of gradients not exceeding 64.4 feet per mile, this maximum being required in crossing the Peloncillo summit. These gradients are generally the surface slopes, and will, of course, involve the necessity of but little earth work in preparing the roadway. Approaching this ridge from the east, on the Boundary Commission road, which leads directly for a gap between a castellated porphyritic protrusion on the right, and a prominent Sugar Loaf (Peloncillo) peak on the left, several favorable depressions are seen on the south of the road, where the continuity of the ridge is somewhat broken, and the slopes of the opposite sides meet, forming broad and smooth summits. That selected is about four and one-half miles south of the Sugar Loaf, and has an altitude above the basin bottom on the east of 391.3 feet, and above the bottom of the Valle del Sauz of 772.5 feet. The approaches to this summit are of such a character as to permit a decrease of gradients by an increase of distance.

SECTION 3.

SECOND DIVISION.—*From Valle del Sauz to mouth of Rio San Pedro.*—The Valle del Sauz and valley of the San Pedro are tributary valleys of the Gila, whose axes are nearly parallel, and distant about fifty-five miles. They embrace an interior plain and valley district which is separated from the two bounding valleys by divides, whose peaks and ridges are as lofty and imposing as the passes are inviting and easy of transit. This division affords a striking illustration of the parallelism of the ridges of this interior region, and their bearings upon the directions of the valleys and their drainage. The Valle del Sauz trends off to the northwest, a broad and open valley, receiving in its course the valley of the Gila as it opens out from the northeast, playing rather the part of tributary than main valley, since it immediately assumes the direction of the Valle del Sauz, and preserves it for about sixty miles. Here the Gila again changes its course to the southwest, and, piercing the Pinaleño mountains, opens from a rugged cañon into the valley of the San Pedro, and trends off twenty-one miles in the direction of its axis, where, encountering another and the last obstacle, it again runs to the west and enters a cañon leading through to a plain, affording a free flow to the Colorado of California. The western limit of the Valle del Sauz is made up of two mountain masses—Mounts Graham and Chiricahui—the grandest and most imposing yet encountered, whose axes topographically form a continuous line, with an intervening gap or break of about eight miles, lying directly in our course westward. That on the north of this gap, Mount Graham, looms up, solid and massive, with an apparently continuous outline, trending off to the northwestward until lost below the horizon. This continuous range is called Pinaleño mountains.

The Chiricahui on the south is not so compact, but broken into radiating ridges and spurs, whose crests are serrated and pinnacled, rendering the mass easily distinguishable at great distances. Near the northern end of this mountain two of these pinnacles stand conspicuously above the profile of the surrounding height, and, from their great uniformity in figure and dimension, are called the Dos Cabezas (Two Heads.) These mountains rise abruptly from the slopes of the surrounding valleys, and are generally rugged, bare, and destitute of timber, a small growth of dwarfish oak, wild cherry, ash, and walnut, (black,) and cedars, being found in the valleys and cañons. On the right bank of the San Pedro trends off a ridge or chain of ridges, which, by their interlocking, form an apparently continuous divide between the San Pedro valley and the interior plain district, of the Playa de los Pimas. This chain, the Calitro* mountains, although secondary to the one preceding, in point of elevation and extent, nevertheless plays a conspicuous part in the physical geography of the narrow belt or zone of our continent contiguous to the thirty-second parallel route, it being the western limit of the great central plateau which extends eastward to the sources of the Colorado of Texas, embracing an area of about ten degrees of longitude, where the mean elevation does not exceed 5,000 feet.

The area embraced by these two mountain chains, is made up of two distinct features, basin

* This name was obtained from the oldest inhabitants of Tuczon, and is, probably, a corruption of calizo, (lime,) there being an abundance of this material there.—A. H. C.

and valley; but these being, in this case, so intimately connected, we will give the whole district the name of the most prominent, the Playa de los Pimas. The term *playa* is given to the beds of these small basins or depressions, which receive the drainage from the surrounding slopes. During the season of rain, the surface waters are collected and spread over a broad level area, soon to be absorbed and evaporated, leaving the beds smooth, and to be baked hard by the mid-day sun of the dry season. These *playas* are often called lagunos, dry lakes, salt lakes, &c., depending solely upon the time or season of the traveller's visit.

The Playa de los Pimas, the largest encountered during our examinations, is immediately to the west of the Dos Cabezas, or northern end of the Chiricahui mountains, and covers an area of about sixty square miles. Its surface was, when crossed February 28, 1854, and also July 30, 1855, hard and smooth, and apparently as level as a frozen lake. In fact, the effect in crossing, excepting in point of temperature, was very analogous to that experienced in crossing a broad, smooth field of ice. Not a particle of vegetation is found upon its surface, which is entirely free from dust, and so hard that our mules and heavily laden wagons scarcely made an impression upon it. It is bounded by smooth and grassy plains, sloping back to the bases of the mountains.

To the northwest of the Playa the plain slopes up to a scarcely perceptible summit, beyond which the waters between Mount Graham and the Calitro Mountains, forming the Aravaypa Creek, are drawn off thirty miles parallel to these mountains, and then meeting an obstacle to its continuous progress to the Gila, turns westward, and by a short cañon through the Calitro Mountains enters the valley of the San Pedro, twelve miles above its mouth, presenting thus, in a small scale, the same striking features as the Upper Gila.

The Rio San Pedro, a tributary of the Gila, the western limit of the 2d section, heads in the plateau in which the Yaqui and other rivers of the Gulf of California take their origin, and trends off one hundred and twenty-six miles to the northwest, draining a valley or trough lying between parallel ranges, the average width of which is about fifteen miles, the alluvial bottom being about three-quarters of a mile wide.

Col. Cooke, in 1846, struck this stream near its source, and followed down its valley, with a train of wagons, fifty-five miles to the Tres Alamos, and there turned westward, following a trail leading through a break in the mountains to Tucson.

At the Tres Alamos, the valley is open, broad, and smooth, bounded by low terraces, which slope back to the bases of the mountains. The valley continues open, down to a point opposite the southern end of the Santa Catarina Mountains, (Colorado Peak,) where the foot spurs of this mountain bluff down, meeting the terraces on the right bank from the Calitro Mountain, and changing the direction of the valley for a short distance, reduces it to a gorge. Below this gorge, the valley alternately widens and narrows to its junction with the Gila, leaving beautiful oval meadows, separated by short stretches of bottom land, which have been narrowed down to a few hundred yards by the bluffs of the impinging spurs.

These meadows are grassy and inviting, and bounded by terraces, the foot slopes of the adjacent ridges, ranging from twenty to one hundred feet in altitude. These terraces are sparsely covered with a growth of grama grass, cereus, and larrea, and the surfaces are generally smooth, forming, in extension, continuous and uniform slopes, but at the same time are much cut up by deep drains and washes, ramifying like the woody fibres of a leaf.

The valley bottom is generally smooth and open, with the stream bed curving through it, sometimes a few inches, and at others as much as fifteen feet below the surface of the meadow.

At the Tres Alamos the stream is about fifteen inches deep and twelve feet wide, and flows with a rapid current over a light, sandy bed, about fifteen feet below its banks, which are nearly vertical. The water here is turbid, and not a stick of timber is seen to mark the meanderings of its bed. In the gorge below, and in some of the meadows, the stream approaches more nearly the surface, and often spreads itself on a wide area, producing a dense growth of cotton-wood, willows and underbrush, which forced us to ascend and cross the out-jutting terraces. The flow of water, however, is not continuous. One or two localities were observed where it had entirely disappeared; but to rise again a few miles distant, clear and limpid.

We thus have along the valley of the San Pedro, with the exception of points which will require a little work, ground highly advantageous in every point of view for an emigrant road, and most favorable for the location of a railroad, which can be connected with the Valle del Sauz by practicable grades, leading through Nugent's pass, in the Calitro mountains; to the Playa, and then by easy ascents and descents through the Railroad Pass, to the terminus of the first section. But the San Pedro, about twelve miles above its mouth, receives a tributary from the Playa de los Pimas basin, and this tributary, the Aravaypa, presents another route, connecting the Valle del Sauz and mouth of San Pedro.

This latter, or Aravaypa route, diverges from the first line near the summit of the Railroad Pass, and skirting the bases of the slopes from Mount Graham, enters this new valley and follows it to its junction with the San Pedro.

By the first line, the entire length of this division is 138 miles, and by the second, 108.25 miles. Starting from the terminus of the first section, in the Valle del Sauz, we have twenty-eight miles to the summit of the Railroad Pass, and an altitude of 892.5 feet to overcome, giving as an average grade of 16.7 feet for eighteen and three-fourths miles, and of 63.6 feet per mile for nine and one-quarter miles. Near the foot of the slope the grade is quite light, and it will be increased on nearing the summits, but will, however, not exceed sixty-four feet per mile. Throughout the greater portion of this distance the surface slope can be adopted for the roadway, but on entering the mouth of the Pass there will be some cutting and filling necessary in ascending and crossing the drains. The summit is open, broad, and smooth, the ground sloping gently in both directions. Looking eastward, a grassy valley trends off to the Sauz, receiving in its course many tributaries from the spurs of the Chiricahui and Mount Graham, with smooth side slopes and rolling, prairie-like divides. By degrees the valley assumes all the characteristic features of a main drain, with a meandering sand bed, and bounded by *mesas* or terraces, ranging from ten to thirty feet in altitude.

Towards the Playa de los Pimas the same feature is observable, but on a much smaller scale; the drain becoming in its descent more extended, and is finally lost in the plain surrounding the Playa

Leaving the summit, and taking the first of the above routes direct, to the San Pedro, we have at first, five miles with a grade of 48.8 feet, which is gradually reduced as we descend to the Playa, where an almost level (eight feet per mile) stretch of ten miles obtains to the base of the slope, extending up to the summit of Nugent's pass, in the Calitro mountains. This pass, like the preceding one, is broad and open, with smooth, rounded hills at its summit, from which a continuous plain slopes down to the Playa. Its western approach from the San Pedro, is by a small drain, which becomes a decided *arroyo*, varying from fifty to three hundred yards in width, and bounded by terraces from twenty to eighty feet in altitude, with side slopes of thirty or forty degrees.

602 feet above the Playa at the Croton springs, and the ascending grade will be about 100 feet per mile. This grade can be materially reduced by taking a direct line from the summit of the Railroad Pass to Nugent's pass, which would place it several miles north of those springs. Such a location would also shorten the distance several miles, but it is open to the objection of being too far from the water, which is below the level of the line of road, and consequently be difficult to obtain. It could be brought into requisition, however, by resorting to a windmill pump, such as are in use on many of the leading lines of railroad in the country, and which may be advantageously used at several localities on the entire route. There is permanent water at Pheasant creek and Antelope springs, which may be conducted to a point on the line north of the Playa, but it is believed that the abundant and never failing supply at Croton springs can be availed of most economically.

From the summit of Nugent's pass to the San Pedro river, a few miles below *Agua Verde*, the distance is twenty-one miles. The difference of elevation is 1,390 feet, giving a maximum descending grade of sixty-six feet per mile. From this point on the San Pedro to its mouth, a distance of sixty-seven and one-half miles, the stream has a fall of twenty feet per mile. Side cutting will be necessary at but few places, to turn the points of the *mesas*, but the work generally will be easy. The right bank affords the best location to within a few miles of the Gila, where several opportunities are offered to bridge the bed of the stream, at points where the water sinks below the surface, and rarely runs above it, and thence continuing on the left bank to the junction of the two valleys.

By the Aravaypa route we have from the point of divergence of the first line, the Railroad Pass, a distance of eighty and one-quarter miles, where the maximum grade will not exceed sixty and three-tenths feet per mile. This grade occurs in the passage of the Calitro mountains, through or near the cañon of the Aravaypa. From the Railroad Pass to the head streams of the Aravaypa, twenty-three miles, the line traverses an immense plain, with long waving undulations, like the ground swell of the ocean. The grades required upon this stretch will be very light, simply requiring a little more than a conformation to the contours of the ground. From this point a most singular and interesting feature presents itself. The *arroyo* of the Aravaypa here begins, and occupies almost the entire remainder of the trough between the Pinaleño mountains on the northeast and the Calitro mountains on the southwest; this vast plain which formerly extended further to the northwest, having been swept away by denuding waters, leaving a valley precisely similar to that of the San Pedro. The descent of this valley is at the rate of forty feet per mile to the entrance of the cañon, and presents no obstacle of any magnitude to its being easily occupied by the road.

The descent through the cañon is more rapid, being ninety-seven feet per mile, but it is proposed to locate the line upon the slopes of this gorge and over the *mesas*, by leaving the stream at the western end of the cañon, and continuing for a short distance over the *mesa* to the bed of an *arroyo* which debouches about three miles below the mouth of the Aravaypa, with a descending grade of sixty-three and two-tenths feet per mile; thence to the mouth of the San Pedro, at about fifteen feet per mile.

The first water which is encountered on the direct line of the road, after leaving the Railroad Pass, is Bear springs, twenty-nine miles distant. There are six of these springs, similar in character to all others encountered in this region, rising from the plain, which, for several hundred square yards around, is covered with salsolaceous plants. The water is abundant and agreeable to the taste. About two miles below these springs water rises in the bed of the stream, forming a *cienega*, and is probably the source of the running water found below.

On the eastern slopes of the Sierra de Calitro there are several springs of a limited capacity, such as Pheasant, Antelope, and Dove springs. These sources are probably too far from the projected route to be of any avail for supplying locomotives. By a divergence, however, these may be brought into requisition. For working parties on construction, or to emigrants who may take this route, or are desirous of recruiting their animals, or troops on scouting expeditions, the Calitro mountains present many advantages; permanent water exists in many places near the plain. The slopes are covered with a luxuriant growth of grama grass, and the gulches are filled with oak, ash, and walnut timber, the whole appearance of the country strikingly resembling many localities among the Coast Range of California, the wild oat being replaced by the grama grass. Game is also abundant—antelope, black tailed deer, and a species of grouse, having been seen there—as the names given to the several springs imply.

The relative length of these two routes is as follows: the one eighty and one-quarter miles, and the other one hundred and ten miles from the summit of the Railroad Pass, a difference of twenty-nine and three-quarters miles in favor of the Aravaypa route. The maximum grade upon the Nugent's pass route is one hundred feet per mile, and on the other sixty and three-tenths feet per mile. Nugent's pass is also two hundred and eighty feet higher than the Railroad Pass and the average surface of the Pinaleño plain. The localities for water are nearly equal on both routes. These items are sufficient to demonstrate the superiority of the Aravaypa route.

Section 4.

Third Division.—*From the mouth of the San Pedro to the Pimas villages.*—This division lies solely in the valley of the Gila, and may be subdivided into the upper or gorge division, and lower or plain division. A short distance below the mouth of the San Pedro, the Gila commences to flow westward, and in so doing encounters and pierces the axes of upheaval, producing short cañons or gorges, separating the valley portions above and below where the side hills recede, and give slopes more favorable for locations. The river bed varies in width according to the locality, occupying in the gorges the entire bottom, while in the open portions it spreads out over an area from fifty to one hundred yards wide, and is made up of a single channel or stream, during ordinary stages of water, together with a number of side drains, which, from the drift wood, sand, and cobble-stone beds, are evidently overflowed, either during the season of rains or on the melting of the snows on the mountains near its sources. The water was clear and palatable, flowing with a moderate current over an alternating bed of sand, pebbles, and rock. The stream was, in July, about twenty feet wide and twelve inches deep. Its banks were fringed throughout with cotton-wood and willow thickets, with mesquite at the base of the terraces.

Below the gorge division, the valley opens out in a broad plain, increasing in width as the Pimas villages are approached. This bottom is covered with dense groves of mesquite, with occasional intervening patches of grass, which, however, become less frequent as the river is descended.

Starting then from the mouth of the San Pedro we have sixty-three miles to the Pimas villages, or rather to the point (Camp 69) where the survey of 1854 leaves the river, and a difference of elevation between these points of 749 feet, giving, therefore, an average descent of 11.9 feet per mile. Taking up this division in detail, we have, from the San Pedro, twelve miles of valley to the entrance of the cañon, where no difficulty presents itself in the way of a favorable location. The cañon or gorge district is but twelve miles long; there are about four localities where the granitoid rocks impinge upon the stream in salient points, which will have to be blasted off or pierced by boring short archways. At points intermediate to these salient spurs the denuded table lands, rounded and intersected by lateral *arroyos*, fill up the valley, affording a simple passage to the river. A location over these rolling slopes will not be attended by heavy graduation but in few instances—the average descent of the stream from the San Pedro to the western limits of the cañon is about 14.5 feet per mile—and it is believed that no material increase of gradient on this route will be required. From the mouth of the cañon to Camp 69 is thirty-nine miles through the open valley, requiring but a grade of 11.5 feet per mile, with little or no earth work. From Camp 69 to the Maricopa wells, sixteen and three quarters miles, the Pimas plains are traversed with a descending grade of only 8.5 feet per mile. This portion of the division, like that immediately preceding it, will require very little more work than is necessary to adjust the sills securely for receiving the rails.

CHARACTERISTICS OF THE ROUTE.

SECTION 1. SOIL.

The character of the soil traversed by the line of survey is two-fold, depending upon the location. That of the river bottom is alluvial and exceedingly fertile, yielding, by irrigation, enormous crops of grain, vegetables, and fruits; while that of the *mesa*, or upland, is loose and light, and is also rich, but, owing to the scarcity of water and failure of rains at the proper season, it is not available as a grain-growing district, but at the same time much of it is well adapted to grazing and stock raising.

In the valley of the Rio Grande, between Frontera and Dona Ana, there are about forty lineal miles of bottom land, but of this area only a small part is now under cultivation. Corn, wheat, beans, and melons succeed admirably; also the grape; the soil, climate, and location, seeming particularly favorable to its culture. On the upper Mimbres, in the vicinity of the Copper Mines, there are several localites where the valley widens, affording attractive sites for the farmer, who would have at the same time fine grazing for his stock on the adjacent hills. On the establishment of Fort Webster, at the Copper Mines, corn was successfully raised in the valleys in the vicinity, but the project was abandoned on the removal of the troops to the Rio Grande. A great portion of the bottom land of the lower San Pedro can be cultivated, its own waters, as well as those of its tributaries, being available for irrigation, and I doubt not but that in several localities irrigation will be unnecessary. Near the Gila the bottom widens, and forms at its junction a large triangular area of rich soil, a small portion of which has already been used by the Apaches for raising corn. Thence down the Gila but few patches in the gorge district are available. Below this, however, is found the broad bottom, which extends below the Pimas and Maricopa villages.

The richness of the soil of this plain is fully attested by the crops raised by these Indians, but it is very doubtful whether much of the bottom land can be made productive, other than that now cultivated in this immediate vicinity, owing to the limited supply of water for irrigation, the bed of the river being entirely dry at times below the villages. About twenty-two miles below the Pimas villages the Gila receives a tributary from the north—the Salinas—whose bottom is broad and extensive, and presents a large area fit for cultivation. The stream is rapid and clear, and, according to Mr. Bartlett, its volume is double that of the Gila.

The piles of ruins and evidences of irrigating canals are sufficient proofs that this valley once supported a large population, and there is no reason why it cannot do so again.

The soil of the plateau or uplands is made up of alternate patches of sandy and clayey districts, owing to the out-cropping rocks on the adjacent elevations, whose debris passes through several gradations down to a finely comminuted material, forming the surface of the *playas*. The growth of grass depends not only on the composition of the soil, but also on the configuration of the surface, the richest being found in the feldspathic districts and near the lines of drainage.

SECTION 2. CLIMATE.

The climate of the interior section is delightful throughout the year; its seasons are two, the dry and the rainy—the former corresponding to our autumn, winter, and spring, while the rains occur during the summer months. This arrangement is just the reverse of what obtains in California. The air of the winter months is elastic and bracing, while the rains temper the heat of midsummer. The temperature along the lower Gila is intense during the summer months. The thermometer, in camp, near its mouth, indicated a mean temperature for June, 1855, 91°.1, the maximum being 106.°2; and at the Maricopa wells, for four and a half days (June 28 to July 1st) the mean temperature was 98°.8, the maximum being 112°. Below the Pimas villages, on July 2, the mean temperature was 107°.9, the maximum being 112°. On the day of our arrival at Fort Yuma, the thermometer at the fort indicated 119°; the greatest degree of heat is felt while traversing the western slope, but it is very sensibly reduced as soon as the plateau is ascended. During the reconnaissance of 1854 the thermometer stood below the freezing point at Tucson, Rio San Pedro, Valle del Sauz, and at the Rio Mimbres; and at the same points, at 3 or 4 p. m., it stood, respectively, 65°, 68°, 78°, 61°. While in camp, at nearly the same localities, during the months of July and August, it ranged at sunrise as follows: 57°.5, 68°.5, and at 3 p. m. 100°, 98°.5, and about 96°.

When we take into consideration the construction, maintenance, and after-working of a railroad, the climate is favorable; for working parties can remain in the field throughout the year, and the daily evolutions of the train will never be interrupted by snow or ice. The above indications of temperature for the summer season may seem to refute the assertion with regard to working parties being employed throughout the year, but it should be borne in mind that, on these elevated plateaus, the atmosphere is remarkably dry; the difference between the wet and dry bulb thermometer often indicating more than 30°, and consequently one never feels that sultriness which so often accompanies high temperatures in the Mississippi valley and on the Atlantic slope. The exhilerating effect of a New Mexican climate is duly attested by almost every person who has experienced it from their often expressed anxiety to return to that region.

SECTION 3. WATER.

The supply of water upon the plateau is limited. Along and near the proposed line it is found at the following localities, and from these the working parties can be supplied:

At Neide's spring, at the southwest corner of the basaltic hills, east of Cooke's spring; Cooke's spring; Rio Mimbres; Agua Fria; Ojo de la Vacca; Ojo de Inez; Valle del Sauz; in the Puerto del Dado; Croton springs at the Playa de los Pimas; Castro spring, near the Railroad Pass under Mount Graham; Pheasant creek; Antelope and Dove springs at the base of the Calitro mountains; and at Bear springs at the head of the Aravaypa. The distances, in direct lines, from one of these localities to another, are as follows:

	Miles.		Miles
From the Rio Grande to Neide's spring...	40	From Puerto del Dado to Castro spring...	3[illegible]
From Neide's spring to Cooke's spring...	12	From Puerto del Dado to Croton springs.	30
From Cooke's spring to Rio Mimbres......	21	From Castro spring to Croton springs.....	18
From Rio Mimbres to Agua Fria...........	15	From Croton springs to Pheasant creek..	12
From Agua Fria to Ojo de la Vacca........	6	From Pheasant creek to Antelope spring.	3
From Ojo de la Vacca to Ojo de Inez......	12	From Antelope spring to Dove spring.....	2½
From Ojo de Inez to Valle del Sauz........	40	From Dove spring to Bear spring...........	16
From Valle del Sauz to Puerto del Dado..	23		

On the San Pedro route water is abundant and convenient, at Chameleon spring and Prospect creek, and in the entire valley of the Rio San Pedro. Besides these permanent supplies, water is found, after the rains, on the *playas* and in depressions in the drains.

Lieut. Andrews, the commanding officer of the escort, found several inches of water on the Playa de los Pimas on his return to California in the month of October. Col. Hays, during the same month of a previous year, camped on the margin of one of the Pyramid *playas*, then covered with water, and called, in Mr. Nugent's notes of this trip, "a small lake." This is doubtless the *Laguna* of Capt. Whipple, a camping place occupied by his parties while engaged upon the survey of the boundary under the treaty of Guadalupe Hidalgo. In the bed of the *arroyo*, at the base of the Sugar Loaf, a limited supply of water is had by digging a couple of feet. Lieut. Andrews had, on the Tucson *jornada,* an abundance of water, where not a drop was found early in July. These rains, in addition to filling the natural reservoirs, give new life to the grasses. The fall and winter months are, therefore, the most favorable for making the trip across this country. For the working parties in the construction of the road, during the dry season, water can be obtained from the several above mentioned permanent sources of supply, but this will involve, of necessity, much haulage, the maximum distance being twenty-three miles. But I am clearly of the opinion that water can be obtained at other points along and near the line of construction by sinking common wells. These *playa* formations are particularly favorable. Being basin-shaped, they receive and retain the drainage from the surrounding country, giving us natural reservoirs, which require only to be tapped to give a constant and plentiful supply. On the Playa de los Pimas we find springs, located along the line of junction, between the surrounding slopes and the bed of the Playa, outlets for the water, which is prevented from rising on the lower level by its impermeable bed of clay.

The fall of rains has averaged, at Fort Fillmore, 9.23 inches per year for three years, but I am of the opinion that this is greatly below the average fall of rain for this region. At Fort Yuma the average fall for three years has been found to be but three inches. To take the mean of these quantities for the fall of rain upon the intermediate plateau, is not, in our opinion, a legitimate conclusion, one of the premises, as we shall endeavor to show, being erroneous. The register doubtless gives the correct amount of rain for the region about the junction of the Gila and Colorado rivers, that locality being surrounded by an inhospitable waste, with no mountains sufficiently lofty, within one hundred miles, to arrest the moisture, which, on account of the ascending currents of heated air, floats high above the plains. The deposition of rains must herefore be light. But it is a notorious fact, that not only at Fort Fillmore, but throughout New Mexico and the recently acquired territory, during the rainy season, clouds are seen almost daily enveloping the lofty summits of the mountains, distilling copious showers, while not a drop is delivered to the plain. In these regions the sky is rarely overcast; and when the ascending currents of warmer air from the circumjacent plains arise, and, in connection with the southeast winds, convey the clouds across the valleys to nestle again on some other range, rains fall on the plains and in the valleys in torrents, but of short duration. The registry of rain, therefore, at Fort Fillmore, and at other posts or towns in the valley of Rio Grande or on open plains to the east or west, must be far below the correct amount. The fall of rain at Fort Bliss averaged in three years 11.21 inches. Its situation with reference to Fort Fillmore is significant and confirmatory of the views above expressed. Fort Fillmore lies west of the Organ mountains, about twelve miles from the summits. Fort Bliss is opposite El Paso, about three miles from a high point of these mountains, and a little to the east of their trend. The southeast winds, moisture-ladened from the Gulf of Mexico, are deprived of a portion of their burden in coming in contact with this barrier, the precipitation being three inches greater on the east than on the west side. The influence of these elevated mountain ranges is shown in a more remarkable manner further north. The annual fall of rain east of Santa Fé, at Fort Union, is about twenty inches; while in the Rio Grande valley, in the same latitude, it is but ten inches; and on the Sierra Madre, as far south as the head of the Gila and Mimbres rivers, it is twenty inches, as is shown by the recent Meteorological Report of the Medical Bureau of the United States Army.

The springs around the Organ mountains, the Rio Grande, Cooke's spring, the Mimbres, Ojo de la Vacca, Ojo de Inez, Cienega del Sauz, the springs of the Playa de los Pimas, of the Calitro mountains, the San Pedro, the Aravaypa, Prospect and Petaya creeks, the Santa Cruz river, and the Gila itself, all, by their abundant and never-failing supply, fully attest the truth of our reasoning in this respect, that the fall of rain is sufficiently abundant for all practicable purposes, provided the configuration of the country is favorable to its being brought into requisition by conduits, artesian wells, common wells, or otherwise.

Water stations.—To supply stations along the line of road as proposed after construction, resort must be had to conduits. Cooke's spring, twelve miles north of the line, may be conveyed south-eastward, and, in connection with Neide's spring, deliver water at a point thirty-five miles from the Rio Grande, the difference of elevation being about six hundred and ninety feet; and it is probable that this water may be conveyed beyond this summit into the Monument basin. The Rio Mimbres, twenty-one miles north of the line, may be conveyed to the summit of the Florida pass, a distance of twenty-seven miles, the difference of elevation being five hundred and twenty-seven feet, and also to the lowest point of its own basin at the line, twenty-one miles below, the difference of elevation between them being eight hundred and twenty feet. The water from Agua Fria may also serve to furnish this point, being about fifteen miles distant. Ojo de la Vacca, eighteen miles north of the line, and six hundred and twenty-seven feet above it, may be conducted to another convenient station, and the water from Ojo de Inez, about eighteen miles north of the line, may be delivered at a station in the vicinity of Cooke's emigrant road, west of the summit of the plateau, the difference of elevation being about seven hundred and fifty feet. At the *playas*, on both sides of the Pyramid Range, there is little doubt but that common wells dug in the usual manner, or bored by machinery to the bottom of the gravelly deposits and tubed, will yield a plentiful supply of water for these stations. In the Valle del Sauz a common well may be resorted to, or conduits laid from the Cienega, fifteen miles above the crossing, and three hundred feet higher. From this point to the Bear springs, at the head of the Aravaypa, no water exits immediately on the line; there may be springs in the unexplored chasms of the Dos Cabezos spur, and in Mount Graham, which may be found to supply stations at the Railroad Pass.

Water from the Playa de los Pimas may be drawn to this summit, and to an immediate point between the Railroad Pass and Bear springs, from Dove and Antelope springs, by means of the force-pump before alluded to.

The distances from station to station, between running water of Rio Grande and Aravaypa, as recapitulated, are as follows:

	Miles.		Miles.
From Rio Grande to station one	31	From station five to station six	10
From station one to station two	19	From station six to station seven	20
From station two to station three	15	From station seven to station eight	21
From station three to station four	22	From station eight to station nine	28
From station four to station five	17	From station nine to station ten	29

SECTION 4. FUEL, TIMBER, AND MINERALS.

The supply of timber and fuel throughout this section is very limited, the plateaux being entirely destitute, and the water-courses are fringed with a sparse growth, which is scarcely available for purposes of construction. The cotton-wood is found in the Rio Grande valley, on the upper Mimbres, lower San Pedro, and Gila, and will answer for cross-ties, but must, however, be replaced in a few years, the wood being light, soft, and not durable. Mesquite is also found in the river bottoms; the trunks are generally short and gnarly, and but few will answer for cross-ties, although about Tucson and in the Santa Cruz valley this tree attains a more respectable growth. The wood is hard and close-grained, and makes most excellent fuel. In the gorges, ravines, and cañons of the surrounding mountains, a few scattering dwarfish oaks, walnut, ash, wild cherry, and cedars are found. In the vicinity of the Copper Mines and sources of the Mimbres, is the largest and most extensive growth of timber to be met with along or near the route. Here are cedars, oaks, and the large-leafed pine.

Taking it all in all, there is not a sufficiency of timber along the line to furnish all that is required in the construction and the after working of the road.

In Appendix C will be found a literal translation of a copy of an archive of the town of Tucson, which will afford some interesting information concerning that section of country. It was copied from the original, by permission of Ensign José Comaduran, M. A., who had temporary command of that post, previous to the completion of the boundary line according to the provisions of the treaty.

It will be seen, from a perusal of this paper, that mention is made of many localities where gold and silver have been found in abundance. The inhabitants of Tucson, at the present day, confirm all these statements, and many rich specimens of gold scales and quartz specimens were exhibited, and their localities described and pointed out. The difficulties of working the placers and veins of these precious metals consist chiefly in the want of water, the want of proper implements, and in the dangers to which "prospectors" and miners are subjected by the roving bands of Apaches who dwell in the mountain fastnesses. There is little doubt but that the entire section recently acquired by the Gadsden treaty is nearly as rich in minerals and metals as California, and the construction of a rail or wagon road, and the establishment of frequent military posts, will serve to develop speedily the immense resources of this nature, which now lie hidden in the mountain gorges or beneath the surface of the wide-spread plains.

SECTION 5. POST ROUTE.

In considering the adaptability of this country to the establishment of a post route, extending from the Mississippi to the Pacific, the advantages presented by the line between the Rio Grande and Pimas villages are indeed highly favorable. The most important element in this question is speed, and to this the excellent natural roads of the plateau contribute largely. Taking the Tucson route, we have from El Paso to the Pimas about four hundred miles, of which there are about three hundred miles of hard and smooth road, resembling a macadamized, and almost equal to a plank road. Stations can be readily maintained at intervals to admit of rapid transit. From El Paso to Fulton, on Red river, the distance is about seven hundred and eighty-seven miles; and, allowing an average speed of fifty-six miles per diem, the trip can be accomplished in fourteen days. From El Paso to the Pimas villages, four hundred and twelve miles, can be accomplished in eight days. From the Pimas villages to Fort Yuma it is one hundred and seventy miles, and thence to San Diego two hundred and twenty miles, giving a distance of three hundred and ninety miles, which can be overcome in eight days. Thus the entire distance from Fulton to San Diego, less than one thousand six hundred miles, can be made in less than thirty days. This, of course, involves the necessity of preparing the road, and of establishing a liberal supply of men and animals for relays along the route, and numerous stations well stocked with forage. The mail has been carried from El Paso to San Antonio, Texas, in an ambulance, in fifteen days, and having, for about five hundred and forty miles, but one set of extra animals, which were driven along to alternate with those in harness. The distance is six hundred and seventy-three miles, giving an average of forty-four miles per diem.*

* This estimate is based upon the present system of carrying the mail from San Antonio, Texas, to the Rio Grande.

MISSION CHURCH OF SAN XAVIER DEL BAC

REMARKS UPON CONSTRUCTION OF A RAILROAD.

SECTION I. ECONOMICAL VIEWS AND PROTECTION OF THE ROUTE, ETC.

The Rio Grande and Pimas villages division being completely isolated and cut off from navigable waters, its construction will depend upon the completion of the sections adjoining—that on the east being about three hundred miles to a point on Red river attainable by steamboats; and that on the west being eighty miles to Fort Yuma, at the mouth of the Gila river. It is now clearly and practicably demonstrated that the Colorado river is navigable up to this point, Fort Yuma having been supplied for the last three years by steamboats, connecting with sailing vessels, which ply between the head of the gulf and ports on the Pacific. Since it is proposed that the thirty-second parallel route should cross the Colorado at the mouth of the Gila, the construction of this portion of the road will, therefore, proceed with advantage by commencing at the point and working in both directions. Thus the road can be made to transport its own material and supplies, the ties and sills being delivered as rapidly as the graduation progresses. Laborers can be readily obtained from Sonora, Chihuahua, and the valley of the Rio Grande, and at rates ranging from eight to twenty dollars per month. The working parties can be readily provisioned throughout this section. The valley of the Rio Grande and Janos, Fronteras, Tubac, and Tucson, points distant from the line about an average of sixty miles, and also the Pimas, will contribute beef, flour, and beans. This supply will be greatly swelled by ranchos, which will be reoccupied immediately on the prosecution of this work. This, of course, presupposes that military protection will be extended to the country through which the line passes. On the headwaters of the Yaqui and Sonora, rivers of the gulf, and of the San Pedro and Santa Cruz, tributaries of the Gila, there are ruins of extensive ranchos and haciendas, sad monuments of the depredations of the ruthless Apaches. These Indians occupy the mountains adjacent to the Gila, covering a breadth of country of about two hundred miles west of the Rio Grande, and bear different names, according to their locality, as the Copper Mine Apaches, Pinaleños, Coyoteros, and the Tontos, but all coming under the general head of Gila Apaches. They have waged incessant war upon the provinces of Mexico adjoining our boundary, and by their forays and incursions have compelled the rancheros to abandon their establishments, and congregate for mutual protection about the small frontier towns. Colonel Cooke found, in 1846, herds of wild cattle roaming over these abandoned ranchos, affording his command for two weeks the luxury of fresh beef. Since then the supply has been almost entirely exhausted by the continual levying of the Indians, who now push their claims further into the interior of Mexico. While crossing this country, both in 1854 and 1855, broad and fresh trails of cattle and horses were frequently crossed passing from the south to the north, particularly in the San Pedro, Playa de los Pimas, and Sauz valleys. These Indians also make occasional depredations in the Rio Grande valley.

In order to punish these Indians, and stop effectually their further inroads, temporary military posts or encampments must be established in their country. There are three points which

I respectfully recommend as being highly favorable for such locations. These are: 1st. On the upper Mimbres, or Copper Mine region; 2d. The valley of the Gila, near the junction of the Sauz; and, 3d. The Rio San Pedro, near its junction with the Gila. These three points form centres from which combined and heavy blows can be dealt, and which, taken in connection with those on the Rio Grande, and also with the aid of the Pimas, who are very active and formidable enemies of the Apaches, and between whom an incessant war is waging, form a line which, I think, will ultimately effectually intercept all parties attempting to cross it. These Indians lead a purely nomadic life, and although not numerous it will require a large force to keep them in check; they being divided up into numerous small bands and parties, occupying the cañons and gorges of the mountains, which are difficult of access, and where elusion is easy. Treaties are of avail only so long as they suit the convenience of these Indians, and until they are exterminated, or their nature changed, the presence of troops in the country is required, *might* being the only law for which they have any respect.

At the Mimbres wood, water, and grass abound; besides, there are patches of bottom land capable of being cultivated. There is also an abundance of timber for building purposes.

At the mouth of Sauz grass is reported by Major Emory, in 1846, to be scarce, and of an inferior quality; but he also reports that the Gila bottom, for a long distance at the base of Mount Graham, is from three to six miles wide, and can be easily irrigated from the waters of the Gila. Cotton-wood and willow fringe the river. Mesquite is also found. Up the Sauz he notes many trails leading to San Bernardino, Fronteras, and Tucson, doubtless the same that we encountered, showing full well the importance of this point being occupied. At the mouth of the San Pedro an abundance of grass is found; also a large area which can be readily irrigated. Cotton-wood and mesquite abound. The supplies for these posts can be drawn from either the Rio Grande or Fort Yuma. It would be better, probably, to supply the Copper Mines and the Sauz from Fort Fillmore, while San Pedro would be supplied from Fort Yuma.

To do this better, however, a road will have to be made for about twenty-four miles down the Gila, where it debouches upon the Pimas plains; thence to Fort Yuma a good natural road is found, with the exception of a few points, where deep sand is encountered and rough ascents and descents of the *mesas*. Below the Pimas grass is very scarce. In the summer and fall months the mesquite bean answers a good purpose in the way of forage. It will probably be found that Guaymas may be a good point for the distribution of supplies for this district of country. The distance thence to Tucson is about three hundred miles, and it is believed this interesting country presents no obstacles to the location of a good wagon-road.

From Fort Fillmore to the Mimbres and Sauz most excellent natural roads are found, with an abundance of grass. Wood is scarce, and during and immediately after the rainy season the supply of water is sufficient.

After a complete and effective chastisement, it will be necessary to occupy only two of the above mentioned posts, and these, in my opinion, will afford full and sufficient protection to the working parties along the line of road. To the emigrant, ever careful and anxious about the strength and condition of his animals, the advantages gained by the San Pedro and Gila route over the Tucson are indeed great and very important. The distance is, however, increased fourteen* miles, but at the same time we have an abundant supply of water and wood throughout, and most excellent grass for more than half the distance, whilst by the Tucson route there is encountered a stretch of seventy-five miles, without a drop of permanent water. The San

*If the road *via* San Xavier is taken, this distance will be reduced to seven miles.

Pedro route must be worked and improved before wagons enter upon it. This can, however, be done in a short time, there being but few points on the San Pedro requiring working, other than removing the underbrush and thickets.

On the Gila, there will be about twelve miles, where it will be necessary to grade down the banks of the river, and remove some rocks in its bed at the crossings, and to cut off the points of some out-jutting rocky spurs. The cost will, however, not exceed ten thousand dollars.

SECTION 2. RECAPITULATION AND COMPARISON OF ROUTES.

Length of central section, from Fronteras, on the Rio Grande, to the Pimas villages, (Maricopa wells:)

By survey of 1854, *via* Tucson, 406 miles.

By survey of 1855, *via* San Pedro, 375 miles.

Do. Do. *via* Aravaypa, 345.25 miles.

Sum of ascents and descents, *via* Tucson, app. 11,000 feet.

Do. do. *via* San Pedro, app. 8,764 feet.

Do. do. *via* Aravaypa, 7,560 feet.

Number of summits on these routes: Tucson, 10.

Do. do. do. San Pedro, 7.

Do. do. do. Aravaypa, 6.

Greatest elevation above sea level: Tucson, 5,183 feet.

Do. do. San Pedro, 4,881 feet.

Do. do. Aravaypa, 4,601 feet.

Maximum grade: Tucson, 93 feet per mile.

Do. do. San Pedro, 100 feet per mile.

Do. do. Aravaypa, 60.3 feet per mile.

It thus appears that by the lines of 1855 we have improved upon the line of 1854 in all the above points—length, number of summits, elevation, and grade. Beside these, another most important improvement is made in regard to the supply of water. The San Pedro is twenty-nine and three-fourth miles longer than the Aravaypa route, but has the advantage of passing through a well watered, cultivable valley of about sixty miles, affording fine sites for stations and settlements. But in locating a line of road of such length as is required to connect the waters of the Mississippi with the Pacific, a saving of distance is one of the chief aims. We will, therefore, adopt the Aravaypa route—giving the entire length of the section, from the crossing of the Rio Grande to the Pimas villages, three hundred and forty-five and one-fourth miles.

SECTION 3. COST OF CONSTRUCTION.

In estimating the cost of constructing the proposed railroad, it is not practicable, without the aid of detailed and minute instrumental surveys of a line of location, to arrive at anything positive and definite with regard to the amount of excavation, embankment, and rock cutting required; and as such surveys were not made, I will attempt an approximation only to the cost, by comparing the character of the country to be traversed and obstacles to be overcome with those already encountered and overcome on roads now in operation. Of the two items of cost, labor and material, the former may safely be put down at rates not exceeding those paid on the Atlantic board and in the Mississippi basin; the provisions can be furnished from the *termini*, and points adjacent to the line. The material will be necessarily much increased in value, owing to the great distances from sources of supply; but by adopting the course recommended—*i. e.*, to commence at the mouth of the Gila, where the rails and other supplies can be delivered by means of the gulf and river navigation—the road as it progresses can transport its own material.

Dividing the country into the three classes—prairie or plain, rolling, and mountainous—we find the central section made up of these several features, as follows:

Prairie	230 miles.
Rolling	65 "
Mountainous	50 "

Where by prairie, it is meant that to prepare for the superstructure, no work is required beyond simple ditching, and even this, in many places, will not be necessary, the character of the soil being such as to render gravelling or ballasting altogether unnecessary. This, of course, involves the necessity of undulating grades to conform to the surface of the plains, but by proper locations these will be gentle throughout. The rolling district embraces those portions of line where earth work is necessary, and where an equable cutting and filling can be obtained. And the mountainous includes those stretches involving side locations and rock cuttings, which will be encountered in descending to the valley of the San Pedro, and at several points along the Gila, before its valley opens out in the Pimas plain.

The following railroads which have been constructed in different parts of the United States are taken for assimilation with the respective districts of a prairie, rolling and mountainous character. These several railroads pass through sections of country very closely resembling those with which they are assimilated. The term mountainous, which is applied to one of the above districts, is hardly admissible, for there is no point on the route which is of that character, as the term is commonly applied.

*The railroads of a prairie character and their cost per mile, including equipment, in round numbers are:

Petersburg and Roanoke railroad	$16,000
Wilmington and Manchester railroad	13,000
Montgomery and West Point railroad	16,000
Average	15,000

Those of a rolling character, &c., are:

Terre Haute and Indiana railroad	$20,500
Galena and Chicago railroad	30,000
Orange and Alexandria railroad	28,400
Cleveland, Columbus and Cincinnati railroad	32,700
Illinois railroad	32,400
Average cost per mile	28,800

Those of a mountainous character, &c., are:

Virginia and Tennessee railroad	$36,700
Providence and Worcester railroad	42,000
Fitchburg railroad	56,000
Average cost per mile	44,900

*The cost of these roads are obtained from the American Railroad Journal, of November 15, 1856.

Adding *one hundred per cent.* to these several costs, we have for the cost per mile of the respective sections $30,000, $57,600, and $89,800. The total amounts are exhibited as follows:

230 miles of prairie division, at $30,000 per mile, gives	$6,900,000
65 miles of rolling division, at $57,600 per mile, gives	3,744,000
*50 miles of mountainous division, at $89,800 per mile, gives	4,490,000
345	$15,134,000
Average cost per mile	$43,866

SECTION 4. DESCRIPTION OF ROUTE. FROM THE PIMAS VILLAGES TO COLORADO RIVER.

To complete the central section so that it shall embrace the entire district between the Rio Grande and Colorado, the best, in fact, the only line of location beyond the Pimas villages, will extend down the Rio Gila, on its left bank, following mainly the trace of the present wagon road to the crossing of the Colorado at Fort Yuma. Immediately beyond the Pimas and Maricopa villages the river makes a bend northward, turning the point of one of the isolated ridges found in that region. To avoid this bend, the line of location should leave the river valley at the Maricopa wells, and cross the ridge at a very favorable depression now occupied by the wagon road.† There are two summits which do not differ much in height, and have an elevation above the river bottom at the Maricopa wells of about three hundred and seventy-four feet, and at the Laguna or Tezotal below about eight hundred feet. The approaches to these summits are exceedingly favorable, being smooth plains extending up from the river bottom to the bases of the superposing ridges, which are broken so as to give an open and free transit through from the Maricopa slope on the one side to the Tezotal slope on the other. There will be required some excavation in the vicinity of the ridges, and the crossing can be effected on an ascending grade of about twenty-eight feet per mile, and a descending one of about thirty feet per mile; thence ascending thirty-three feet per mile to the western summit; thence to the Gila, with a descending grade depending upon the point at which the river is reached, between thirty and seventy feet per mile; yet, by following the river valley around the point of the ridge, a continuously descending grade of 5.6 feet per mile can be had, but at the sacrifice of about thirty miles in distance. This route may be found preferable on account of its passing near the mouth of the Salinas river, a large tributary from the north and east, draining an extensive district reported to be suitable for extensive agricultural operations.

From Tezotal to Fort Yuma the river valley can be followed the entire distance one hundred and twenty-two miles. Of this distance there are about one hundred miles which are highly favorable to a rapid and very economical construction of road, the river bottom being broad and smooth, affording fine opportunities for long tangents. At several points, however, the basaltic *mesas* impinge upon the river, but these can be passed without much labor, the underlying strata being soft and friable sandstones, and in some instances simply diluvial or tertiary beds of gravel and clay, &c., where these bluffs occupy both sides; the narrow *berme* at their foot can be easily protected by rip-rap work, and rendered available for the support of a road bed. The difference in elevation between Tezotal and the crossing of the Colorado is about five hundred and seventy feet, giving an average descending grade of about 4.6 feet per mile.‡

*Many miles of this distance properly belong to the preceding division in character, though more rugged, and will require a greater outlay per mile. The actual mountainous section, as it is termed, does not exceed fifteen miles.

†This cut-off is called the *Jornada de las Estrellas.*

‡The descent of the river bed in all its meanderings is much less.

From Pimas, Maricopa well, to Fort Yuma, is 167 miles.

Maximum grade will not exceed, per mile, 4.5 feet.

Approximate cost per mile, $24,000.

Total cost, $4,008,000.

The valley of the Gila being so convenient to the navigable waters of the Colorado, and supplies and material can be readily delivered, that it is thought that an addition of 50 per cent. to eastern prices is ample for this portion of the route.

SECTION 5. THIRTY-SECOND PARALLEL ROUTE FROM MISSISSIPPI RIVER TO SAN DIEGO AND SAN FRANCISCO.

This route may be divided into the three sections, eastern, central, and western. The Eastern section extends from Fulton, on the Red river, to the crossing of the Rio Grande, at Molino, and forms the route surveyed by Captain John Pope, Topographical Engineers.

Its total length is 787 miles, and approximate cost is estimated at $31,575,000. To connect this section with the central, and to have the crossing of the Rio Grande within our own boundary line, it will be necessary to ascend the Rio Grande about five miles from Molino to opposite Frontera, crossing about one half mile above the initial point of the boundary.

Assuming Captain Humphreys' rate of estimate, we have for this connecting link—

Five miles, at $45,000 per mile	$225,000
Bridge across Rio Grande	12,000
	237,000
Making total cost of eastern section	$31,812,000

The Central section, from Fronteras to Fort Yuma, 545 miles, adding $480,000 for 32 miles ($15,000 per mile) up the Rio Grande valley, is estimated to cost $19,622,000.

The Western section depends, of course, upon the adopted terminus of road on the Pacific coast, whether at San Diego or San Francisco. The Fort Yuma and San Francisco section is subdivided into the Fort Yuma and Los Angelos, and Los Angelos and San Francisco sections. The former, from the survey and examinations of Lieutenant Williamson, Topographical Engineers, made in 1853, has a length of about 238 miles, and it is estimated by Captain Humphreys to cost about $10,710,000.

From Los Angelos to San Francisco, *via* the coast route, the distance is 396 miles, and the approximate cost is about $20,668,750, (see page 18;) making the total length of western section, taking San Francisco as the terminus, 634 miles, and approximate cost $31,378,750.

Since Lieutenant Williamson's examination of the passes leading from the Colorado basin through the mountains to San Diego, a more detailed examination has been made of this mountainous district, resulting in the development of new features in regard to the approaches to the main pass, which were of so favorable a character that a detailed instrumental survey of the new route, through Warner's, was undertaken under the auspices of the San Diego and Gila Railroad Company. This survey was conducted by Mr. Charles H. Poole, Civil Engineer, and the report and estimates in detail, which he kindly tendered me, will be found in Appendix B. From this report it appears that the total length of the Fort Yuma and Diego section is 189.1 miles, and the total cost $7,571,500. The greatest elevation to be overcome is 3,579 feet; maxinum grade, 107 miles.

Summing up these several sections, we find the lengths and cost of proposed roads to San Diego and San Francisco to be as follows:

	Length, miles.	Cost.
Fulton to Frontera	793	$31,812,000
Frontera to Fort Yuma	545	19,622,000
Fort Yuma to San Diego	189	*7,571,500
From Fulton to San Diego	1,527	59,005,500
Average cost per mile		$38,641

	Length, miles.	Cost.
Fulton to Frontera	793	$31,812,000
Frontera to Fort Yuma	545	19,622,000
Fort Yuma to San Francisco bay	634	31,378,750
From Fulton to San Francisco	1,972	82,812,750
Average cost per mile		$41,991

In contemplating the question of the construction of a railroad from the valley of the Mississippi to the Pacific ocean, the three features, length of road, elevation to be overcome, and climate of the district to be traversed, are important considerations, and in the greatest degree determine the practicability of the route proposed. The route by the 32d parallel possesses decided advantages, as regards these three features, viz: 1st, by making San Diego the terminus, it is by far the shortest line between the Mississippi river and the Pacific ocean.

2d. The elevations to be overcome are the least, and it is believed that the maximum elevation on the line, which is east of the Rio Grande, will be materially diminished by future explorations.

3d. The climate is particularly favorable, in regard both to the construction and the running of the road, there being no obstacles to parties working throughout the year, and no snows to embarrass the track.

There is also another advantage possessed by this route alone. The material and supplies for construction can be delivered at the crossing of the Colorado, a point to which steamboats are now plying from the head of the Gulf of California, and by this means the track-lying can be pushed both eastward and westward, in addition to that progressing from the two *termini*.

The grades are generally very light, and the character of country is such as will admit of rapid construction. The disadvantage of this route is the scarcity of wood and water along portions of the proposed line on the great plateau of the continent, but this is true in a greater or less degree of every other line across the continent, particularly in regard to the supply of wood. The scarcity of water is found on plain stretches, where the grades will be exceedingly light, so that the maximum effective force of the locomotive, on portions of the road where heavier grades are encountered, will not be materially diminished by the additional weight of water required to traverse the increased interval between stations where the lightest grades exist.

As to the time required to complete the construction, this will depend on other considerations

* Applying the same standard to the western section from Fort Yuma to San Diego, as applied to the most difficult portion of this route, between the Pimas villages and the Rio Grande, and to the portion of the Gila valley from the Pimas villages to Fort Yuma, we have to add to Poole's estimate $3,258,500, which gives for the total amount of western section to San Diego, $62,264,000. Average cost per mile, $40,775.

than those of the engineering difficulties; and so far as they are concerned, I am clearly of the opinion that the work can be accomplished, under judicious superintendence, and with a liberal supply of means, within eight years.

Before closing this report, I take pleasure in stating that much credit is due to my several assistants, Messrs. Albert H. Campbell, N. H. Hutton, H. Custer, George G. Garner, Dr. Thomas Antisell, and J. Nevin King, for the ability, zeal, and fidelity with which they discharged their respective duties, both in the field collecting the data, and in the office collecting and compiling the results. To Mr. Albert H. Campbell, civil engineer and surveyor, I am under many obligations for the efficient aid rendered in conducting the tributary reconnaissances when the main party was divided, and for much valuable information contributed in regard to the location of the road and its details. To Dr. Antisell was entrusted the geological investigations; his report is appended, and is of itself a sufficient evidence of the great energy he displayed in collecting the facts and data therein detailed. It is a valuable paper, and will doubtless contribute much towards the full development of the geology of those very interesting districts, the Coast Range of California and the great plateau of the continent. Lieutenant George H. Mendell, Corps Topographical Engineers, accompanied the expedition from Benicia to San Diego, California, by authority of General Wool, commanding the department of the Pacific. For his many kind offices, warm interest in the success of the exploration, and valuable assistance rendered, he has my grateful acknowledgments.

Lieutenants William A. Winder and George T. Andrews, of 3d regiment artillery, were each, in turn, in command of the escort—the former while in California, up to the time of our reaching San Diego, and the latter thence to Fort Fillmore, on the Rio Grande. The field duties of the party being then completed, the services of the escort were dispensed with, and Lieutenant Andrews returned with his command to California.

PART II.

1 U

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WAR DEPARTMENT.

ROUTES IN CALIFORNIA TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS, AND ROUTE NEAR THE THIRTY-SECOND PARALLEL, BETWEEN THE RIO GRANDE AND PIMAS VILLAGES, EXPLORED BY LIEUTENANT JOHN G. PARKE, CORPS TOPOGRAPHICAL ENGINEERS, IN 1854 AND 1855.

GEOLOGICAL REPORT,

BY

THOMAS ANTISELL, M. D.,

GEOLOGIST OF THE EXPEDITION.

WASHINGTON, D. C.

1856.

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Extent of survey.—Of the coast mountains.—Erroneous notions of.—Parallel ranges.—Number of and geographical position.—Northern extension.—Depression across the line of strike at San Francisco.—Monte Diablo range.—Effect of the topography on commercial destiny.—Absence of navigable rivers.—Flow of the waters.—Outline of topography of the State in the south.—Climate independent of other lands.—Effect of mountains.—No distinct winter season.—Rainy season.—Fall of rain.—Drought.—Earthquake movements, frequency of.—Elevation of coast range.—Geological period of.—Igneous rocks.—Different points of elevation.—Depression of fissures of the strata.—Resemblance of the orography to Mediterranean Europe.—Palæozoic strata not discovered.—Of the miocene period on the Pacific.—Upheaval of the Sierra Nevada.—Probable effect upon the level of the great basin.—Absence of polar drift.—Of the quaternary period.—Of the coast line of California.

The geological examinations in southern California occupied from November 22, 1854, to April 5, 1855. The explorations were made in five counties within that period, viz: Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, and Los Angeles. In the counties of San Diego, San Bernardino, and Tulare, only a few observations were noted. The five above named counties occupy almost the whole shore-line of southern California, and embrace within their limits the numerous series of parallel ranges of hills, which are erroneously located as one upon the maps of the present time, and which are confusedly included under the common name of the Coast Range.

It would be well if this name were obliterated altogether from the maps and geographies of the State. There is no single range of hills which in its whole extent can be termed the Coast Range in these counties. These ranges have, as they travel south, a deviation more easterly than the shore-line, and pass into the interior, leaving a fresh chain to occupy a littoral position for a few miles further south. The western commencement of these ranges form the headland along shore, and give that peculiar indentation of the coast and crescentic shape to the bays which is so peculiar to this State. Thus, from Point Pinos, in Monterey, to Point Concepcion, in Santa Barbara county, as many as four ranges may be counted, each one being the Coast Range at its outset, and gliding, in turn, behind a range which, further south, outflanks it, itself to be displaced, in turn, by its western neighbor. Viewed from the shore, as in the vessels sailing coastwise, these appear one uniform continuous chain, and from this, no doubt, has arisen the erroneous term, which, if longer retained, must, from its very comprehensiveness, become a source of error and confusion.

Throughout the majority of the counties as many as three different ranges may be traced, running in a direction somewhat parallel to each other, and converging into a focal point in latitude 34°. At this point of junction an immense upheaval of primitive rock occupies the region, rendering it an uninhabitable and almost impassable district.

In the vicinity and south of the Bay of San Francisco, the parallelism of mountain ranges, already alluded to, is remarkable. This district, which embraces Contra Costa, Alameda, and San Francisco counties, San Jaoquin, Santa Clara, Santa Cruz, and the northern part of

Monterey, is divided into a series of parallel valleys by three well marked hill ranges, running southeast from the southern shores of San Pablo and Suisun bays, and from the Golden Gate.

The most westerly of these is the Santa Cruz mountains, which, under the name of Monte San Bruno and the Presidio hills, form the termination of the promontory on which San Francisco city is built. Lows hill at this point, as they pass south they increase in height, until, in Santa Cruz and Santa Clara counties, they attain the average altitude of 2,000 feet. A single hill in this chain, in San Francisco county, "Loma Prieto," reaches an altitude above that point; but it is in Santa Clara county that these hills attain a continuous and lofty elevation, which they preserve for the rest of their course south, until at the Pajaro river, near the southern border of Santa Clara county, this range abruptly drops down. The total length of this chain is about 85 miles, and the general strike is north 70° west; a greater meridional deviation than the chain lying immediately east has, whence it occurs that these two chains approach each other, after travelling 70 miles parallel, and close up, by their approximation, the Santa Clara valley, dividing it from the narrow valley of San Juan.

The Santa Cruz range does not terminate, in a geological sense, at the Golden Gate, but is found extending itself north of the strait or entrance of the bay, in which the islands of Alcatrez and Los Angeles are its representatives, passing northwest along the shore of Marin county and dropping down terminates at Bodigo Head. Indeed, all the ranges found south of the bays Suisun and San Pablo may be traced northward, forming by their elevation the valleys of Napa, Petaluma, and Sonoma, until they terminate at Cape Mendocino. A great depression or chasm has been produced across the strike of these ranges, by the exertion of volcanic forces acting after they had been elevated; and in the depressed valley running east and west, thus produced, the waters of the ocean have advanced to meet the Sacramento and Joachim rivers, which roll down their several valleys from opposite points.

This great transverse depression of the whole land, from the ocean to the base of the Sierra Nevada, along the parallel of 37° 31′′ north latitude, has assisted in making San Francisco what she ever will remain of these extreme western possessions. A similar transverse depression, between latitude 41°—42°, has determined the course of the Klamath, and still further north, in Oregon, a third depression is indicated by the Columbia river. Nor are these depressions confined to the shores of the Pacific east of the Sierra Nevada. Humboldt river pursues a course which cannot be said to be a true one, as its course is across the strike of the small ranges; and the Gila river has been adduced, in a later portion of this report, as a remarkable example of a river which for many hundred miles pursues its course across the strike of mountain ranges, forcing its way through cañons, and forming a course difficult to the traveller to follow.

From the southern shores of San Pablo and the Straits of Carquinez extends the second range of coast mountains. These hills, like the former, are low toward their north extremity, in Contra Costa county; but rising gradually in Alameda county and Santa Clara, attain an altitude equal to the Santa Cruz, which they almost join, near the mission San Juan, in Monterey county.

By this approximation of both ranges at the south, an acute angled triangle is formed, whose sides are these hills, and the base occupied with the Bay of San Francisco, which, running up into, terminates in Santa Clara valley, forming the apex of the triangle.

East of this second range lies an elevated undulating country, hill and vale, extending fifteen to twenty miles, until the Monte Diablo range is reached. This third range, so called from the prominent hill forming its northern limit, and presenting a beautiful picture to the southern shores of Suisun bay—this hill, nearly fifty-five miles inland, can be seen distinctly at sea, from its great elevation above the low land (3,800 feet.) From the height to which, by its upheaval, the sedimentary strata have been raised, it has impressed the whole district more than any other hill range. Though not a continuous range, yet it has its parallelism well defined, and its hills form larger masses than those of the previously described ranges; it also passes southeast, and in its course are found the Santa Aña hills and Pacheco's Peak; and the Gavilan, which is a mighty mass of primitive rock, can be looked upon as nothing but a continuation south of the same range. The chain, as stated, is not however a continuous crest, and occasionally the whole drops down, or is represented by low hills or a diffused disturbance over a great breadth of ground.

East of the Monte Diablo range lies the valley San Joaquin, beyond which rise the Sierra Nevada, the summits glistening with snow, or covered with clouds. Thus in the district described we have enumerated, between the ocean and the Sierra, three distinct ranges of hills: the Santa Cruz, the Monte Diablo, and the range lying between these two, for which I could not ascertain that there was any distinct appellation, and which may be described under the term "Central" range—traverse from north to south, producing those deep longitudinal valleys of Santa Clara and San Joaquin, whose level is but little above that of the sea, and whose only outlet is by the Bay of San Francisco and the Golden Gate.

This parallelism of hill ranges is repeated through Monterey and Santa Barbara counties, producing longitudinal valleys of less area than the foregoing, but resembling it, inasmuch as they are cut off from direct access with the ocean, an intervening chain generally preventing the exit of the valley streams. On account of the proximity of these ranges to each other, there are no large rivers in southern California—there are no navigable streams; and on account of the north and south direction of the chains, there are no rivers which run a course from east to west into the ocean; every stream runs *along the strike* of the chains, or in the valley between two ranges, and rarely is it that, like the Santa Maria, it is able to force its way through one of the littoral ranges to reach the Pacific. From the same orographic conformation of California, there are no estuaries on the shores; a few headlands, the continuation of the chains, a few of which have been alluded to, run out into points until they are lost in the ocean, constitute the coast features, forming curve lines of shores facing either the northwest or southwest, (generally the former,) but which are never aided by a corresponding ridge on the opposite shore so as to produce a gulf or an estuary. These ranges of hills cut off the interior of the south of California from the coast, and have precluded the formation of gulfs, harbors, or deep rivers running up into the land. The south of the State cannot, therefore, be a commercial district, and not endowed with auriferous localities equal in value or number to the north, it will ever remain an agricultural region, with social habits and political feelings very different from the gold bearing counties. Beside the foregoing ranges, the others are the Santa Lucia hills, San Rafael and Santa Inez mountains. As full descriptions of these are given under their respective titles, it is unnecessary to anticipate. It may be said, however, that the more westerly the chains lie, the more the direction varies from the meridian and approaches an easterly trend. The Sierras Monica and Susanna, which ought scarcely be classed as coast mountains, lie almost due east and west.

The waters of the northern part of California flow southward; those in the south, in the coast mountains and Tulare valley, flow northward; and either Monterey bay or San Francisco waters receive the rivers of two-thirds of the surface of California. As the mountains run north and south, so do the rivers in the same direction, rarely cutting a mountain chain, but generally keeping the valley bottom, and in the southern portion never forming a stream navigable for even a small steamer. This meridional direction of the coast mountains determines the shape of the coast line, and it is only necessary to inspect a correct view of the shore line of the State to be enabled to say where the coast ridges touch on the shore. The coast line has the appearance of a series of semicircles, with their concavities to the sea; where the extremities of two of these connected segments meet, there a mountain range runs out. These shore curvatures disappear south of Santa Barbara, because the Coast Ranges, blending with the Cordilleras, receive a new direction, more north and south, when passing into lower California. The Cordilleras of Los Angeles and San Diego counties are not, geologically, the continuation of the Sierra Nevada, but rather a distinct axis, coeval with the litoral ranges of the northern counties. The coeval representatives of the Sierra Nevada are not reproduced on the northern continent. The Andes appear to be in the same line of force, at least the eastern range of this chain.

The portion of California visited under this survey presents many features of interest to the geographer and physicist, a few of which are possessed in common by the northern portion of the State, while the others are chiefly or wholly peculiar.

The topographical conditions of the State are simple, viz: The Sierra Nevada, determining its grand divisions—into a long valley trough lying along its western base, containing the only navigable rivers of the State, and between these vallies and the shore a series of hill ranges running almost parallel with the coast, commencing in latitude 41°, and terminating in latitude 34°. Such a disposition of surface on an eastern continent would produce much greater alternations of climate and temperature in the inland valley or coast hills than occurs in its present western position; or had it been placed further north, would have covered it with extensive forests, deep lakes, and noble rivers.

California is one of those few countries which are uninfluenced either in climate or soil by its neighboring Territory. No rivers roll westward into California, carrying the debris and detritus of a higher land to the sea level. The basin conformation of the country lying east confines its rivers to its own bosom, and the lofty heights of the Sierra Nevada prevent even the winds of the Great Basin from passing over. That range shelters California from the dry east wind which, in the winter months, would have reduced its temperature considerably, and protects it also from the more oppressive overheated air of the summer. The gentler slopes of the Sierra are to the shore, the abrupt sides inland; hence the waters roll in larger channels and with greater volume toward the west, and render the whole of the State a paradise of vegetation during the first six months of the year.

Owing to the greater height of the Sierra Nevada in the north, its summits are covered with snow many months of the year, the melting of which form the Klamath, the Sacramento, and American rivers, with their tributaries, besides a few lakes of large dimensions. In the southern half the Sierra drops down 2,000 or 3,000 feet, and in a warmer latitude are capped with snow only a few months; hence the rivers are feeble and dry up in summer, and the lakes partake of the nature of lagoons, being shallow, muddy, saline, and fugitive.

This condition of the water courses is aided by the climate of the south; there is no such thing as a distinct winter. The thermometer rarely goes down to 32°. The average winter temperature of the middle of the State (Sacramento) is 40°, produced by the prevalence of the northwest wind and the accompanying rain. That of the southern part of the State is 50°, which is only produced so long as the wind is north. Along shore, from Point Concepcion south, where the level plains are sheltered by the mountains from this wind, the winter months are a genial, pleasant season, during which vegetation is growing rapidly, and the only distinctions of the year are a wet and a dry season. During the rainy season, ploughing, planting, and all the operations of spring, are carried on. The whole of the rain of this period not falling at once, but at intervals, like "the former and the latter rain" of Judea, allow of the operations of the field being carried on with advantage during the interval of the rain fall.

The annual fall of rain in the central counties is about twenty inches. In the south it ranges from ten to twelve inches; as this quantity does not suffice to keep rivers running throughout the year, or to soak the soil thoroughly with moisture, irrigation is necessary during the early summer months. In the later periods of the year everything languishes for drought, and the valleys which blossomed like the rose in March and April with every wild flower, rare, beautiful, or fragrant, becomes, from July till October, brown, parched, fissured, and the abode of the grasshopper and the reptile. During October, sooner or later with the latitude, comes the first rain, and vegetable nature starts again into life and variety.

The coast mountains have some lofty peaks in their course north of San Francisco, but the chains are short and ill defined. South of that city, or from latitude 38°, they extend south through 4° of latitude until the eastern ranges become blended with the Sierra Nevada, and the western ones run out along shore, and reappear in the islands Santa Rosa, San Miguel, Clemente, Anacapa, with the minor islets. As many as four chains of the range run for some miles parallel, and, being remarkably continuous, they have but few breaks or passes; so that they form a perfect barrier, allowing none of the inland waters (save one, the Santa Maria) to escape by any other outlet than the northern termination of the ranges. Hence it is that San Francisco bay becomes the receptacle of so much of the river waters of the south. These chains, however, contain no such high mountains as the northern ones, and but two such elevations, as Mount Ripley, which is 7,500, or Mount Hood, 8,000. These are San Emilio, which approaches 9,000 feet, and the high mountain west of it, in the Santa Lucia hills, which is almost 10,000 feet high.

Southern California is remarkably subject to earthquakes. In the counties of Santa Barbara, Los Angeles, and San Diego, they are felt several times in the year; within the last six years the ascertained number felt amounted to fifty-nine, or more than nine shocks a year. There is thus convincing evidence that plutonic forces are not quiescent there; other proofs, however, exist in the but recently extinguished fires of the northern volcanoes, and the still open fissures in the southern chain, whence steam acid vapors, and even flame, yet occasionally escape. These forces, still in activity, have elevated the Cortes rocks, in 1853, as the result of a submarine volcanic action, whose total effect has been to elevate the coast mountains to their present level. Such an upheaval is never produced by a single effort, but by several successive elevatory actions, with long intervals of rest between, during which the incumbent but comparatively shallow waters flowed over the surface with a gentle current motion, and formed the deposits of sand and gravel, and produced the ancient terraced flats so numerous over the whole State.

The elevation of the Coast Range above the water level was an event much later in time than that of the Sierra Nevada. During the Eocene period the latter range must have had its crest considerably above water, and was uplifted, finally, after the Miocene period; but it is probable that during the whole of the Miocene period the Coast Range was altogether beneath the sea level. Anterior to the Quaternary period, the erupted rock tilted up their strata, which, perhaps, did not reach the level of the ocean surface, and upon these smoothed edges were deposited the unconsolidated clays and local drift. They had not, however, fully appeared above the surface of the ocean until the close of the Quaternary period. The elevated sea beaches found distributed over so large an extent of country, from north to south, at a level of from 100 to 150 feet above the sea, and containing species, all of which are now existing, show how comparatively recent is the final elevation of the lower lands of the State, and places the period of elevation of this range in the early portion of the Quaternary epoch. The plutonic rocks of the coast hills also attest the comparative newness of the land; pumice, obsidian, felspathic lava, trachyte, amygdaloidal greenstone, and serpentine. Volcanic rocks of the latest kind are those which are commonly distributed both in the form of axes and veins, or seams. Granite is also found, though not so extensive as a disturbing agent or an elevator of a mountain ridge. When found in place it is an older rock than those previously mentioned, being cut through and injected by them in many places; but the granite in the coast mountains is a modern granite, being either highly felspathic, passing into leucite, and even trachyte in many places, or it is hornblendic, and passes into a hornblende porphyry; micaceous granite is very sparingly distributed in southern California. The elevation of the Coast Range must have taken place from two points, one in the north and one in the south; the latter force commencing in the southern part of San Luis Obispo and the eastern of Santa Barbara counties, and thence extending north; as the upheaving force passed northward, its power became spent, and unable to lift the imposed strata; a similar action from the north, acting in a southerly direction with less vigor, produced an uplift, whose action ceased between latitude 37° and 38°. So that while the consolidated crust of the State was uplifted at each end, it was quiescent, or nearly so, in the middle; and the two forces acting against each other may have produced a rupture of the superficial strata, and even a depression of the surface below the sea level, in which the waters of San Pablo, Suisun, and San Francisco, have taken their resting place.

Depressions of the strata and fissures from east to west across the line of the mountain ranges are common along the Pacific, north of this point, latitude 38°, and extend inland even east of the Sierra Nevada. In the course of these depressions rivers run. The Klamath and the Columbia are examples; which rivers might possibly never have emptied their waters into the Pacific, but for this fracturing effect produced by opposing volcanic forces.

The upheaval of the Coast Ranges have brought to view only tertiary strata of the Miocene group and beds of clay of the Quaternary period. These beds are thicker and more extensively distributed in a connected series than anywhere else (known) on this continent. In this respect they rival or even excel the strata on the shores of the Mediterranean. It is interesting to trace the resemblance of form and outline of hills produced by similarity of geological circumstances, whether of formation or upheaval. Many of the scenes of California resemble those on the shores of northern Greece, Roumelia, northern Syria, and the Calabrian peninsula.

The strata known as "palæozoic," have not been found in the southern section of the State. It would be hazarding, perhaps, too much to say that they do not exist, although some circumstances might warrant it. The tertiary conglomerate has been found, in very many instances, within a few yards of the granite, and occasionally in actual contact. Those rocks, which are fossiliferous, are tertiary in character. There were but two varieties of rock found, perhaps, not of that age—primary and metamorphic limestone and gneiss; the former was found along the Sierra Nevada and the Cordilleras, which extend south into Mexico, and it was almost a marble, or it was found in the valleys near San Francisco bay, in contact with trap and serpentine. With regard to the gneiss, the writer is not inclined to class it with sedimentary strata.

This absence of palæozoic,or secondary rock, holds true only of California, south of parallel 37°; north of that line a secondary limestone, probably, does exist in the interior and littoral counties.

The elevation of the Coast Ranges has disclosed a series of middle tertiary beds, above 2,000 feet in thickness, possessing fossils in great abundance, some of the species of which are altogether new, and almost all of them new to the tertiaries of this continent, differing in their fauna from what are esteemed coeval beds on the Atlantic slope; showing that conditions of difference in the waters of both oceans of those periods existed then, though, perhaps, not so marked as now. This itself is remarkable, since at that period of the history of this continent, (*i. e.*, anterior to the elevation of California,) the Pacific ocean must have stretched inland over the Great Basin and Desert, and washed the base of the Wahsatch, or even of the Rocky mountains. The Sierra Nevada then existed as an island, or a series of islands; and the Pacific thus approaching 400 miles nearer to the Atlantic, which itself spread over the surface of the eastern Atlantic States, both oceans must have been nearer to each other, and had their conditions more alike. Yet they must have been sufficiently unlike to produce different varieties of a like species.

The upheaval of so continuous and lofty a chain as the Sierra Nevada could not have been accomplished without an elevation of the superficial crust upon the east as well as the west side. If, by that elevation, Tulare valley was cut off from its original connection with the country round the head of the Gulf of California, and so upraised as to slope to the Sacramento valley, it is not unreasonable to suppose that that action of elevation was propagated to the Great Basin, and that it was also gently lifted out of the waters of the deep. But the mode of elevation of the Great Basin is much more complicated: in Salt Lake valley it is above 4,000 feet over sea level, and on parallel 32° it is at that level, or only a few feet above; and thence north into Utah it rises by steppes, not by mountain chains, until it attains the upper level, each plateau forming a basin for its own waters. In travelling west, across these upper plateaus, the Sierra Nevada is not the lofty mountains as known in California, on account of the basin level being so much above that of the Sacramento valley. Several thousand feet of altitude are lost to the mountains when viewed from the basin. Something like this occurs in the steppes of Thibet and Tartary, where, travelling south, the Himalaya mountains are apt to be under estimated, because the plateau of the steppe country is so elevated; but, on crossing these mountains into India, the traveller descends several thousand feet, and attains a much lower level of land on the Hindostan side. So it happens in travelling through any of the northern passes of California, at Noble's or Carson's passes, the ascent is comparatively small until the summit is reached, when the descent is more sudden and much greater until the valley is descended.

Inasmuch as the elevation of the Sierra in the north of California and that of the Cascade mountains of Oregon is much greater than that of the southern portion of the Sierra, it might be supposed that the elevation of the contiguous crust would be in proportion. That if the elevation of the Sierra up to 7,000 feet was sufficient to lift the Colorado desert up to the sea level—as it now stands—then an elevation of the same Sierra to the north to an altitude of 12,000, or even 17,000 feet, might suffice to raise the Great Basin to the level of Salt Lake valley. The elevation of the northern Sierra is certainly sufficient to produce such an uplift, were its lateral force produced so far eastward. On parallel 32° the influence of the Sierra can be traced 100 miles east; further north, where it is more than twice as high, its lateral influence should augment in a corresponding ratio. Be this as it may, it is certain that, at a remote period (geologically) the basin country was receiving palæozoic deposits, both aluminous and calcareous, which were not made in waters of great depth, or far removed from the main continent. Perhaps the northern plateaus of the basin may have been more elevated than the southern, even before the upheaval of the Sierra. At present there is no good evidence to prove that the southern portions of California were circumstanced so as to receive any of the mud or siliceous deposits of the palæozoic age.

There are no phenomena in California referable to the period of the polar drift or ancient alluvium, when the transport of those large blocks or *boulders* occurred. This phenomenon, so well marked on the Atlantic coast of this continent, from the polar regions down to latitude 40°, by the carriage of the large masses of rock from distances more or less apart, without much regard to the intervening level, and across opposing bodies of water, but always from north to south, is totally absent in California from parallel 37° southwards. The prodigious force which was exerted to produce these phenomena, which could transport huge erratic blocks of stone from Newfoundland to Ireland, from the Shetland isles to Norway, from Sweden to Livonia and Prussia, from Canada to New York, and from northern New York to Long Island; this force, whatever it may have been, whether of ice of glaciers, or of current water, or of both, was not exerted. Over the extensive plains east of the Sierra Nevada, in Tulare valley, in the pleasant little oak valleys of the Coast Ranges, or on the terrace plains of the shore, not a single boulder is to be met with—not a stone from which the plough might turn aside.

This period of ancient erratic transport, the most ancient of the Quaternary or Supra-Tertiary epoch, known by the three phenomena of distant transport, northerly direction, and grooving and polishing of rocks, in latitudes north of 39° north, was apparently one of quiet in this State. Yet the mountain chains were elevated throughout the State at this period. The topography almost the same as at present, save that the whole plain country was below the water level; there were, therefore, elevated ranges from which the counties along the coast might have had scattered over their surface these blocks; but the Sierra Nevada has contributed no boulders upon these plains, nor is there any stone included in the terraces which may not be classed as belonging to those ranges immediately bounding the deposit.

Not that the whole Quaternary epoch was passed without producing its effects: denudation on an extensive scale, lacustrine deposits, immense deposits of clay, sands, and gravels, attest the long periods alike of action and of repose which characterize the later Quaternary period, when the effects were more local, and every valley and plain had its beds of gravel and clay formed from its mountain margins.

We have already adverted to the singular shore conformation, without an estuary or deep river indentation, consequent on the peculiar direction of the mountain chains. In connection with this, we may notice Mr. Dana's valuable reflections on the connection between deep shore indentations and the deposit of erratic blocks. He remarks of the former, that these deep gulfs or fiords are common in the higher latitudes, while they are wholly absent from the coasts of lower, temperate, and torrid zones. "Along the west coast of America they abound to the north above 48°, and to the south, in Lower Patagonia and Terra del Fuego, south of 48°, there are similar passages intersecting the land, and often cutting it into islands; but between these limits the coast has few bays, and fewer still of these channel-like indentations. On the eastern coast of the continent we observe the same general fact. To the north of the equator the coast is singularly even in its outline, until we reach Maine, north of latitude 43°, where, as may be seen on a good map, fiords become very numerous, and deep and complex in their long windings and ramifications. The same remarks will apply to the eastern continent. The fiords of Norway are well known, and this coast is a singular contrast to that of France, Spain, and Africa."*

The intimate relation between these fiords and the deposit of boulders has been observed by several geological writers, who have considered their formation as a part of the history of the drift period, having been formed by the grinding, polishing, and grooving action of the immense amount of broken rock carried down into the lower depths of the then existing seas. The rocks in the neighborhood of the Scandinavian fiords are worn off, polished, and scratched, effects which may be traced down even below the level of the sea; it is in the softer rocks that the deepest excavations occur. The lines of grooving are in the same direction with the fiords, and as these deep channels could not have been worn by the modern alluvia, or by existing forces, and as they have been produced since the tertiary era, the evidence of their production during the boulder period is pretty satisfactory. The absence of these two features—drift deposit and fiords—in the State of California, is an interesting illustration of the connection between geography and geology.

* Geology U. S. Expl. Exp., p. 675.

CHAPTER II.

GEOLOGY OF THE COAST RANGES.

Two different axes in.—Occasional blending of volcanic rocks.—Prevalence of felspathic rocks.—Age of the granites — Different strike of granitic and volcanic rocks.—Uniformity of elevation and deposit.—Climatic condition of the miocene period.—Mode of elevation of the coast range.—Grouping of the ranges.—Enumeration of the ranges, their direction and axial rock.—Extension of the ranges south into the sea.—Reappearance in the channel islands.—Examination of the coast soundings.—Connexion of the fossils of the various strata with each other.—Dissimilarity to European tertiaries of the miocene age not necessarily coeval in distant oceans.—Relation in fauna of the several beds of southern California.—Evidences of marine life and deposits.—Difficulty of reducing them to analogous Atlantic shore deposits.—Slight or doubtful development of palæozoic beds south of 37° north latitude.

Of these mountain ranges it may be remarked that the igneous rocks which form their axes are of two kinds, the granitic and the trachytic. These two species, although quite distinct in the mode of aggregation of the mineral constituents when taken in their extreme types, yet, when they approach each other, not merely in topographical proximity, but also in geological age, they merge these separate differences. This has been frequently observed in the survey. Epidote and serpentine have been found in the granites, and in the trappean rocks of Monterey and San Luis counties. In Los Angeles county, along the Sierra Monica, amygdaloidal trachyte, and red felspar porphyry, have been seen to merge into each other, and the latter change into a granitoid rock. In the San José mountains, San Luis Obispo county, this last change has been frequently observed; and in the San Emilio mountain it has been at times difficult to say whether the rock was a granite or a trachyte, the characteristics of either became so indistinct.

It may be remarked that, of the two classes of volcanic rock which correspond to the miocene period, that which has the *felspathic* type, as trachyte, trachytic porphyry, phonolite, obsidian, pumice, trachytic conglomerate, &c., is most commonly met in the coast mountains, or west of the Sierra Nevada; while the *pyroxenic* type, as basalt, dolerite, scoriaceous lava, &c., is not observed extensively distributed west, but eastward, as in the Mojave valley, and still more markedly east of the Colorado river it is very abundant.

The age of the granites of the Sierra Nevada and the Cordilleras in parallels 32°—34° is anterior to the eocene deposits, and posterior to the later palæozoic; the age of the Coast Ranges is posterior to the miocene.* Erupted, finally uplifted, at a comparatively late period in the history of our planet, it might be expected that the lines of direction of the forces of both ranges would be somewhat similar; they so far correspond as to have a common direction north and

* The writer desires that his ideas on the antiquity of California igneous rocks may not be misunderstood. The age of an axial rock combines the idea of its first upheave through the hardened crust, and, to some extent, the period of its *appearance above water*, though not necessarily the latter idea. The Coast Ranges were upheaved and uplifted above water posterior to the miocene deposit; but the Sierra Nevada were upheaved some thousand feet through the crust anterior to the eocene; the crested summit was, in all probability, from 1,000 to 2,000 feet above water during the miocene, and its final uplift was in all probability subsequent to the quaternary deposits on its slopes—both those of San Bernardino plains, and those of the Mojave valley.

T. A.

south. In the entire State there is no chain of mountains which runs east and west; but while the Sierra Nevada, in its southern portion, runs almost north and south, the chains of the Coast Range, in their south course, have an easterly trend of not less than 45°. On account of this deviation from the meridian course of the Sierra Nevada, the two mountain ranges appear to merge into each other about latitude 34° 30′.

It may be remarked of the Coast Ranges that the granitic chains lie more in the meridian than the volcanic chains, and where a granitic axis and an intrusion of pyroxenic rock, or of serpentine, trap, and amygdaloid occurs, then the latter, having a greater trend to the southeast, cuts across the granitic ridge. Hence it is that most of the valleys are triangular in shape; that they are of less size in the southern counties than in the north; and that they all apparently converge in the northern part of Los Angeles county. The serpentine and amygdaloid prevail as axial rocks in San Luis Obispo and Los Angeles counties, and give the direction to the chains.

The conditions of deposit of the various strata flanking the mountain ranges of California are remarkably uniform over large areas. Volcanic rocks pursue a course unusually constant in direction for hundreds of miles, and their mineral character differs but little throughout. The subterranean forces to which the country between latitude 37° and 32° was subjected, were, if not powerful to produce lofty chains, at least sufficiently prolonged to extend over 500 miles from north to south, without much loss of energy. All of these phenomena taking place while, as yet, the whole was a deep sea bottom, whose shore was several degrees to the east.

All the observed sedimentary rocks were of the post cretaceous period, so that this portion of the United States, while it is one which has emerged most recently from below the level of the sea to a height several thousand feet above it, is also interesting from the thickness of the tertiary deposits, rivalling those of Mediterranean Europe, and exceeding anything of the kind on the Atlantic shores. Nor is it the mere thickness of the deposit—the time of deposition unusually prolonged, as it must have been, since it bears the mark of a quiet deposit everywhere—which is alone interesting, but it is the variety and abundance of aquatic life which these beds have disclosed; species and varieties in endless profusion tenanted these waters, from the molluscs of mammoth form, as the ostrea of the Panza and Santa Margarita valley, to the foraminifera, whose tiny shells require the aid of the lens to recognize them.

The great distance apart at which these similar fossils are found indicate that the climate, and other conditions, as depth and temperature of the waters, must have been pretty much alike over the whole of the south of California; thus the polythalamous shells have been found at the town of Monterey, on the shore near Santa Barbara, and on the plains of Los Angeles, involving distances 300 miles apart. Considerations founded on the zoological characters of the molluscs of the Miocene period of Europe, have led to the belief that the temperature of that epoch approached very much to that of Spain and Italy at the present time, or a mean temperature about 66° Fahrenheit. As that temperature is almost the exact figure for a great portion of the area observed, it follows that there is little, if any, difference between the climate of the Miocene of Europe and the present period in those places; and since the drift of California is local, and not general, and there are no traces on the surface of rocks exposed, of scratching or grooving, no moraines, no polished rocks, (roches moutonnees,) no traces of glacier action, perhaps it may be asserted with safety that the climate and temperature of this region, from the Miocene period to the present time, has preserved a constancy and equality which latitudes more polar than 40° never possessed.

It is remarkable of the tertiary beds of the Coast Range that they all belong to the middle group, or to what is known as *Miocene* beds in Europe, and that no Eocene beds have been discovered in this survey. The fossils found in these beds approach, in some respect, the Atlantic Miocene beds in Virginia, and bear a remote resemblance, indeed, to the European beds of analogous position. Like the European strata of the Miocene period, these beds are destitute of vegetation, there being but feeble remains of sea-weed in the sandstones of Santa Barbara, and but one evidence of land vegetation in the remains of fossil exogenous wood, found in a boulder derived from the blue calcareous bed of the Sierra Monica group, the uppermost series of the whole. Such slight evidence of the existence of dry land, to any extent, appears to warrant the statement already advanced, namely, that during this period of geological history this portion of California was separated from the main continent by a wide ocean, occupying the region between the Sierra Nevada and the mountains near the Rio Grande. They must have existed as mere oceanic islands, whose vegetation, if any, was drifted away from where it grew. The Miocene group, wherever observed, appears to prove that there was less land above water then than at the period preceding (Eocene) or succeeding (Pliocene,) and the chief bulk of the vegetation is of that character which indicates a moist and warm climate.

Such a climate must have reacted sensibly upon the fauna of the period, and to this, perhaps, more than to any other cause, would be due the different forms of mollusc life which distinguish the Californian beds from any others yet known. The Virginian beds are its nearest representatives, but the latter were deposited in waters under latitude 37°, a difference of four degrees on the western side of the continent, not involving, certainly, much variation of parallel, but a vast diversity of climate, for, in the Miocene period, the Panama isthmus was under water, and the equatorial warm belt of water, flowing across the continent, warmed the western side more than it is at present, and by its not forming the Gulf stream, cooled the Virginian Miocene waters in a corresponding degree. Thus the difference between the two coasts was not merely in latitude, but in temperature. Much greater was the difference between the Californian and the European beds; besides a cooler ocean, the latter also was placed near latitude 47°, or fifteen degrees further to the north.

Deposited in waters removed from a continent by a large interval, the sediments subsided slowly and in order, and not having suffered much from subsequent denudation, excepting in the present river valleys, these beds have attained a thickness and importance which cause them to overshadow the tertiaries elsewhere on this continent, and to be regarded as one of the most interesting geological features of our western shores.

Partly from their lithological character, and partly from the arrangement of their fauna, the Miocenes of the Coast Range may be conveniently divided into three subdivisions, the upper, middle, and lower beds, whose total thickness exceeds 2,000 feet.

The absorption of the trappean and trachytic ranges of the coast into the Sierra Nevada, in Los Angeles county, previously alluded to, is only apparent, and arises from a false view taken of the course of elevation of the ranges. It is usual to trace a mountain range from north to south, because the map happens to have its north at top; it would be erroneous to consider that this was the order of upheaval of these chains; two circumstances would lead to the belief that the elevation occurred first in the south, and thence extended northward. The first of these is, that these ranges in the south are all loftier than towards the north or San Francisco, and not only the mountains but the valleys are on elevated table-land, from 900 to 2,000 feet in altitude. The second is derived from a study of the valley at the foot of the Sierra Nevada, known as

Sacramento, San Joachin, and Tulare valleys, all naturally one; originally elevated in one mass without much difference of level, it has since then undergone an elevation both at its northern and southern ends, raising it several hundred feet upwards at each extreme, and throwing the flow of its waters to the middle, where they would have accumulated and formed an inland basin sea, had not the same upheaval extended itself to the Coast Range, and by depressing these in the latitude of San Francisco and crushing the fractured edges together, left a chink through which the ocean might have found its way inward, and the inland drainage outward, whose long continued action at last wore for themselves the wide channels and basins of Suisun, San Pablo, and San Francisco. The same upheave which produced this alteration of level of Sacramento and Tulare valley, would also have raised each of the valleys to a higher level at their southern than at their northern end, and this is found to be uniformly so. The Salinas, Estrella, Santa Maria, Santa Clara, and every other valley (Estero excepted) slope northwards; even the open plains, such as those of Los Angelos and San Bernardino, are higher at the southern than at the northern end.

These considerations would lead to the belief that the commencement of upheaval and the point of divergence was south of latitude 34°. In that vicinity is the loftiest area of any extent south of San Francisco; and, as eruptive forces are most powerful at or near their commencement, we must conclude that the final elevating forces initiated in the south and travelled northward. Subterranean reactions are now going on with more intensity in the south than in the middle or north. Earthquakes are more frequent; warm springs, acid vapors, and bituminous exudations abundant. Indeed, the force is at present actively exerted at sea, southwest of the islands off Santa Barbara shore, throwing up immense quantities of bitumen in the oleaginous and semi-fluid condition. These islands themselves are the result of such forces exerted; and so far from viewing this portion of California as a sinking continent, it is more in accordance with geological facts to consider them as the dawn of a new land, which, when fully elevated, will have its mountain ridges and intervening valleys, like those of San Luis Obispo and Santa Barbara counties; its sandstones, argillites and bituminous shales; its lofty terraces and elevated sea beaches, like its predecessors ashore.

Having dwelt thus much on the character and age of the several ranges known as the Coast Mountains, it only remains to notice somewhat in detail their direction or trend. A few of these ranges are not continuous, but drop down into high rolling land for a few miles, rising up again and pursuing the same direction. This is very common in the granite ranges. Some of the serpentine ranges have their continuity only indicated by an elevated butte, which may be connected by the compass with its congener several miles apart. It is probable that at a former period these chains were more connected as a whole, and have since suffered from the effects of extensive denundations, their detritus forming the local conglomerates. The ranges may be enumerated in the order commencing at the east and passing westward—thus the range most eastward would be—

Division 1.—Granitic.

Group 1.—Gavilan, or Monte Diablo range.—This forms the boundary between Tulare valley and the coast. It may be traced from the Agua de Paleta, near the Cañada de las Uvas, to the Gavilan Mount, in Monterey county, southeast of the bay. In its course it forms the eastern limit of Estero plain, the elevated lands of Carizo and Panza, and the eastern border of the Salinas valley. It is a coarse felspathic granite in its northern, and porphyritic in the southern terminations. Its general direction, north 45° west.

Group 2.—San Emilio, San José, Point Pinos. These three series of mountains lie in the same direction and have the same mineral character. Very lofty in the south, where they give rise to the Santa Maria river; they form the eastern boundary of its valley, assist in giving rise to the west fork of the Salinas from the eastern boundary of Santa Margarita valley. South of the mission San Miguel they lie on the west side of the Salinas, where, as the Point Pinos mountains, the northern termination occurs at Monterey Bay. The course of the whole chain is about north 47° west. Granite, with epidote, adularia, and a serpentine paste intermingled with flesh-colored felspar.

DIVISION 2.—SERPENTINE AND TRACHYTE.

Group 3.—Santa Lucia range, the longest and most elevated chain possessing this mineral character, may be traced from the head waters of the San Buenaventura river to Punto Gordo, on the coast of Monterey county. Through a great portion of its extent it forms the west boundary of the valley of the Santa Maria river, separates Santa Margarita and San Luis Obispo valleys, and is lost by running into the ocean further north at Punto Gordo. Direction, north 46° west. Serpentine, trap, amygdaloid, trachyte.

Group 4.—The buttes of San Luis valley, San Rafael hills, near Mission creek; the Sierra at Carpenteria, and the protrusions at Rincon, on Santa Barbara shore, are points all in one line, north 48° west. Serpentine, trachytic lava.

Group 5.—Another series of buttes and low hills, extending from Corral de Piedras, San Luis county, by mouth of Arroyo Grande, near Napoma ranche, and the range at the head of Guadalupe Largo. Further south, the volcanic rock may be traced into the Saint Inez range, above San Marcus, and runs into the sea four miles south of the town of Santa Barbara. Direction, north 47° west. Trachytic porphyry, amygdaloid, trachyte.

Group 6.—First seen near Camp 19, then at head of rancho de los Alamos, and at San Marcus pass, where it runs towards the pueblo of Santa Barbara. This is one of the least clearly marked ranges; direction, north 47° west. Serpentine, trachytic, lava.

Group 7.—Punto Sal, Ranche Todos Santos, Alamos hills, Camps 21 and 24, on Arroyo Hondo, near Ortegas ranche. Direction, north 48° west. Serpentine, talcose clays.

Group 8.—An indistinct line of force observed west of Sal si Puedes ranche, at mouth of Saint Inez river, and lying seven miles east of Point Concepcion.

On the geological map of the State, annexed to this report, these lines of volcanic force are indicated by black lines, with the numbers appended.

It may be affirmed truly of the above ranges that they show a diminished intensity of elevating power as the list is passed downwards. This is certainly the case with the serpentine and trachyte ranges: No. 3 is both the longest and the loftiest, and No. 8 the shortest and the lowest. The trachytes abound more in the western and short ranges. Almost all of these outpourings of volcanic rock may be traced to the edge of the ocean; were the lines of force prolonged under water in the same direction, it would be found that some of them would pass through the islands lying off Santa Barbara shore. Thus 8, if prolonged, would run into Santa Cruz island; both 3 and 4 into Catalina; and either 5 or 6 (perhaps both) into San Clemente. It no doubt is along some of these lines that the bitumen escapes beneath the ocean, both inside and outside of these islands; and it may not be unreasonable to suppose that the activity of these forces led to the elevation of the islands themselves. An examination of the soundings which have been made, by orders of the Coast Survey, along the California shores to some extent prove this supposition, although, had they been made with that special object in view, the question might be settled.

The soundings show that, commencing at a point twenty miles west of Point Concepcion, and sailing in a southeast direction—S. 46° E.—a high ridge of land stretches along the sea bottom with deeper waters on each side; this direction would include in its transit the islands Santa Rosa and San Nicolas. Between Santa Rosa and Concepcion the crest lies sixty fathoms below water's edge; between Santa Rosa and San Nicolas the crest lies from eighty to sixty fathoms deep; the lead brings up yellow marl, sand, and mud. Along this line the water deepens in places to 100 fathoms, and to others no bottom at 105 fathoms. Santa Cruz is another island lying directly east of Santa Rosa; projecting a line in the same southeast direction, the island of San Clemente is covered. This island is an oblong shape, and lies in the direction of this projected line, while Santa Cruz is an island lying transversely with two mountain elevations, one on either end of the island, which is of a crescentic shape; the western limb is that which is connected with San Clemente by a uniform line of soundings ninety fathoms deep; the eastern limb is connected with a depth from eighty to ninety fathoms. East of this line lies the island of Santa Catalina. The waters between San Clemente and San Nicolas deepen considerably, so that even at 120 fathoms no bottom is reached. Even this happens west of San Clemente, showing that the land there has the same peculiarity of some of the Coast Ranges, namely, presenting bluff sides to the west, with more elevated valleys eastward; from this it is evident that there runs certainly two parallel ridges beneath the sea of Santa Barbara channel, which include in their line four of the islands; and there is little doubt that were a series of soundings instituted for the express purpose of determining the exact trend of the submarine ridges, that a third ridge would be found still more eastward, which would include the island of Santa Catalina.

To the west of all these ridges, and southwest of San Clemente, lies the Cortez shoal, a few years since a submarine volcano with fifty fathoms of water superincumbent; from this a line of sounding carried eastward to San Diego gives a continued average of seventy fathoms water. This appears to require a revision of soundings, for nothing short of a continuous coral reef could afford such figures; and while the general conclusion implies an elevated plateau stretching under water along the base of the peninsula of California, somewhat like the Los Angeles and San Bernardino plains to the northeast, yet it is difficult to understand how a line directly west from shore, in such a disturbed region, could give an even line of soundings.

It is worthy of note that the fossiliferous beds of the country examined are connected together by the presence of similar species; so that no one bed in any locality is without possessing at least *one* species common to another.

Thus the Estrella fossiliferous beds are connected with those of Santa Margarita by *Ostrea Titan*, *Cyclas permacra*, and *Balanus Estrellanus.* The latter fossil connects these two beds with the upper layers of Santa Inez. The *Natica Inezana* connects the Santa Inez and the Sierra Monica, and the *Pecten deserti* is common to the latter hills, and those at Carizo above Panza. San Rafael is connected to Santa Inez by *Pecten Meekii*, and by *Balanus* to the Inez, Panza, and Margarita fossils. *Dosinia* is found in the strata below the Panza and Margarita fossils, and *Arca* always above them.

Hinnites appear peculiar to Santa Margarita, *Pallium* to Estrella, and *Pachyderma* to Santa Inez.

There is no doubt that, when this interesting region of California shall have been better examined, greater similarities will be observed, and the now partially connected chain may be made a series of uniformly interwoven links; and what an extensively developed series of tertiaries will it not prove to be?—interesting, as well from the novelty of its fauna, as from its very great thickness, in which latter particular it rivals any known beds. It appears, from the examination of Mr. Conrad, that there is not one Eocene fossil in the whole number obtained; and as most of these beds reposed directly on primary or plutonic rock, there is no place for Eocene rocks, and it may yet appear that there are no Eocene beds in the southern counties of California. The eminent naturalist whose report is annexed classes the whole collection as Miocene, and in describing the Santa Inez fossiliferous beds, they have been, with some hesitation, likened to the faluns of Touraine. But the writer believes it to be neither safe nor useful to classify our tertiary beds synchronously with those of Europe. It must ever be remembered that tertiary deposits are but local, and cannot, on that very account, be over any extent of the globe synchronous. Their periods of formation and duration bear a certain relation of time to the strata upon which they lie; but it is not by any means certain that their periods of formation were to any extent cotemporary with congeneric beds in distant continents.

Almost all the strata are wholly of marine origin; and though not deposited in very deep waters, yet few were settled where brackish water could exist. The upper sandstone of the Sierra Monica, with its blue calcareous stratum, appears to be the only one which shows an estuary action in the minute shells of brackish water which are scattered through the mass, and in the fact of the occurrence of a small portion of dicotyledonous wood found included in a nodule of the limestone. A few casts of fucus in the brown sandstone of the Gaviote pass are the only distinct traces of marine vegetation; and of the flora of that period, with the above exception, not a single trace. The sandstones with lignites, which are found so abundant near the Bay of San Francisco, have had no representatives found out by the survey.

It is easy, in making out the geological relations of a country or district, to fill in the detail, and apparently so complete the work that but little would seem to be left desired in the future examinations. Does not the history of the science during each year disclose to us the fact, that new strata and even new epochs of geological history are discovered in localities where the number and frequency of observation would seem to have precluded either error or omission? A bed of thin power, perhaps a few feet of thickness, is the only representative of what elsewhere is a few thousand feet in depth. A bed of such attenuated proportions may easily be overlooked, and hence it may happen that while, as now in California, tertiary beds are declared to exist to the exclusion of the palæozoic strata, future explorations may expose to view all the representatives of our eastern continental slope. Yet this cannot do away or lessen the great fact disclosed in this survey, namely, that the tertiary period in California was by much the most prolonged, and that in this epoch three distinct periods are well defined: that of the deposition of the brown sandstones, with traces of lignite, as in the sandstones of Monte Diablo and Gavilan; the calcareous beds of the valleys, as at Santa Margarita; and the quartzose, bituminous and polythalamous beds of the coast. That these deposits follow each other in chronological order is evident, and may have their representatives, to some extent, along the Atlantic coast, and those who desire to connect periods of deposit may class the Californian tertiaries with those of the southern States; but as tertiary beds are but local deposits, and are produced by similar circumstances acting under similar conditions, it is, perhaps, hasty to conclude that the tertiaries of both slopes of the continent are coeval; there is only with certainty implied that the circumstances were similar; that the conditions and not the times were alike. When the different thicknesses of tertiary beds in different countries are considered, from the trifling and unconsolidated beds of Ireland and Sweden, to the extensive deposits of the northern shores of the Mediterranean, or the thinner beds of the southern States, with the more extensive ones west of the Sierra Nevada, it must be admitted that more time was consumed in the formation of the one than in the other. Both bear evidences of quiet deposition, and the rate of deposition might have been the same on both slopes; yet, as the Californian beds are much thicker, more time was consumed in their formation, and while their later beds were being formed, either there was a cessation of deposit on the eastern slope, or the Quaternary period had already commenced there.

Whether palæozoic or silurian be hereafter found in southern California or no, it must, however, be admitted that these beds are of slight thickness; for it would not be easy for beds of carboniferous limestone, having the thickness found at the slope of the Organ mountains or on the Pinaleño ranges, in New Mexico, to have escaped observation, especially as they were sought for, nor could the more powerful Devonian sandstones of Calitro and the Mogollon mountains be overlooked; if such beds are represented in south California, they must have thinned out very much as they passed westward; if they exist at all beneath the Colorado desert and lower steppe of the Basin, (the Mojave Basin,) the upheavals have not been sufficiently pronounced to disclose them; but there have been many granitic exposures in south California, and not one position where the older stratified beds can be said to be in place and unaltered.

CHAPTER III.

SANTA CLARA VALLEY.

Position and boundaries of the Santa Clara valley.—Structure of the hills bounding the sides of the valley.—Subsoil and strata of the valley.—Artesian wells in.—Depth of the quaternary clays.—Climate and productions.—Fruit orchards.—Cereals.—Productiveness of the soil.—Cinnabar mine of New Almaden.—Position of the mine, village, and hacienda.—Geological relations of the ore.—Method of mining.—Quantity extracted.—Operations at the hacienda furnaces.—Mode of charging.—Unhealthiness of the operation arising chiefly from unskilfulness in the conducting of the processes.—Recommendations for remedying it.—Value of the shipments.—Pajaro valley.—Extent and character.—Geological structure.—San Bonito river, terraces upon.

The Santa Clara, or, as it is sometimes called, the San José valley, is of a triangular shape, with its base to the north, where it is intruded upon by the Bay of San Francisco. Its length is about thirty miles, when it narrows by the convergence of the two ranges of the Coast mountains—the Monte Diablo and the Santa Cruz mountains. At the south it is closed by the Llomas Muertas, a small chain given off from the Gavilan range. Properly describing the valley, would be to include the whole Bay of San Francisco as occupying all the lower level, and its southern borders would be the hills of Alameda and Contra Costa on the one hand, and the rugged peninsular of San Francisco county on the other. These latter, including the Monte Bruno, are chiefly trappean and serpentine rocks, with diallage rock, talcose slates, and occasionally masses of hornblende schist, and average from 1,500 to 2,000 feet in height.

The range on the east side of the valley is the continuation southward of the trappean and laval uplifts on the west side of the granite of Monte Diablo, and is more elevated than the Santa Cruz range. The sedimentary rocks, uplifted by the plutonic action, are conglomerate grits and sandstones, with a very high dip to the west, and which extend from the shores of the Bay of Suisun, the Straits of Carquinez, and the eastern portion of the Bay of San Pablo. The sandstones are in places cut through and injected with lava and quartz veins, and in places merely hardened and rendered metamorphic.

The valley bottom is composed of beds of heavy alluvial clay, of considerable depth, which repose on the beds of sandstone just adverted to, which, dipping west under the valley, rise again on the opposite side of the Santa Cruz mountains. The oak which grows on the plain is of a dwarfed character, and only suitable for fire-wood or fencing. But little timber is found on the Santa Cruz hills.

The lowest portions of the valley below the towns of San José and Alviso, embracing the head of the bay, is a continuous mud flat, which reaches round the east margin of the bay into Alameda county. It grows only salt marsh grass and rush in its wet condition, but when drained and cultivated, as has been done on the east side of the bay, it is found to be one of the most productive of soils. Miles of the bay shore might be enclosed, drained and reclaimed, and be made suitable for any crop, for the presence of rush and salt grass is an indication of a soil well charged with vegetable matter.

The subsoil and underlying strata of the valley are well supplied with water. Artesian borings have been made in several places in the valley, near the town of San José, with signal success, in having reached abundant supplies of good water. In two borings through the alluvial clays, to the depths of 80 and 140 feet, the water rose to the height of 20 inches above the valley level. These clays are mostly of a yellow color, and in great part derived from the degradation of the tertiary sandstones flanking the ranges on each side. The lower beds are a bluish clay, resembling those of Los Angeles valley, although not by any means so deep. At 120 feet below the surface the sand rock has been reached in the centre of the valley, near the town of San José. It is not likely that these unconsolidated beds have a much greater thickness in any other part of the valley. Through these loose deposits the Caoti, Guadalupe, and other minor streams which water the valley, cut their way, wearing a channel 15 and 20 feet below the surface. The bed of the Caoti is filled with pebbles of obsidian, trachyte, and lava, derived from the hills on the east. Mixed with these were fragments of chloritic and aluminous slate, from the same sources.

Owing to the rapid travel through this valley, nothing but a slight reconnoissance could be made of the nature and disposition of the strata. The sandstones are a continuation of those of the Salinas valley and Gavilan, and therefore probably of the same age. These are noticed when describing that valley.

This valley may be called the garden of San Francisco. Located at the extremity of the bay, so that the products can be transmitted cheaply to market, it has every advantage which position and climate could confer upon it. Defended by the Santa Cruz mountains from the sea shore, it is freed from the abruptly chilling influences of the sea breezes, yet deriving great advantages from the vapor wafted over the tops of that range, and which are, to some extent, seized upon and appropriated by the higher hills east of the valley. It receives abundant supplies of water, and enjoys an equable and warm climate, with a good deal of moisture. With these essentials of fertility, it adds a soil which partakes of the nature of a sandy loam, and appears capable of raising every cereal and useful plant. The orchards and nurseries established here are remarkably productive. That of Mr. Jesse Beard, near the Mission, in the original Mission orchard, has a farm of over 150 acres under cultivation besides the orchard, which contains, besides several thousand young trees in rows, 1,800 apple trees, 1,000 peach, 200 cherry, 250 plum, with pear, quince, fig, and grape trees. The peach trees have been remarkably productive, yielding three, four, and even five to a cluster, and some trees bearing hundreds of double peaches. The fig trees attain a height approaching fifty feet, and from two and a half to five feet in circumference, with the leaves eighteen inches across, and some fruit measures eight inches around. The pears hang in clusters or ropes from the branch, bending it over, making the tree resemble a willow. The Jullien variety is much cultivated.

Mr. Lewellan has planted an orchard near Mr. Beard's, which, among other fruit trees, contains over 6,000 apple trees, and nearly 9,000 trees of all kinds. The "tune" cactus is cultivated here, and grows well sixteen to twenty feet high.

Wheat has commenced to be extensively cultivated in the valley. The "California bearded wheat" and the "Chile" are the two varieties, of which the latter appears to grow best, being more free from smut. It is a white grain of a good size, and averages forty bushels—running up to fifty bushels per acre; but this is esteemed by no means a large crop. In Alameda county, Messrs. Hawley & Cornell, of Union City, have estimated their yield of Chile wheat as fifty bushels; Australian wheat, 40; barley, 75; and oats, 100 bushels per acre.

In connexion with the Santa Clara valley may be described the quicksilver mines of New Almaden, a village situated among the lower hills of the Santa Cruz mountains, about twelve miles southwest from the town of San José. To reach the mine a road leads from the valley, entering a chain of low sandstone hills which form the edge of the Basin valley, behind and above which the town and mine is situated; the "hacienda," or works with the furnaces, are near the town, which is about 400 feet above the valley—950 feet above the hacienda is the mine. The mountain mass in which the latter lies is of serpentine with chloritic and talcose slates. Seams of limestone occur intercalated in threads, and masses of metamorphic limestone, twelve feet thick, occur on the ascent, before the serpentine is reached; the limestone is whitish, semicrystalline, and without fossils. The trend is northwest and southeast, which is also the direction of the metalliferous veins, (if this term be appropriate;) the dip is variable in inclination, but always to the east. The ascent to the mine is by a steep winding road 6,000 feet long. The mine is of comparatively old date, having been worked by the Spanish and Mexican settlers, and opened originally by them. Traditions are current of the Columbia river Indians having wrought there. Stone hammers and chisels of basalt, and aboriginal skeletons, have been taken from the openings made in the early diggings, which lie 100 feet above the scene of present operations. Doubtless the old site was pitched upon, as the ore crops out in its immediate proximity.

The entrance to the present mine is by a long tunnel, about eight feet wide—the width of the vein; this is cut in the serpentine and talc slate, which is here intruded on and altered by trap. The talc slate is the most abundant rock, but the serpentine and trap are associated with it in the mine. The water which percolates through the roof and sides of the tunnel deposites carbonate of magnesia in amorphous white incrustations on its floor. The tunnels extend several hundred yards into the hill and then diverge in nine different directions, as the ore is found in pockets in the vein, and not in a continuous or regular seam, hence the working turns sometimes suddenly round and upwards, so as to run in another exploration. On the sides of the adit the cinnabar may be seen intermingled in the trap and serpentine, and some decayed portions of this rock removed yield 10 per cent. of ore. The diffusion is in the serpentine rock, the trap is the metalliferous vein rock—the average yield of which is 20 per cent. When a pocket, however, is tapped, the ore is considerably purer, running up to 80 per cent., and an average of the whole yield of the mine would be 50 per cent.—the extremes being from 25 to 72 per cent. One hundred tons are removed weekly by the miners, who are native Californians and Indians. It is removed in trucks running on a tramway along the tunnel from the gallery to the sorting yard. The sorting is performed in the usual way by the hammer. Women as well as men being employed, the latter chiefly carrying the sorted ore into heaps and packing the mules with baskets of sorted ore to be carried down to the hacienda. On account of the steep descent, the sure-footed mule is preferred to the horse, and a load of 70 or 80 pounds is placed in each basket, on either side of the beast, which constitutes its ordinary burden. The delivery of the ore might be accomplished more effectually by taking advantage of the descent, and employing one or more "chutes" instead of quadrupeds or sometimes Indians, as formerly occurred; a wagon and horse has been recently introduced.

The gangue stone associated with the cinnabar is quartz, forming geodic cavities; sulphate of barytes occurs crystalized in some seams—the sulphuret is found in masses, toward which the quartz veins lead; thus the thin and thready part of the vein may be found filled with quartz, while, as it widens, the sulphuret is found to take its place, and that, most frequently, suddenly, and not by gradual substitution ; external to the quartz vein is a layer of oxide iron (limonite) into which the sulphuret sends cross filaments- the limonite bounds the quartz vein on both sides, which latter presents the appearance of a succession of deposits out of a siliceous solution into which the cinnabar was carried, and, by its superior density, supplanted the silica in the even line of deposit.

The trend of the small range in which the cinnabar vein is located is N. E. and S. W., and the slate rock and serpentine have a westerly dip. Felspathic trap cuts through this, and is accompanied by quartz, and the mineral accompanies the quartz and the trap. The vein is vertical, or nearly so, and is about eight feet wide at the level of the adit. Crystals of cinnabar were not observed while examining the ore in place, nor could it be ascertained that metallic mercury was found associated with the sulphuret.

The furnaces at the hacienda are 13 in number. The retorts are of brick, about 5 feet long and 12 inches diameter in the clear ; at the further extremities three flues connect with iron stove-pipe chimneys, leading to a spacious cool chamber, and are cooled by water playing on their outsides, so as to condense the volatilized mercury.

The duration of the charge in the retort is six hours, and the fuel used is the wood from the mountain. Under the strong heat the ore, sulphuret of mercury, is first volatilized and then decomposed, the sulphur passing off and the mercury retained by the cooling of the flues which lead to the receiving chamber. It is obvious to any one acquainted with metallurgic operations that some of the mercury is lost by this process ; this, in fact, occurs to a large extent, producing waste of ore and ill health among the furnace men, with whom salivation is no uncommon occurrence, followed by tremblings and occasionally total paralysis, and in one noted instance by insanity. On account of its unhealthiness, the men are allowed to work only two weeks connectedly at the furnaces, during which time they receive double pay. On the other hand, the miners are a healthy class, never being compelled to drop work from any effect of mercurial poison, so that the sickness of the furnace men is due to the escape of mercury from waste in conducting the processes. The present mode of sublimation by heat alone is adopted from supposed motives of economy, but it is a matter of little doubt that more is lost than gained by that method of saving.

Under the former management of the works iron retorts were used, and lime used along with the cinnabar to reduce it, by which an economy of fuel was obtained, as the sulphur is separated, from the mercury at a lower temperature in the presence of the lime; but, since the hacienda has come under the control of Mr. Halleck, of San Francisco, clay retorts have been substituted for iron, as the latter were found to be much corroded by the sulphur escaping, and the use of lime omitted altogether, thus entailing a much higher heat, and, as wood is not plentiful, an increased expense. Mr. Halleck thinks that, owing to the difficulty about obtaining and repairing iron works there, that the balance is in favor of clay retorts and excessive heat, as the use of lime is prohibited in clay vessels on account of its fluxing the retorts ; the whole of the cinnabar is never reduced by heat alone, and owing to the high temperature, both the vapor of metallic mercury and some of the sulphuret escape decomposition, are volatilized, and pervading the atmosphere of the works produce the usual symptoms of poisoning by mercury, as salivation, paralytic tremblings, and disease of the brain, terminating in insanity, which symptoms are only exhibited in the hacienda.

There is no doubt that by proper management of the furnaces these mercurial poisonings might be avoided, and the occupation of furnace-men, unhealthy at the best, might be rendered less destructive to health. The practice at New Almaden is that which is adopted in the mines at Idria, (Carniola,) which does not yield more than an average of eight per cent. of metal; at Almaden, (Spain,) a roasting is all that is performed, which volatilize the mercury and separates the sulphur as sulphurous acid. In the Palatinate and at the Duchy of Deuxponts the ore is mixed with caustic lime, and distilled in iron vessels. This is the proper treatment for rich cinnabar ores, which, if subjected to heat alone, suffer much loss from the escape of undecomposed sulphuret carried off by the flues, and also from some sulphuret remaining undecomposed in the ore. The refuse of these works contains undecomposed cinnabar, and in some specimens of waste as much as ten per cent. has been found; this is equivalent to a loss of nine per cent. metal, as the pure ore yields 86 per cent. of metallic mercury.

Notwithstanding this double loss from faulty distillation, the yield of metallic mercury is, annually, very great. The total shipments of quicksilver from San Francisco, for the year 1853, was 18,800 flasks, (each flask 75 lbs. weight,) or 1,410,000 lbs., valued at $683,189. In 1854 the number of flasks was 19,320, or 1,449,000 lbs., valued at $724,500. In the first quarter of the year 1855 the export was 6,056 flasks, in the second quarter of the year 1855 the export was 5,082 flasks, making for the first half of 1856 a total of 11,158 flasks, of 75 lbs. each. The export was mostly to Valparaiso, Callao, San Blas, and Hong Kong. Besides this a quantity was set apart for the home market, for amalgamating the gold. It would appear that the mine is worked merely to supply the demand, without producing as much as the works could profitably do and then seek for wider markets. The actual produce of the works is from 30 to 35,000 lbs. of mercury weekly, or perhaps a maximum of 1,700,000 lbs. per annum, which, with the above export, would leave 250,000 lbs. for the home market.

According to the foregoing calculation of loss in the refuse of the furnace, it would appear that the enormous quantity of 155,000 lbs. of mercury was wasted in the year 1854.

PAJARO VALLEY.

The Pajaro valley is a small alluvial plain which opens upon the coast of Santa Cruz county, and runs at nearly a right angle to the Santa Clara valley, between which and the Salinas river it is situate. Through the valley the Pajaro creek runs in its westward course from the mountains to the ocean. The valley is of a triangular shape, broad at the shore and running nine or ten miles inland, where it is cut short by the Llomas Muertas, or foot hills of Gavilan, which separates it from the Salinas valley. On the north it is separated from the valley Santa Clara by the Santa Cruz mountains. The lower portion of the valley is swamp land from the influx and infiltration of sea water, forming lagoons near the bay. The land beside and above the immediate river bed is of great fertility; the bottom of alluvial sands and clays derived from the soft Quaternary sandstones which form the low hills bounding the valley. These appear almost horizontal, but have a small dip to the west, which is better observed at a distance. These strata have undergone no disturbance (by contact) since their deposition, having been elevated slowly a few feet in one unbroken mass, and belongs to the more recent elevations of the tertiary period in California. The basal rock is a felspathic granite, the debris of which is intermingled with and enriches the sandstone detritus. The junction of the recent sand rock with the granite was not observed. In places the river cuts through heavy clays between thirty and forty feet deep, near the Ranche de Los Anges.

The upper portion only of the valley was crossed on the road to San Juan. The Santa Cruz hills on the northwest were 1,500 feet high near their termination, while the Llomas Muertas were not more than 300 feet high. At the junction of the Arroyo Pescadero with the Pajaro diallage hornblende rock is exposed; this is a spur thrown off from the Gavilan with a strike north a little east; west of this, on the right bank of the Pajaro, a stratum of limestone, metamorphic, and about thirty feet in thickness, is exposed; it is a hard, dark, flinty rock, without any fossils apparent. From the low hills described, the fossil *Venus Pajaroana*, (Conrad,) a Miocene fossil, was obtained. As the beds containing *Dosinia*, which are found so plentifully on the Salinas, were not observed here in relation with this fossiliferous bed, it is impossible to connect the order of position.

Leaving the Santa Clara valley, the Arroyo Bonito was crossed before entering the valley of San Juan. This stream flows through a small valley bounded on the north by the termination of the trachytic range, which formed the east side of the Santa Clara valley, and on the south by the low hills alluded to, which approach the river from each side, forming small but beautiful valleys, which are terraced on both banks. That on the right or east bank is somewhat higher than the opposite one; both extend along the river for eight miles, or so far as the valleys were examined, and at the point where the river was first touched the height of the terrace was forty feet; a few miles further up it did not appear to be more than twenty feet, the river having worn its valley down at the lower end; the upper surface of the terraces were smooth, with a few drift pebbles on the surface, but no beds of sand or apparent shore action.

CHAPTER IV.

SALINAS RIVER VALLEY.

EXTENT AND POSITION OF THE VALLEY.—GRADUAL SLOPE.—CHARACTER OF THE RIVER.—NON-NAVIGABILITY.—GEOLOGICAL CHARACTER OF THE VALLEY.—ALLUVIAL PLAIN, WITH TERRACES OR FLATS.—NATURAL VEGETATION AND PRODUCTIVENESS OF.—WESTERLY WINDS IN THE SOUTH OF THE VALLEY.—EFFECT UPON THE CLIMATE.—THE GAVILAN HILLS.—STRUCTURE AND DISPOSITION.—POINT PINOS RANGE.—INTRUSION OF TRAP THROUGH THE SANDSTONE.—METAMORPHIC EFFECTS PRODUCED IN.—SANDSTONES OF THE SAN ANTONIO HILLS.—STRUCTURE AND FOSSILS OF.—RECAPITULATION AND OBSERVATIONS UPON THE GEOLOGY.

THE valley of the Salinas river is a plain of great extent, being almost 100 miles long and in places nearly 20 miles wide, in general narrowing as it advances southeast, until in places it is not more than half a mile in breadth. Its northern portion lies in Monterey county, stretching, as it advances south, into San Luis Obispo county. Like the Santa Clara valley, it is also of a triangular shape, presenting its base N.N.W. toward Monterey bay, upon which it opens without any intervening ridge, the slope of the valley being so slight and its surface so much depressed at the level of the tide that much of the low land is swampy and overgrown with tule, rush, willows, and marsh vegetation, through which the river lazily winds its way, forming small lagoons, from not having force enough to sweep its waters into the bay. The lower 60 miles of its course is over the gradual slope of the plain, which does not exceed 20 inches to the mile, so that its waters are easily arrested; further up, south of San Miguel mission, where the valley narrows and the river in places cuts through a granitic region, its fall becomes more rapid; owing to this slight momentum, sand bars are heaped up by the ocean at its debouche into the bay, which completely destroys its navigation.

It is not possible to navigate this river far up, the depth, 40 miles from its mouth, being under three feet in its deepest part, where its width might be nearly 100 yards; but when it is considered that this is the only river in the southern section of the State which does not cañon through mountain passes to reach the ocean, and which rolls through an extensive and fertile valley, no doubt, as the population fills in, some efforts will be made which will both free the bars from its mouth and narrow the area covered by the lagoons and marsh in the lower 15 miles of the plain.

The whole valley may be described as an ancient alluvium derived from the degradation of the granitic, serpentine, chloritic, and sandstone formations, which go to form the mountains on either side; above this alluvium, and intermingled with its upper layers, is the modern detritus and fluviatile additions. But how little has been accomplished by modern action in either denuding or covering up the ancient alluvium, is evinced by the smooth surface of the plain, running even up to the base of the hills, and by the remains of the terraces, both upon the valley surface and upon the edges of the hills a few yards above the present base.

The lower 60 miles of this valley is not a plain of uniform level, but a series of low, flat terraces which extend in a north and south direction, and require to be ascended when the valley is crossed from west to east. The lower terrace is a fine stiff clay, occupying the west side of the valley, and containing the present bed of the river in the lower part of its course; it is nearly five miles wide; above this rises the second terrace to a height of 10 feet above the first; it is also a fine stiff clay with less vegetable matter, and of a lighter color than the preceding; its width is a little more, about six miles in breadth; the third terrace lies at the slope of the Gavilan range, is about five miles across in its widest place, and is not so level as the other two terraces. It is covered over with the debris of the volcanic rocks and sandstones, and is the least fertile; wild mustard covers it to some extent, but its chief growth is a coarse grass. From the silicious character of the soil, it does not seem capable of producing vegetation in the abundance which prevails on the lower levels. Much of the lower plain is covered by the wild onion; cotton-woods grow on the river bank, which is only 4 to 10 feet below the level of the lower terrace; the bed of the stream is a fine white micaceous sandstone, which forms quicksands, and renders the fording of the stream very dangerous.

The capability of production of the lower terraces is very great when put under cultivation. At Mr. Hill's farm near the town of Salinas, sixteen miles east of Monterey, sixty bushels of wheat have been raised off the acre, and occasionally eighty-five bushels. Barley, one hundred bushels, running up to one hundred and forty-nine bushels, and vegetables in proportion. In December, (the time of visit,) these plains were crowded with wild geese, cranes, and brandt. The geese are in such multitudes as to darken the air, and cover hundreds of acres when they alight.

During most of the stay on these plains the winds blew from a southerly point, accompanied with cold and rain; but when the wind shifted round north and west the rain ceased, and a curious phenomenon presented itself—that of immense volumes of clouds pouring into the valley from off the sea, and, entering it at its lower portion, rolling along the plain and collecting on the hill-tops of the eastern side, depositing its waters there. Such winds blowing over the lower valley through the funnel opening at the Bay of Monterey, always occur in California, under similar conditions, *i. e.*, whenever there is an opening in the littoral chain to allow the shore winds access into the interior, the inward current being produced by the ascent of the overheated air of the plain, leaving a partial vacuum, which the sea breeze rushes in to fill. In such places a land breeze prevails at night. The influx of such cold winds, charged with moisture, lessens the mean temperature of the summer of these plains, while at the same time it adds very considerably to the fertility of the soil, which at times would be almost reduced to barrenness from the drought. In several places on the middle terrace the soil was cracked in fissures a foot wide, some yards long, and 3 or 4 feet in depth, the result of the excessive summer heat on a plastic clay.

The Gavilan range of hills forms the eastern boundary of this valley. This range at its northern part is essentially granitic, flanked on its west side by metamorphic limestone, (crystalline carbonate in places,) 300 to 400 feet in thickness; lower down, the foot hills are made up of a series of soft sandstones, which extend in an almost straight line from the mouth of the Pajaro to the Mission San Miguel, a distance of eighty or ninety miles. These sedimentary beds dip towards the valley, or in a southwest direction, and form the true bottom of the valley, having been reached at the depth of 40 feet in sinking a well near Mr. Hill's. These sandstones also form the low hills upon the west side of the valley, where they constitute the base of the wide mountain ridge, here one of the coast ranges. This ridge, which commences at Point Pinos, the south point of Monterey runs in a southeast direction, and approaches the Salinas river fifty-five miles from its mouth, has a central axis of felspathic granite, coarse-grained, and of a bluish tint on a fresh fracture, owing to the presence of adularia. This rock, which occupies only a few miles of the surface at the shore of the bay, as the mountain rises to a greater elevation further south, also covers a greater width and forms the highest summits of the range, which exceeds 3,500 feet; as it passes south it becomes more hornblendic and magnesian in its character. East of the granitic axis a mass of slaty, serpentine, and trappean rocks is protruded, forming a second ridge running a parallel course, whose altitude does not reach that of the granitic chain, but which, from its proximity to the plain, hides from the latter the granitic hills, and presents to view its sharp and angular crests. As this igneous rock runs south it sends spurs out into the valley, which, upheaving the later formed strata, narrow the plain so as to reduce it to 2 or 3 miles broad, 10 miles north of Mission San Miguel, and south of that to lessen it merely to the condition of the river bed without a lateral plain.

The sandstones and overlying beds have been both partially elevated and cut through by these serpentine and trappean rocks; in places the sandstone is hard, rings to the hammer, and has a slaty appearance. A few miles north of the Mission San Miguel, trappean dykes cross the road, cutting the sandstone at an oblique angle to the line of strike. In the upper beds the calcareous strata are separated by a quartzose bed, 4 to 10 feet thick, which presents the appearance of agate and opalescent quartz veins, 1 to 2 inches thick, and separated a few feet from each other; three and sometimes four of these veins occur in the sandy bed; these silicious veins are in places accompanied by serpentine and talcose clays which tinge the edges of the veins green; when any portion of this vein stone is removed, it is found to be intersected by lines of former fracture cemented anew, giving a pretty agate appearance to the various tints of the quartz lines. These veins mostly correspond to the plane of deposition of the strata in which they are included; in a few instances they have been seen cutting the strata through at a slight angle. The presence of these veins serve, from their hardness and readiness to recognize them, as a good mark to determine the presence of the upper fossiliferous beds. In themselves they are the evidences of the existence of thermal waters highly charged with soluble silica traversing fissures in the strata and insinuating the fluid between the laminæ of deposition. These layers were first observed in leaving the Salinas and ascending the hills in which the San Antonio river heads. Here a better view of the constitution of the Point Pinos chain was had than elsewhere below, when, on account of the width of the plain, the road lay along the river side away from the mountains.

South of the Mission Solidad, which lies 35 miles up the valley, the mountains converge considerably, and the low foot hills spread into and narrow the plain. The diluvial clays are deep, often more than 40 feet exposed. The yellow sandstones which, from Hill's ranche for 30 miles southward, is observed to rise up from the valley with a gentle slope, now disappears, and a whitish argillo-calcareous rock takes its place; it is probably an upper stratum of the series brought to light by the lesser slope. The paste of the rock is soft, friable, and easily worn down by the elements; of a slightly green tint, calcareous, and very full of casts of dosinia, venus, natica, &c., (*vide* Mr. Conrad's report,) many of which were very imperfect; a few pecten impressions were intermingled; small masses of this rock were scattered over the terrace and the plain beneath. The observed thickness of this bed was about 50 feet, its whole depth not being exposed. On crossing the divort* between the small stream, a tributary of the Salinas, and the

* "*Divort.*"—This word expresses fully what no other word at present in use does. The word "divide" is not etymologically applicable, as it does not convey the idea of altitude as the cause of separation; while the word *divort* implies elevation, the cause of the "divortia aquarum"—whence its derivation also. It is hoped that this expression will meet with favor and application.

waters of the San Antonio, this bed was found to occupy a large surface and to be the uppermost rock. Its dip, when first observed, was to the southwest, so that it lay on the west or Pacific slope of the Point Pinos chain, which is here a series of low and broad hills. Underneath this whitish clay rock lies a bed of conglomerate, made up of a clay paste cementing rounded and broken pebbles of prase, hyalitic, jaspery quartz, obsidian and serpentine. The observed thickness of this conglomerate was 80 feet. It contains no fossils. Below the conglomerate a reddish sandstone grit was observed. This grit is one of the beds which repose on the east side of the range, and dip under the Salinas river, and rises up again on the sides of the Gavilan range. This constitutes the whole section of stratified rocks. The axial rocks did not appear exposed, but the arroyos brought down, beside serpentine, obsidian, and trap, broken angular fragments of gneissose rock and felspathic granite. So that a section of these hills would afford the following details:

Igneous rock.—Granite, gneiss, serpentine, obsidian, trap, in veins.

Sedimentary rock.—From below upward: Reddish sandstone grit; conglomerate green, quartzose; whitish green calcareous and fossiliferous beds, in brown sandstone, with *Dosinia* and *Pecten.*

A section of the San Antonio hills and Salinas valley is given on Plate I, figures 1 and 3.

The whitish green calcareous rock is met the entire length of the chain for 30 miles, terminating a few miles south of Mission San Miguel, where they can be traced passing up the Estrella river, and forming the side hills of the river bottom upon which the terraces are placed.

The fossils found in the sandstones on the west side were: *Dosinia Montereyana, Dosinia Montana, Dosinia Subobliqua, Dosinia Longula,* (*vide* Mr. Conrad's report;) which extended from the Salinas river, at Mr. Hill's, at the north extremity of the valley, to near the Mission San Miguel, at the south end. Ten miles south of the junction of the Estrella and Salinas rivers the valley of the Salinas may be said to terminate. The granitic rocks and sandstones of the Point Pinos chain cross the river and form the western boundary of that stream for some miles further south.

The granitic rocks at this point are low hills, flanked by the sandstones, having a slight dip to the southwest. By following the course of the river, which here comes from the S.S.E., a small valley is reached—the valley of the Mission Santa Margarita.

The geological structure of this valley was obtained very imperfectly, partly on account of its great size and the rapid transit over it, but chiefly on account of the fogs, which for some days so completely hid the plain as to render everything further off than 50 yards wholly undiscernible. Fossils similar to those found on San Antonio hill slopes were found in the bed of the river near Mr. Hill's ranch; so that this upper layer of the sandstones of the Point Pinos range extends the whole length of the valley on its west side. They are, however, inferior to the beds containing the Ostrea and Echinoderms of Santa Margarita valley.

CHAPTER V.

SANTA MARGARITA VALLEY.

Extent and limits of the valley.—Its beauty and fertility.—Geological structure.—Character of the granite.—Disturbed rocks.—Trap protrusions.—Stratified rocks of the valley.—Order of position and nature of the beds.—Nature of the fossils included.—Relative position of the fossils in four beds.—Relation of position of the beds of this valley with those in the Salinas valley.—Summary of the observations on the valley.

The valley of Santa Margarita, in San Luis Obispo county, comprises the sources of the Salinas river. It is a small plain, whose greatest breadth is nine miles, narrowed towards its southern end to a width of three miles by upheaval of low hills; it lies between the valley of San Luis Obispo on the west and the valley of the Estrella or San Juan river on the east, and may be looked upon as the southern prolongation of the Salinas valley, from which it is separated by the low hills south of San Miguel. Its eastern boundary is the prolongation of the Point Pinos range of hills, which have been described as running southeast from Monterey, and which, fifty miles south of that city, become less elevated and more spread out; in their southerly course they cross the Salinas river, and in its upper portion become the eastern boundary, as they were its western lower down; along this valley they are low mountains, not more than 1,000 to 1,200 feet above the level of the plain, itself 950 feet above the sea; further south these hills rise to a considerable height, are more pronounced, and known then as the San José mountains. The western boundary of the plain is another of the coast ranges; the Santa Lucia hills, one of the longest and most decided of the coast ranges, with few breaks or passes in it, and rising to a height of 2,500 feet. The valley between these limits is one of the most beautiful and fertile in south California, possessing fine grass, with abundance of running streams in the bottom, the side hills clothed with live oaks and cotton-wood, and covered with a luxuriant crop of wild oats, (avena fatua,) which was naturally preserved, and at the time of visit, (January,) served as food for the multitude of deer and horned cattle, which found abundant sustenance here. The oak trees are covered, as to their branches, with the beautiful ramalina, which, hanging gracefully in festoons, with its light green tint, convey the idea of spring at a season when vegetable growth is nearly suspended. The Salinas river flows upon the east side of this valley, from the level plain of which it is separated by a range of low hills of sandstone grits; beyond (east of) the river the granitic axis of this range appears, having the same mineral constitution as further north, largely felspathic, with well defined orthose crystals, of a light flesh color, vitreous quartz, and small plates of diallage, whose green tint adds a lively contrast to the felspar, and gives an appearance of syenite to the whole mass; the rock is cut through by thin green threads of oxide of chrome, along the line of which the mass breaks into small rhombic fragments. It is a granite which decays readily from the separation of the felspar crystal, which drops out by the weathering of the paste.

At the southern end of this valley the granite becomes highly magnesian from the intermixture of serpentine protrusions. These are derived from the Santa Lucia, whose axis is serpentine and trappean rock, spurs of which are given off and enter the plain at various points. One of these protrusions occurs in the centre of the valley, within one and a half mile of the entrance of the pass to San Luis valley; it is a mass of augitic trap, which rises up from the plain in knobs ten to fifteen feet high, increasing in height to the south, where it is found elevating the brown sandstones from one hundred to five hundred feet high, and forming central bosses from fifty to one hundred feet on the summit. These hills are covered with wild oats and oak, and produce the finest pasture in the valley; as they increase in height they merge into the main mass of the Santa Lucia. To the northwest the trap vein can be traced along the valley several miles, until it passes into the same range west of the Old Mission, Santa Margarita, (Don Joachin de Estrada's residence.)

The Old Mission establishment stands on a terrace raised about sixteen feet above the plain, on its western side; at the base of the terrace lies one of the forks of the Salinas, which heads up in the Santa Lucia range a few miles southwest; the terrace is not more than one-fourth of a mile wide, and stretches northwest for one and a half miles; where the river cuts its margin it exposes here and there sandstone and argillite beds similar to those of the San Antonio river, cut up and altered by intrusion of trap rock, steatitic and talcose clays, and shales, which have flexed and contorted the strata in various directions. This intruded rock can be traced several miles, both north and south, preserving a direction of N. 60° W., S. 60° E.

The valley is closed at its south extremity by an elevation of the sandstones, caused by the intrusion of a mass of serpentine with augite, which runs in an easterly direction towards the Toro hills, small masses of granite, outliers of the San José mountains, and forms a natural division between the Santa Margarita and San José valleys.

On account of the frequent and extensive intrusions of augite and serpentine in this valley, it is difficult, in many places, to say what is the original dip of the strata; thus, in the north, the white fossiliferous beds dip to the southwest, conforming to the dip of the strata of the San Antonio river, and there on the west flank of the Point Pinos range, while in the south of the valley the same strata dip eastward. Observation had however shown, that as an elevating agent, the Point Pinos (or San José) mountain range extended its influence to a much greater extent laterally than the Santa Lucia mountains, and that where the strata repose without any subsequent alteration or flexion they are found to be conformable to the Point Pinos granitic axis.

The sedimentary bed lowest in position in this valley is the same as that observed at San Antonio, a breccia conglomerate of quartzose and jaspery pebbles in an aluminous paste, the whole having a light brownish green color. This was not occupying a prominent position, but was found cropping out near the river beyond the low hills on the east side of the plain. Above this is a fine-grained sandstone, greyish white in color, friable, and weathering readily into holes, intersected with threads of sulphate of lime, which traverse the rock in horizontal lines, having a direction north 20° west; the gypsum was in places granular and compact; in others, crystalline; the seams one-half to an inch thick, and stained green with carbonate of copper, (malachite,) this appearance was presented wherever augitic rock cut through the elevated sandstone, and was well displayed at the Rinconada hills. The gypsum, being readily removed by the weathering of the rock, is dissolved by the waters, and finds its way into the Salinas, to which it imparts its flavor and unhealthy action, and from which being present the river has derived its name. Besides the gypsum veins, another set of threads cross the foregoing at an oblique angle; these are filled with limonite, (peroxide of iron.) These two classes of veins render the sandstone readily recognizable wherever found. The thickness of this bed in the valley was 250 feet. In Panza valley, lying several miles to the east, and on the other slope of the granitic axis, it was found much thicker. No fossils were observed in either of these rocks; but it is probable that the upper layers may yet be found fossiliferous.

Above these, and conformable to them, was a whitish sandstone rock, coarse in its lower layers, with pebbles of rounded white quartz. Calcareous fossiliferous layers occurred in the upper part of this sandstone, which, in places, had a dip of 35° to the southwest; the strike, north 46° west. The total thickness of this rock is nearly 450 feet, and may be subdivided conveniently into four beds, commencing with the most inferior.

First bed reposes on the agatic or flinty layers described as met with at the upper end of the Salinas valley; is about 200 feet thick; a whitish sandstone grit, containing calcareous layers two to four feet thick; these layers are mostly made up of ostrea titan, (Conrad,) in a condition tolerably perfect, cemented by a calcareous paste, the debris of the shells comminuted finely; the paste includes fine grains of rounded quartz pebble. This bed of ostrea was the first one encountered on entering the valley where it was found, fifty yards to the left of the wagon road, and less than four miles north of Don Joachim's residence.

Second bed lies above the foregoing, from which it is separated by a quartz grit layer; it is a grey sandstone, including a calcareous cement; it contains a mass of broken shells, forming a cement mass in which are imbeded layers of ostrea and pecten; the ostrea in this bed have not the size of the mollusc of the first bed. The pectens are large, rarely perfect, and when so, in such a soft condition that it was found difficult to preserve them. The pecten, (hinnites crassa, *vide* Conrad's report,) as a fossil, more abundant than the oyster. This bed averages from 70 to 85 feet in thickness.

Third bed varies from 60 to 90 feet thick; is made up almost completely of white calcareous cement, broken shell, and quartz pebble. The fossils lie in two layers, separated by a bed of sand rock. The lower layer contained ostrea and pecten (hinnites) about 60 inches thick; in the upper, ostrea and asterodapsis. The latter (echinoderm) is the characteristic of this bed; it was not found in the lower beds; the individuals vary in size from $\frac{1}{4}$ to $1\frac{1}{2}$ inch across; they are in every respect similar to the Estrella fossils; pecten *discus* of a small size was found in this upper bed.

Fourth bed. A soft brown sandstone, which splits readily into thin slabs, perforated with circular holes, three-fourths inch in diameter, bored obliquely, showing the action of boring molluscs upon it; thickness from three to six feet.

Accompanying the echinoderms was a mass of broken fragments of their own species; this comminution took place while the bed was yet soft and inhabited, as few of the specimens are broken in place, though so brittle that it is difficult to remove them; they lie crowded together and conformable to the plane of deposition, as do also the ostrea and pecten. The ostrea lie in regular layers with their flat shell uppermost, apparently undisturbed except by the general elevation.

Mr. Conrad has described the pecten as a hinnites, and given the characters of the fossils in his report.

These four beds were never found together in the same immediate locality, but usually within a longitudinal range of five miles. The first bed was rarely upheaved, and constituted the level ground of the valley; while beds two and three were usually found cropping out of the low hills on the east side of the valley; the continuity was, however, satisfactorily traced in several instances. Some of the beds, as that containing the asterodapsis (*laganum*,) was brittle so as to render it difficult to preserve the specimens from falling to pieces; while the ostrea layers were sometimes imbedded in so hard a matrix that it was difficult to remove them without fracture. Measured by the foot, several of the oyster shells were fourteen inches long by seven inches wide, and few of them were less than six inches long. The thickness of the under shell is remarkable, some of them being five inches in depth.

It is worthy of remark that the beds, although within few yards of each other, had not their fossils intermingled, as it were; thus the asterodapsis, though the most abundant shell of the upper bed, was not found in the second lowest ostrea bed—this might more properly be called the hinnites bed—which latter was also unattended by the Janira estrellana, which, however, was freely intermingled with the laganum; and, lastly, that the layers perforated by the pholadines were only found above the upper bed, and formed loose stones upon the surface, accompanied by rounded pebbles of jasper and quartz.

The height of these hills rarely exceeded 100 feet, more frequently about 80 feet, with rounded sides and summit, and presenting bluff edges to the west. As this was the direction of the dip, which did not anywhere in these beds exceed 40°, the strata were uncovered by denudation; indeed, everywhere these hills were examined they were found to have suffered extensively by the denuding effects of currents, which, sweeping in a meridional direction, removed large masses of this stratum, and converted what was an inclined slope into a series of rounded hills.

The flattened summits of these hillocks with the bored slates tend to show that, at the time when these were last covered by water, they must have nearly reached the level of the sea of that period. It may be remarked of the sandstone hills of the west side of the valley, that those which are first met with are also flat on their summit and under 150 feet in altitude.

Below these beds, interesting from their fossil contents, and separating them from the gypseous sandstones, lies the white argillaceous rock with the layers of chalcedonic and opalescent quartz, already spoken of as met with on the San Antonio hills, beds containing *dosinia*, *venus*, and *natica*. In a geological sense, as well as topographical, the argillite is inferior; for it here occupies the middle of the valley beside the stream; it dipped N.W. from 60° to 70°, and was so hidden up by alluvium as to prevent any exploration of its beds. It has a light yellow tint, becoming in places almost white; granular in texture, and breaking with a splintry fracture. In places the strata were almost vertical, not more than 50 feet was exposed.

These white ostrea beds were the most modern rocks observed in the valley. Passing westward for a couple of miles, no rock was exposed; and when the Pacific side of the valley was reached, protrusions of trap and serpentine presented themselves to view, with the brown sandstones dipping toward the centre of the plain.

These are the foot hills of the Santa Lucia range, a mountain chain which is described elsewhere in the report.

These sandstones underlie the valley, dipping beneath the strata already described, and having a position below the breccia conglomerate of the east of the plain, and lying between it and the granitoid axis. I look upon them as repetitions of the gypseous and saline sandstones found near the base of Panza.

The relative positions of the strata of this valley are shown in plate 1, fig. 4; and a view of the characteristic beds in fig. 1, plate 2.

The valley is thus a true basin: the conglomerate of the east rising up near the summit of Santa Lucia, range; above it the brown and yellow gypseous sandstones; then the San Antonio beds with dosinia; above these, the ostrea and pecten beds—all conformable to each other and to the volcanic rock and the granite, and all having their dip reversed in portions of the valley from local upheaval.

The whole number of species found in these beds were: ostrea titan, hinnites crassa, cyclas permacra, balanus estrellanus, pecten discus, astrodapsis Antiselli.

Cyclas and hinnites with pecten were found in bed two. Balanus was found in bed three, with asterodapsis.

CHAPTER VI.

POINT PINOS RANGE AND SIERRA SAN JOSE.

Great extent of the range.—Different names.—Height.—Mineral structure at point pinos.—Relation of the serpentine to the granite.—Gold washing at san antonio.—Sandstones at san miguel mission.—Position of stratified beds in salinas valley slope of this range.—Structure of the chain from west to east.—Strata along the slope in santa margarita valley.—Height and direction of the san josé range.—Geological structure of.—Mineral character of the granites.—Sedimentary beds of.—Diagram of geological sections.—Thickness of the strata.—Position and character of the green conglomerates.—Relation of these to the fossiliferous beds, both of this range and elsewhere in the south of the state.

This important chain of the Coast Range was first encountered in the centre of San Luis Obispo county, where it forms the eastern boundary of the Salinas valley, separating the upper course of that river from its tributary, the Estrella. The junction of these streams is near the Mission San Miguel; the low hills which form the eastern boundary of the Salinas valley at this point are made up of the soft, brownish sandstones which, further north, have been also found lying at the slopes of Gavilan, whose upper strata contain the dosinia species, of which four varieties have been enumerated by Mr. Conrad. In this place these strata slope at an unusual angle to the west; and although no primary rock is observed in passing eastward across these hills, yet both north and south of the point the granitic rock is considerably upraised. If from the Mission a line be drawn in direction southeast, it will accurately cover the range until it is merged in the immense primary upheave called San Emilio mountain. Projecting a line in a northwest direction, also from the Mission, it traverses the trend of a mountain chain which, in its course gives rise to the waters of San Antonio river, and forms a prominent feature of the Coast Range of Monterey county, and finally terminates in the southwest extremity of Monterey bay at Point Pinos. With the short break alluded to as lying in the Salinas valley, it is a continuous chain, and might, perhaps, receive a common name. By the title of San José mountains, that portion between the upper waters of the Salinas river and the valley of Panza and Cariso are known. There, it is a chain approximating 3,000 feet above the sea, and from 12 to 16 miles in breadth. While we restrict the name of San José to this southern portion, we shall, both topographically and geographically, look upon the whole line from Point Pinos to the head-waters of the Santa Clara and Santa Maria rivers as one mountain system extending 250 miles from north to south, throughout the whole of which extent it preserves a character remarkably similar. The northern termination at Monterey bay displays the usual character of the axial rock, a felsphatic granite, containing only scattered crystals of mica with adularia and epidote, which communicate a greenish tinge to the mass. The superficial portions of the rock are soft, the felspar crystals standing out distinctly from the paste; it is of a flesh brown color externally, with a bluish shade on fracture, well seen on the south side of the harbor of Monterey, near the steam landing, and thence to Point Pinos, upon the low bosses forming which the light-house is built; it is probable that it is due to the alkaline nature of the soil, produced by the disintegration of the rock, that the cedar and

Sequoia flourish down even to the level of the sea, a point much below the usual altitudes common to those trees.

There the granite is nearly five miles broad, where it dips under the alluvium forming the low land around the inner harbor. Southward it extends in a line southeast, forming the chief mass of the mountain, occupying its western and highest ridge until it reaches the river San Antonio. East of the granite lies a great width of serpentine rock running parallel with the granite and forming a sharp, narrow crested ridge, which, by its abruptness upon the Salinas, hides the main granitic ridge from view when travelling along that river. Still, the presence of the granitic rock is revealed by the wash of almost every mountain stream which carries down a large portion of primary rock among its debris. On the east of the serpentine lie talcose and chloritic slates, intersected by filamentous veins of quartz. These being the mineral conditions under which gold is found, it was suspected that the precious metal might be found in this range; in the winter of 1854–'55 prospecting was carried on to a small extent on the head-waters of the San Antonio, in the northern part of San Luis Obispo county. A few native Californians commenced washing there, and obtained about $4 per day for each hand; the quantity, however, ultimately obtained was but small, and the washings were abandoned after a little. The protrusions of serpentine and magnesian slates drop down before the range approaches San Miguel mission, and do not reappear again. The fossiliferous sandstones with dosinia, underlying the Salinas river, rest on these, have been upraised by them, and are in places rendered metamorphic by contact. The granite itself drops down, as stated, and while diminishing in height covers a greater breadth to the east. Owing to the close approach of the magnesian rocks to the river valley, the trail is obliged to leave it and cross the eastern portion of the range, where it meets with the San Antonio river, which rises in the granitic hills further north, and passes in the small trough between the serpentine and granitic ridges of the mountain; this trough is filled up by the fossiliferous sandstones which here dip to the southwest, being influenced by the serpentine upheaval rather than by the granitic, the latter being the rock first elevated. The sandstone is in places converted into a rock resembling novaculite, and near the Mission Solidad beds of jasper and reddish porphyritic rock are found. Angular fragments of prase occur in the arroyos which found their way into the valley; a bed of conglomerate lies below the sandstones; this stratum is of a greenish tint, and contains pebbles of hyaloid quartz, prase, serpentine, and porphyry. It was not fully exposed, so that not more than 40 feet of thickness could be attributed to it. Above this sandstone is whitish argillite, a soft rock, easily degraded, and fossiliferous. The dip of this upper bed is very variable, dipping in every direction east and west, and occasionally vertical. It appears to have suffered considerably by the talcose upheaves and by subsequent denudations, the terraces which are found at the base of the range being covered with angular fragments derived from the degradation of these strata. The fossils of these strata are described elsewhere in this report. The total thickness of this upper bed is about 80 feet where observed. The sandstones which lie beneath this are of two kinds, brown and red. The brown beds are soft and easily decay; the other bed is made of white quartz grains in a reddish paste; this bed is not fossiliferous, but at several points between the Mission Solidad and San Miguel, these two bands of sandstone were separated by a calcareous stratum, whitish, and in places 15 feet thick, with particles of comminuted shell, and casts of *Dosinia alta*, and *obliqua*, and a small *Venus*. Above both sandstones were found, near San Miguel, (south,) occasionally cropping out, *Ostrea*, *Hinnites*, and *Pallium*; but few specimens could be collected complete, owing to the brittle character of the fossils, from dislocations of the rock; the fossils are, however, noticed in full when describing Santa Margarita valley.

From the outline it would appear that the structure of the chain is simple, and may be stated as follows, commencing west with the axis, and travelling east:

WEST.
Granite, 1½ to 5 miles wide.
Serpentine.
Talcose and chloritic slates.
Green conglomerates, 60 feet exposed.
Brown and red sandstones, with *Dosinia*, 200 feet.
Soft white calcareous.
Conglomerate, *Ostrea*, 50 feet. EAST.

Upon the latter two series the terraces are placed south of the Mission San Miguel, and east of the valley Santa Margarita the San José mountains proper commence. Those hitherto treated of are the geological extension northward.

At Santa Margarita, the Salinas river flows on the east side of the valley; there is a collection of granitic hills from 600 to 1,000 feet in height, set close together, with deep cut gorges between. This granite occupies a breadth of six miles from the Salinas, eastward, when it disappears under the elevated sandstones of the Estrella. On the slopes of this granite occur tertiary sandstones, similar to the fossiliferous beds of Santa Margarita. Running in a direction south 48° east, it attains a high elevation, and twenty miles southeast of Santa Margarita is almost 3,000 feet, its greatest probable height; it preserves its height for nearly fifty miles further south, where it forms the eastern edge of the Cuyamas plain, separating the latter from the shallow basin of the Estero and from Tulare valley. As a mountain range it is there lost. It may be traced, geologically, in the porphyritic hills separating the upper waters of the Santa Maria from those of Tulare, or from the Great Basin, and becomes confounded with the mountain mass of San Emilio.

In this portion of its course the chain has an axis purely granitic, either felspathic granite or gneissose rock. South of San Miguel there is no longer any parallel ridge of serpentine, any talcose or chloritic slates. The magnesian rocks are wholly wanting, and are only represented by the addition of hornblende to the granitic rock, which gradually creeps in the further south the range extends, entering largely into the gneissoze portion, and rendering the whole rock more compact. Mica is still a mineral little abundant, the felspar predominating, which is sometimes bluish from adularia and sometimes cemented by a paste of epidote. The felspar in the northern range is flesh-colored, and contrasts strongly with the clear green of the epidote, giving a porphyritic appearance to the rock. The granites of this range are wholly of the first system, containing the highest amount of oxygen in them, and are mostly of the formula of orthose, which is found of a whitish color, and in rhomboidal prisms in the northern portions of the range. In San Luis and Santa Barbara counties the orthose crystals are usually in hexagonal prisms, with dihedral summits of a flesh-color, approaching a brick-red; the quartz in amorphous pasty masses, very few crystals of brown mica interspersed, and a large amount of the paste is of serpentine, which gives a greenish tint to the whole rock, contrasting strongly with the colored felspar. In the interspaces between the lines of fissure of the blocks a coating of amorphous carbonate of magnesia covers the surface of the granite. In Santa Barbara county hornblende enters into the granite very largely, giving it more the appearance of hornblende porphyry than a true granite. The amphibole mineral appears to replace the serpentine.

Gneiss, which is rare in the State, is found in the rolling country east of Cuyama valley, where it is met with in the bed of the stream, (Carizo,) and occupying a width of several miles of the undulating land east of this range; the gneiss is hornblendic, and accompanies the granite in its further southern course, keeping on its eastern edge until this sierra merges into the mass of San Emilo and the country round about the Tejon. The gneiss was cut up in several places by dykes of granite, in the vicinity of Panza ranche. The sedimentary strata dip, both east and west, from this axis, which through its whole course has tilted the strata on its western side to a much higher angle than those on its eastern. The latter country being the much higher ground. In crossing from the Santa Maria river at Cuyama valley, eastward toward Carizo, the ascent is toilsome and precipitous across strata, some of which are at an angle of 70°; the bed next to the granite, a greenish conglomerate, standing with its weathered pinnacles almost erect, forming the lofty and prominent crest of the range, which then drops down by slow descents over rounded granitic hills until, after a few miles, the sedimentary strata are again met with, dipping in an opposite direction at an angle of not more than 25° to the northeast, which drop gently into the upland swells of Carizo.

This chain was crossed in two places four several times, viz: at Camp 19, in the valley San José, and again about twenty-five miles further to the south, to enter Cuyama valley. The strata presented to view differed but slightly in the two places, viz:

A.—*Section at crossing from Camp in San José to Panza.*

On west side.

Granite.	Dip.	Thickness.
1. Green grits and conglomerate	64° to 70° SW.	150 feet.
2. Coarse porphyritic conglomerate	56° SW.	200 "
3. Brown and yellow sandstones		600 "
4. Conglomerate of serpentine and quartz pebbles		50 "
5. Whitish sandstones and layers of argillite, with gypsum; remains of Ostrea and Pallium	45° SW.	250 "
	Total	1,250 feet.

On east side.

Granite.	Dip.	Thickness.
1. Green grits		300 feet. (1 and 2)
2. Coarse porphyry conglomerate	35° NE.	
3. Brown and yellow sandstones	20° NE. (3 and 4)	500 "
4. Serpentine conglomerate		80 "
5. Gypseous beds, with argillite	15° NE.	200 "
	Total	1,080 feet.

B.—*Section crossing from Cuyama to Carizo.*

ON WEST SIDE.

Granite.	Dip.	Thickness.
1. Coarse grits and green conglomerates	35° S. 75° W.	700 feet.
2. Yellow arenaceous grits		
3. Brown sandstones and shales	30° SW.	
4 *a*. Reddish conglomerate of jasper		
4 *b*. Fine reddish grits, with gypsum	22° SW.	200 "
5. Gypseous sandstones, with ostrea and calcareous beds	15° S. 60° W.	75 "
	Total	975 feet.

ON EAST SIDE.

Granite.	Dip.	Thickness.
1. Green conglomerate	Not observed.	
2. Brown and yellow sandstones	20° NE.	400 feet.
3. Reddish conglomerate		60 "
4. Gypseous sandstones, with calcareous layers containing ostrea, and argillite beds superimposed	10° NE.	400 "
	Total (observed)	860 feet.

As the figures expressing the thickness of the strata are only approximative, they may be somewhat under estimated; they show, however, that on the eastern slopes of the axis the deposits are thicker than on the western. This thickening is independent of any elevating cause. The yellow sandstones, No. 3, are thicker still further to the east, on the Panza hills, than they are found upon this range, indicating the source of deposit to be towards the east.

The contact of the green conglomerates with the granitic rock was frequently observed in these hills; the only rock which at any time separated them was hornblendic gneiss, which, on the east side and towards the south, intervened. No metamorphic rocks—no doubtful schists were here; no silurian or palæozoic rocks. The crystaline and metamorphic limestone which occasionally lies next the granite, as on Mount Diablo, Gavilan, and the Cordilleras of Los Angeles and San Bernardino, are wanting, and nothing but tertiary sandstones, efflorescent with gypsum and cut through with thin seams of brown peroxide of iron, conglomerates of magnesian origin, and those of jasper and porphyry, with superimposed beds of fine sandstone and clay, highly fossiliferous, constitute the stratified rocks; these average 1,000 feet in thickness.

The green conglomerate bed is the most persistent of the whole group, being made up of rounded fragments of serpentine, chlorite, and trappean rock, cemented by a brown aluminous sand, and found in close proximity to the granite; it occupies the highest points of the range, and forms the pinnacled summits which serve as good landmarks from a distance. The red conglomerate bed is made up of fragments of jasper and brownish quartz, with obsidian, and occasionally amygdaloid greenstone. As these latter rocks are found more abundant to the north and east than in the counties traversed by the range in its southern prolongation, it is likely that it may have been derived from that source, possibly from the basin east of the Sierra Nevada, which may not have risen fully up at the time of the deposition of these beds. This bed is not found in the ranges lying to the west. The older conglomerate (serpentine) is derived from the degradation of the serpentine and trappean ranges north and east of this. Neither of these conglomerate beds contain any trace of fossils. Of the fossils of the sandstone beds notice will be made elsewhere. It may be mentioned here that the fine clay bed, the uppermost described, (A No. 5,) is found on both sides of the range where examined; it was also found further east, on Panza, (fifteen miles,) in Santa Margarita valley, San Luis Obispo valley, and thence on the shore line to near Santa Barbara, a remarkable extent of country, forming a line of sixty miles, from north to south, and doubly remarkable when the light and tender nature of the stratum—a soft clay rock, impressible with the nail—is considered.

Figure 5 of plate 2 illustrates the positions of the several strata described. Figures 2 and 3 of plate 1 also reveal the constitution of the chain. Beds 2 and 3 B are the sandstones of Panza, which can be traced to the Monte Diablo range; they are also the lower sandstones of Saint Inez, where they are described. Bed 4 B, east side, is the Santa Margarita fossiliferous beds, described when treating of that valley.

The western slopes of this range in Cuyama valley are terraced for a length of 30 miles; on the eastern side they are terraced also in Panza valley and the lower part of the basin of the Estrella creek.

CHAPTER VII.

SANTA MARIA RIVER AND CUYAMA PLAIN.

THE SANTA MARIA RIVER.—ITS LENGTH AND DIRECTION.—LOCAL IGNORANCE OF.—EFFECTS OF ITS PASSAGE THROUGH THE SANTA LUCIA HILLS.—LIMITS OF THE RIVER VALLEY.—CHARACTER OF THE COUNTRY BETWEEN THE UPPER WATERS OF THE SANTA MARIA AND TULARE VALLEY.—PORPHYRITIC HILLS OF ESTERO PLAIN.—NATURE OF THE PLAIN.—STRATA ON THE EAST SIDE OF CUYAMA VALLEY.—GYPSIFEROUS SANDSTONES.—WEST SIDE OF THE VALLEY.—BROWN SANDSTONES.—STRUCTURE OF THE CUYAMA VALLEY.—TERRACES OF.—CENTRAL ISLET.—TRACES OF DENUDATION AND LITTORAL ACTION.—RELATIVE AND ABSOLUTE HEIGHT OF THE TERRACE LEVELS.

EXCEPTING the Salinas, the Santa Maria is by much the longest river of southern California; having its head-waters in the mountainous district of San Emilio, the melting of the snows, and the unusual fall of rains upon which, are its chief sources, it traverses the course common to Californian rivers, a northwesterly course, through a long valley—the Cuyama valley—during which it receives small tributaries from either side; reaching the northern or lower end of the valley, its further northwest course is arrested by the irregular hilly district lying between the valley of San José and that of this river. These hills are granitic outliers of the San José mountains, with serpentine and trappean upheaves, sent off laterally from the Santa Lucia range. A continuation of the upheaves similar to those called the Rinconado hills, further north, which closes up Santa Margarita plain. Unable to force its way further northward, the river suddenly takes a sweep west and enters the Santa Lucia range, passing through deep gorges and breaks in this chain until it finds its way to the head of the plain of Guadalupe Largo, where it resumes its northwest course, and empties into the sea north of Punto Sal. In its course through the mountain range it winds frequently, but its main course is due west. So little is known of this river, even by the natives resident near, that it is not even known to be the same in its whole course, being called the Cuyama river in its southern portion, and Santa Maria near its mouth. It rises in longitude 120° W. and latitude 34° 40′ N., and is separated by not more than two miles distance from the head-waters of the Peyrou, one of the tributaries of the Santa Clara river, and making allowance for its flexions, its length cannot be less than 170 miles. The valley of the river is 50 miles long, and varies from 4 to 8 miles wide, increasing in breadth to the south, where it stretches out into plains by the depression of the continuation of the San José range. This is the portion known as the Cuyama. In the lower part of the valley (north) the river flows rapidly through an alluvial bed, cut from 10 to 12 feet through clays; higher up, the river flows less rapidly, is not more than 6 to 8 feet below the plain, which is a loose sandy clay, the bed of the stream being a micaceous and quartzose sand. Everywhere through its course its waters are bitter and saline, charged with common salt and gypsum, derived from the sandstones over which it rolls for many miles. The soils of the plains communicate their ingredients, being themselves disintegrated sandstones commingled with basalt, trap, and porphyry pebbles.

Passing over so large a plain surface of an inland valley, and not receiving large tributaries, the river becomes smaller as it descends the valley, and would infallibly dwindle into a petty stream, or wholly disappear, were it not compelled to enter the Santa Lucia range, and thus receive from its well watered summits numerous additional rivulets which swell up its lower channel as it enters Guadalupe Largo plain.

The valley is bounded on the east by the prolongation of the San José mountains—these, which have been already described as the continuation of the Point Pinos range, extend up the valley in a southeasterly direction ; in its course it sends a spur in a more southerly line into the valley—while the main chain further east continues to form the boundary between it and Estero plain to within 20 miles of the termination of Tulare valley ; in so doing, it appears to lose the character of mountains, and to resemble low hills bounding the plain ; but the fact is, that the valley of the river rises considerably in level, the elevating force being spread over the area of the Santa Maria valley in its upper course. The hills in the southern extremity, where it separates the valley from Estero plain, are mostly porphyritic felspar, containing albite in well marked hexagons. The hills are rounded swells, which have deep valleys or breaks between them, allowing of passes from Tulare valley and Estero plain into the valley of this river. These porphyry domes present the appearance of a series of wash-basins inverted. Estero plain is properly a longitudinal valley in this range, being uplifted by it to an elevation considerably exceeding that of the valleys on either side ; for while both Tulare and Santa Maria valleys roll their waters north, Estero plain sends its stream, the Agua de Paleta, in a southerly course into Tulare valley, the level of which is below that of the Santa Maria.

This granitoid felspar porphyry range has a strike S. 40° E., with an exposed width of 7 to 10 miles of elevated rolling hills, forming a true anticlinal axis, throwing the strata into Tulare valley with a dip of 15° to 20° eastward, and into Santa Maria valley on the west at an angle scarcely exceeding 15° to the N. W. The porphyritic rock may be traced south into the eastern and northern portions of the San Emilio mountain.

The strata dipping toward the valley consist of 3 beds, as observed from above downward.

1st. A hard, whitish, compact clay rock, absorbent to tongue, with veins of crystallized gypsum and cavities, where the crystals had weathered out; layers of silicified rock, occur through this bed; 120 feet of this stratum was observed.

2d. Stratum of brownish yellow clay rock; gypsiferous, gypsum disseminated in amorphous masses, accompanied with seams of crystalline mineral; about 30 feet of this rock was exposed.

3d. White quartz grit; pebbles rounded—a clay paste with seams of sulphate intercalated; 25 feet of this rock exposed.

In the hasty survey made no fossils were observed, and the exact age cannot, therefore, be determined; in lithological character they resemble the lower gypsiferous sandstones of Panza hills and the beds of sandstone which lie above the conglomerate of Santa Margarita and Santa Inez.

The gypsum is washed out readily from these strata into the plain, where, in low situations, it forms an efflorescent crust on the soil, and attaches itself as a thin frosting round the roots and stems of the grasses.

At the northern and lower end of the valley the San José mountains form the eastern limit. The character of this range has been described under its appropriate head, and need only be slightly noticed here. The newest strata of that range dip into the valley at an angle of 25° to the southwest. The uppermost bed is the soft clay rock, containing impressions of *arca* obispoensis, similar to that described in the San Luis valley as forming the most recent series in California. Upon these were found the terraces which stretched for many miles up the valley.

The western boundary of the valley is the Santa Lucia range in its course south. This mountain ridge loses none of its height or power as a physical feature; at the northern edge of the plain its thickness is from 16 to 20 miles through where the river cañons; south of this, for 40 miles, there are no passes through it, presenting, as it does, a lofty range of sharply defined crests of height increasing southward, and uniting with the lofty land where the San Rafael and the Saint Inez mountains in their course blend together and form a hilly and almost impassable district in the northern part of Santa Barbara and Los Angeles counties. This range was not examined closely in its southern course; the streams which rolled down carried as debris serpentine, massive and foliated, trappean and porphyritic jasper stones, transparent and hyalitic quartz, but no granitic pebbles; nowhere along the range has there been the smallest trace of a granitoid rock observed; and the sharp sky outlines of the range, when viewed from the valley, forbid the idea of its existence.

Brown sandstones were observed flanking the slopes of this range at the northern end of the valley; sufficient time was not afforded for exploring them for fossils, but in lithological character they closely resembled the brown and yellow sandstones which clothe the same axis in the Santa Margarita valley, which lie beneath the layers of ostrea and are the superior beds of the gypsiferous and saline grits of Panza. These slope abruptly down to the valley bottom, and spreading in places out into long foot ranges, with their summits abraded smoothly so as to form an extended flat or terrace extending for several miles out toward the valley from the base of the main mass of mountain.

The Santa Maria or Cuyama valley differs from any other observed in not having a true outlet. On the south it is shut up by the San Emilio mountain region; on the east by the low porphyritic felspar range running into that mountain also; on the north it is occluded by the cross ranges given off from the Santa Lucia, and by this range on its west, throughout the whole length; it is completely shut in, except at the point where the river cañons through the narrow gorges of the Santa Lucia. This is a channel which the river itself has partly cut for itself, and scarcely can be called the natural outlet of a plain. The slope of the base of the plain is to the north by west, and would naturally pour its waters into the small valleys of San José and Santa Margarita were it not prevented by the serpentine ridges crossing it at the head of these localities. The observer, first casting his eye over this extended plain, widening towards the south by the recession of the mountain ranges, would at once set it down as the basin of a great arm of the sea, which ran up toward the north, and that the natural debouche was toward the southeast, or opening into Tulare plain. This may have been the case once; but at such time Tulare plain itself was not so elevated or cut off from communication with the desert east as at present. The elevation of Tulare and Santa Maria were coeval. The sandstones and gypseous beds found northwest of the Cañada de los Uvas may be traced round the sides of the porphyry domes into the Cuyama valley as a continuous series, elevated by the same local action; and as the Estero plain lies between Tulare and Santa Maria valley, upon the crests or in a trough between the porphyry ranges, the continuation of the San José range, which also stretches under Panza and Cariso, that plain (Estero) belongs to the same age, and the San José range, by its elevation, separated for the first time the previously connected plains of Cuyama and Tulare valley.

Whichever may have been the original outlet, which at present is closed up, it is, perhaps, difficult to decide now; but the valley everywhere, especially at the lower end, (north,) presents the usual marks of running water in the terraces found on its mountain sides, and on such a large scale as to induce the examiner to look upon the whole plain as once an extensive lake, the level of whose waters were then 200 feet above the present level of the plain below. Near the centre of the valley—that is, about twenty-five miles up from the north end of the plain—low sandstone hills run out from the Santa Lucia range into the valley in long promontory ridges, with flat backs, having a slight slope to the plain, (not more than three degrees,) the lower edge for a few hundred yards being perfectly horizontal and covered with loose sandy detritus and angular fragments of stone, derived from the strata of the vicinity. A little south of this the centre of the plain is occupied with an elevated mass, which leaves a passage round it between the mountains east and west; on the former side the Santa Maria runs at present; the latter is not now occupied by any permanent stream. This elevation is steep in the ascent and requires to be gained by following to some distance the winding gashes formed in its soft sides by the waters rolling off the summit. Its height does not exceed 100 feet, perhaps eighty, more correctly. The summit is perfectly flat, in an extended view, and covered with fine sandy clay and angular detritus of the sandstones, with a few red jasper and porphyritic pebbles. The strata of which this elevation is composed are the yellow and brown sandstones found clothing the sides of the San José mountains, with the dip of which it corresponds, the beds sloping southwest or towards the Santa Lucia range. The width of this elevated flat-topped plain might be about three miles, and the observed length eight to ten; how much further south it extended there was no means of deciding, as the valley was not traversed further at this point. When examined by entering the valley from the south, several weeks afterwards, at the distance of more than twenty miles it was not possible to distinguish. But judging from the manner in which the surrounding bottom looked, it was conjectured that the southern edge was also sloped down, though not as bluff as the north, which has a slope from 25° to 40°. From the edge, looking for miles, the river could be traced along its eastern margin in the narrow plain between the foot of this insulated elevation and the San José mountains, on whose sides, about 150 feet up, could be traced extended flattened shoulders of the sandstone, forming terraces, whose level was nearly that of this plain. On looking west to the Santa Lucia, those prolonged spurs, with their terraced edges, corresponded in level with that of the plain under foot, from which it was separated by an excavation or drop in the strata three to four miles wide.

Here were fine examples of denudation and littoral action. The currents, which denuded the valley to near its present level, left standing in the centre a mass of sandstone rock, the edges of which it wore down on each side to form channels of outlet. It is evident that the soft strata of the San José range covered up this valley the depth of fully 100 feet above its present level—that these have been in great part removed, leaving only the insulated mass in the centre of the valley. It is probable this current action was slow and continued, rather than violent and short of duration, since there are no masses of rock scattered about the plain—no large pebbles; everything indicates a quiet and easy motion, which, while it undermined the strata in some places, and removed them, gently washed and wore them smooth, leaving a beach detritus of fine quartz sand, to which the partially decomposed material of the underlying stratum has been added since. These waters must have stood above 100 feet over the present plain level, and the current probably flowed from north to south, as the southern edges of the elevated mass in the centre is of so steep a grade.

These are the highest indications of water-current action in this valley; the lines on the western side have preserved their parallelism with the central island, while on the eastern side the terrace line is somewhat higher up, as if that whole chain had been uplifted since to a greater height than the plain generally; there are, however, indications of lower water-level, which are less extensive and less distinctly marked; they occur in the north part of the valley, and are disposed thus: The present river flows about four to six feet below its bank; the bottom of the river forms a small alluvial flat about a mile in breadth; on each side of this a higher plain, the more ancient bottom, extending for a mile on each side, and about twelve feet higher than the true bottom; this ancient bottom reaches to the foot of the mountain ranges. Thirty feet high on the San José mountains a terrace is found, which may be traced for several miles north and south; the line of this terrace is not horizontal, but apparently falls to the southeast; this may, however, be only apparent, as the level of the plain slopes in the opposite direction. Opposite to this, near the camp at Quadre Domingo, the terrace on the sandstone of the Santa Lucia is about the same height, and is covered with pebbles of red and green conglomerate, quartz, and porphyry. That on the San José is white clay and sand rock, in angular fragments, with pebbles of the opalescent quartz found underlying the ostrea bed of Santa Margarita; above this terrace line is that one first described. The order of all these would be thus:

	Total elevation above sea, in feet.
Terrace 100—150 feet high on mountain	1,690
30 do	1,542
12 old river bottom	1,512
— present bottom	1,500
River 4 feet below	

Plate 2, fig. 4, affords sections of these terrace levels, and an outline of the valley.

CHAPTER VIII.

SANTA LUCIA MOUNTAINS.

Classification of the range.—Peculiarity of the range in its axial rocks.—Absence of true granitic rock.—General elevation, increased height toward the south.—Different level of the valleys east and west of this range—Due to the width of the San Jose granite.—Serpentine and trap containing calcite.—Tufaceous deposit.—Metamorphic limestone.—Nature of the changes which elevated this range.—San Luis pass.—Volcanic rock occurring in.—Cañon of the Santa Maria.—Geological structure in—Disposition of the mountain chain in lesser ridges.—Age of the sedimentary beds.—Are there palæozoic beds in this range?

This range has been incidentally alluded to when noticing the coast ranges collectively under division 2, group 3. It is the first of the ranges which are wholly of volcanic rock (as far as examined) in passing from the east to the west. The Monte Diablo, the most eastern ridge, merges into the Gavilan, which may be considered its reproduction further south. In that range, trappean rock, trachyte, and scoriaceous lava, lie upon the east side of the granitic range, and for 40 miles disturb the strata; but the granite still predominates as the upheaving rock. So with the next chain to the west, the Point Pinos or San José range. It is granitic where the axis occurs, the serpentine and trap constituting an upheaving force on the east side, and forming a distinct crested hill; these volcanic rocks further south also disappear as a connected plutonic vein, rising up here and there in partial dislocated localities. It is different, however, with this range; the granitic rock is wanting as an axial force, the whole upheaval appearing to be produced by trap, serpentine, and amygdaloidal felspathic rock, approaching trachyte in character. This class of igneous rock produces uplifts in the northern part of the chain 2,500 to 3,000 feet; toward the south a lofty mountain rises in this chain above 7,000 feet high, the streams flowing down from the snows and rains of this mountain contribute on its east side to form a tributary of the Santa Maria in the extreme southern end of Cuyama valley. The geology of this portion of the range not having been studied, owing to rapid transit over the district, it cannot be affirmed that primary rock does not exist, but the sky outline of the range, and the fact that the washed stones brought down by the stream into the Santa Maria valley are all of volcanic origin, serpentine, trap and felspathic porphyry, a red, compact, argillitic rock, chalcedonic quartz, such as abounds further to the southwest in the Sierra Monica, are strong evidences of its non-existence; while in the localities where the hill range was passed through by the survey, no trace of a granitic rock was observable; trap and its accompanying serpentine were the invariable plutonic rocks, sometimes axial, but more frequently elevating the strata to one side, and appearing as a naked rock on the other; this latter phenomenon presenting itself where the elevation of the range was not at its greatest; the general tilt was to the east, and when it occurred as an axial rock the eastern slope was the easiest, that of the west being steep and above 45°.

The valleys east of this range have a much higher level than those west. Santa Margarita valley, San José valley, and that of the Santa Maria river, are several hundred feet higher than the valley of San Luis Obispo ; the lowest of them, the first named, being nearly 800 feet above its neighbor to the west, the valley of San Luis. Hence this range, viewed from the west, appears a much more imposing mountain mass than when seen from the interior valleys.

This increased altitude of the inner valleys named is not to be attributed to this volcanic range; its influence upon the valleys has been but slight, and perhaps only resulted in defining its limits on the west; the elevation must be attributed to the San José granite range, which has elevated the whole district east and west of itself; in the Santa Margarita, San José and Santa Maria, the dip of the strata under the level of the plain, wherever observed, has always been noticed as westward or toward the Santa Lucia range; this direction being observed up to the very base of the latter chain, and the dip less abrupt than that of the volcanic range; from which it would appear that the district was first upheaved by the San José range, and that subsequently the trappean and trachytic eruption along the line of Santa Lucia elevated the sandstones to a high angle, carrying up those in proximity to it, but not influencing the strata to any distance. The range is thus looked upon as produced by a volcanic outburst upon the western edge of the granitic slope, which view explains the sudden dropping down of the valley on the west, and the non-existence of granitic rock west of this chain.

The lowest pass, indeed the only one known over this range, is that from Santa Margarita valley into San Luis Obispo valley; the height of this pass is 1,350 feet, being 400 feet above the level of Santa Margarita and 1,200 feet above San Luis valley. In going through this pass, which is about six miles across, upon the summit the trappean rock is met with—an amygdaloid augitic variety—the cavities filled with carbonate of lime. A short distance east of this a brownish trachytic vein appears running westnorthwest. The serpentine conglomerate is found lying next to this and dipping southeast or toward the valley; lying upon these conformably are he brown and yellow sandstone and fine grits and conglomerates similar to those upon the eastern edge of the valley Santa Margarita; these rocks varied in dip from 15° in the lower part of the valley to 55° near the summit. On the west side of the trap occurs an immense mass of serpentine, compact, in places foliated and rising in a crested hill 1,000 to 1,200 feet above the level of the pass; the descent is very abrupt, over masses of serpentine and sandstone, sloping steeply to west; the brown grits were observed on the west slope; further south and high up on the top of a crest were observed the agatic layers and the beds of ostrea similar to those in the Santa Margarita valley.

Near the summit on the east side a bed of calcareous tufa, of small local extent and not more than 20 feet thick, was observed; on fracturing it some of the exposed portions exhibited the impressions of dicotyledonous leaves; it was looked upon as of recent origin arising from the drainage from the calcareous traps. Observing that the cavities of the trap were found filled with crystals of calcite, search was made for the rock affording it; crystals of cromic iron abounded also in the trap. Between the amygdaloid and the brown trachyte a dark blue rock, which effervesced strongly, was met with—tinged greenish by intrusions of serpentine, veined with quartz and intersected by rhomboidal crystals of calcite—it was evidently a metamorphic sedimentary limestone; no traces of stratification were observable; only 20 feet of it was exposed, dipping at a high angle apparently to the west. No fossils were observable in the fractured surfaces.

The party of survey crossed this range again, where the Santa Maria cañons through it, to reach the Guadalupe Largo plain; not being present, a geological section was not accurately made, but, from the observations kindly made by Mr. Campbell, the same volcanic rocks were observed as axial beds, here producing an anticlinal axis of trap and serpentine, and throwing the serpentine and sandrocks on each side. The beds in proximity to the volcanic rock were the serpentine and trap conglomerate, upon these the red and brown grits, and above all the soft calcareous and clay beds observed in the Santa Maria valley. The rocks in juxtaposition with the serpentine were stated to be very much hardened and metamorphosed. There is no distinct pass in this locality, but deep gorges, the present bed of the river, which winds its way tortuously around and across the ridges. The range is not a continued crested ridge but a series of smaller ridges 8 to 12 miles long, which have a direction somewhat more east and west than the direction of the main chain; thus, while the trend of the range is north 46° west, that of the several links is about north 60° west, running their southern extremities into the inland valleys; through one of these re-entering angles the pass is found.

The age of the stratified sandstones has been already noticed in describing the Santa Margarita valley, in which they occupy a well marked basin position.

But what shall be said of the metamorphic limestone, found lying below the serpentine conglomerate, and lying between it and trap, to which latter rock it has contributed considerably, by the filling up of the cavities? Were this layer met for the first time it would not have demanded attention, but it had been already met in San José valley, flanking the serpentine along the west of the valley, where it may be traced for 30 miles continuously. Inquiry from those living in the Salinas valley near hills, ascertained that it lay up the mountains on the east side; it has been described as lining the San Juan valley on both its sides, and it is well known in the neighborhood of Monte Diablo; on the west side of Gavilan it is found 400 feet thick, and in Alameda county at Oaklands, nearly opposite San Francisco, across the bay, a magnesian limestone has lately been found. Thus a bed of stratified blue limestone has been traced on both sides of San José valley, and, therefore, underlying it, also underlying San Juan; found on the east side of the Salinas valley, and on the west of Santa Margarita. Further south on the Coast Range it has not been detected, but this may be owing to the fact that the upheaval has not been sufficiently powerful, since the green conglomerate is rarely elevated in those lower ranges so as to expose its whole thickness.

Passing inland to the Sierra Nevada, a limestone bed is also found, as a primary rock, a crystalline carbonate, found in the Cañada de las Uvas, lining both sides of the pass, found in round masses washed out of the Cajon pass, and also in every other pass of the Cordilleras, where it was looked for; it is there in contact with granitic rock, and should it chance to be coeval with the blue limestone of the Coast Range, its characters of resemblance are wholly gone; but what is the age of the latter? is it silurian, carboniferous, or upper secondary? In the absence of the exploration for fossils in the quarries in San José valley, or at Monte Diablo, it were idle to speculate; and knowing that in the territories north of this State carboniferous limestone does exist, one would be hardy who would deny this to be of palæozoic age.

A section of this range, obtained from the cañon of the Santa Maria river, is given in figure 2, plate 2. Plate 7, figure 2, affords a section through the pass of San Luis Obispo, leading into San Luis valley, and the relative position of the chain is shown in plate 1, figure 2, and plate 5, figure 1.

CHAPTER IX.

VALLEY OF SAN LUIS OBISPO.

Topography of the valley slope and direction of the strata.—Effect of the disposition of the ranges upon the coast line and upon the climate.—Drainage of the valley.—Structure of the coast hills.—Number of the beds included under the asphalte groupe.—Polythalamous beds—Fossils of the group.—Probable geological age of this series.—Relation of position to the Santa Margarita valley.—Position of the group on Santa Maria river.—Geographical extent.—Variety in dip.—Alteration in beds subsequent to deposition.—Denudation.—Character of the valley proper.

The valley or plain of San Luis Obispo is separated from that of Santa Margarita by the Santa Lucia mountains; between this range and the Pacific ocean is a plain in which the village of San Luis Obispo lies, and from which the plain derives its name.

The level of this valley is much below that of Santa Margarita, its altitude not much exceeding 150 feet; it slopes gradually to the ocean, from which it is separated by a range of hills which stretch from the shore to a distance of six miles inward; these hills do not exceed 600 feet high, and dip variously in opposite ends of the valley; about the San Luis river, which finds its way to the sea through a break in them, and from thence southward the strata dip toward the shore, while in the northern part of the valley these strata dip toward the valley. This different dip is caused by the serpentine and trappean protrusions, which are the elevating rocks of the valley, passing across the strata in an oblique line from N. W. to S. E., not producing anticlinal axes, but simply lifting the beds to the east at the north end of the valley and to the west on the shore. The consequence of this different dip is evident by inspecting the coast line, north of the bay of San Luis, where the dip is to the east and the lowermost beds of the series are exposed; these are hard conglomerates of a greenish tint, arising from pebbles of serpentine and trappean rock, and have a dip from 15° to 20° S. 35° E. Here the strata stretch out into the sea and form bold headlands which are washed and torn by the force of the waves; this character of shore line continuing to Estero bay on the north, where, owing to the occurrence of the soft uppermost rocks on shore, the sea makes an inroad, which is checked further north by the sharp crest of the Santa Lucia range, at Punto Gordo. Between this headland and the south border of the Estero bay the valley of San Luis extends, opening to the N. W., and allowing the winds and moisture to enter and supply it with a much greater rainfall and heavier dews than are to be found in the valleys east of the range; owing to this, as well as the lesser altitude, the climate is warmer, and the vegetation approaches an intertropical character.

The eastern margin of the valley is formed of the sandstone lying against the serpentine axis of the Santa Lucia range; these sandstones dip toward the valley, and are lost beneath the alluvium.

Along the east side of the valley, lying close to the foot of the sandstones,(not more than one mile west,) is a series of elevated buttes of serpentine and trappean rock, which can be traced traversing the valley from its northern limit, following the base of the Santa Lucia range, of a triangular form, the serpentine, lying on the west side of the butte, forming its chief mass and determining its crested outline; the eastern slope of the conglomerate rock is at an angle of 45°, serpentine lying underneath it and protruding on the western edge of the buttes.

Further to the south these buttes converge in direction, or nearly so, with the upheaving rock of the low hills along the coast, and both unite in closing the San Luis valley to the south, forming the elevated land of Napoma, and thence south till the valley of Guadalupe Largo is reached.

From these buttes the valley is a plain or a gradual slope from four to six miles, when the low hills between it and the coast are encountered; towards these hills the waters roll and find their way partly out by low passes into the ocean, while in some places large ponds and marshes are formed by their collection. The low hills of the coast can be well seen immediately west of the town, whence the river, which waters the village San Luis Obispo, finds its way out west of the Corral de Piedras. The first stratum met with is a thick bed of conglomerate and grit rock; beds of quartzose pebbles, cemented by a calcareous clay paste, of a greenish yellow color, mostly made up of broken trap rock, a few serpentine and porphyry pebbles, are also enclosed, but it is chiefly trappean, and is thus easily distinguished from the green conglomerates of the Santa Margarita valley. The thickness of this bed is not less than 300 feet, including some intercalated layers of finer yellow grit with white quartz pebble; above this is a yellow sandstone, soft, and easily disintegrated; this sandstone is 150 feet in thickness; then occurs the asphalt rock, a greenish yellow bed, where not highly charged with bitumen; where it is, it is blackish, composed of fine grains of white quartz, cemented together by a calcareous and clay paste; some layers in this bed were highly charged with foraminifera; the total thickness of this asphalt group of rocks here might be about 120 feet. Upon this reposed a layer of soft, white felspathic clay rock, in a state of minute division; in places so soft as to be readily cut with the knife; in others, hard, and almost slaty; in places partly calcareous; in others, pure argillite, or kaolin clay. These beds were a little thicker than the foregoing, and perhaps were 200 feet in thickness. In these occurred the arca obispoana, of Conrad's report. As these beds were first encountered in this plain, and were afterwards found at several points along shore to the south as far as Los Angeles, and as they are almost always associated with asphaltum, they will deserve a somewhat fuller notice.

The total thickness of these beds approaches 800 feet. From the Santa Lucia sandstones it is locally separated by the serpentine buttes and intervening valley. Its geological connexion could not be traced at this point, the lowland and swamp of the valley occupying a large surface.

In the lower conglomerate no fossils were observed, nor in the yellow sandstone lying above it; the two upper beds contained fossiliferous layers: the asphalt rock containing the polythalamous shells, and the soft argillite containing impressions of arca obispoana, this fossil cast alone being found; while in other places, broken casts of fish scales and dorsal spines of minute dimensions were found scattered throughout.

The upper thirty feet of this stratum is harder, and approaches a slate, readily splitting into thin laminæ. This and the cream yellow tint, with the included fossil, serves to recognize the bed.

The polythalamous layers were intercalated between strata of fine sand rock, made up of minute rounded grains of transparent quartz, not cemented, but adhering by cohesion; these could be separated at the edges by mere pressure of the fingers. Among the polythalamia, the forms of rotalina and orbicularia were the most abundant.

I am inclined to look upon this series as the most recently elevated strata in California; the upper soft rock, which is the most persistent and easiest recognized, being the distinguishing stratum. I have not observed them north of San Luis bay, not having reached the coast north of that point. It is likely they extend along shore to Punto Gordo; the deeply excavated beach would imply some such soft rocks at the base of the Santa Lucia range. From San Luis, south, they may be traced, by Napoma, along shore, and occupying the low hills of the Saint Inez range, at Point Concepcion; thence under the terrace at Gaviote pass, and along shore, close to Santa Barbara, where it rises up to form a terrace cliff barrier 100 feet high.

From Santa Barbara it may be traced, not far from the shore, to San Buenaventura; and east of the Santa Clara river it leaves the shore, running directly east, and forming the upper beds of the low hills called the Sierra Monica, whence they may be found running out north of the town of Los Angeles.

In the Santa Margarita valley these strata were not observed occupying a prominent position—perhaps the centre of the plain may be occupied by them—but they were found in the northern end of the Santa Maria valley, where they form the latest beds of the San José mountains on both slopes, and are found occupying a position superior to the ostrea and pecten beds, corresponding to those described in the account of Santa Margarita valley. In the valley of Santa Maria river they were found traversing the base of the hills about 150 to 300 feet above the level of the valley; upon these layers the lowest hill terrace of the valley was placed, the strata extended twenty miles along the hills towards the head-waters of the river. This is the furthest point inland at which they were observed, about sixty miles from the sea. In their extended course (above 200 miles from north to south) they have a varied dip along the San José range, whose axis is granite; they are unaltered in character, and have an elevation on the east side not more than 15°, while on the west it approaches 45°.

In the valley of San Luis the dip is 20°, while along the coast at Gaviote pass it is 40° Both in Santa Barbara and Los Angeles counties it varies from 8° to verticality, in proportion to its proximity to the trappean and trachyte eruptions. In the eastern end of the Sierra Monica, north of Los Angeles, the strata are almost vertical.

Though not observed further north on this survey than Estero bay, there is no reason to doubt of their occurrence in the valleys of the Coast Range further inland. From Dr. Trask's description, I am inclined to think that beds found by him near the mouth of the Pajaro river, and those observed by Mr. W. P. Blake, near the town of Monterey, are extensions of those to the north. Dr. Trask notices that these beds, the two upper series of the group described here, are never found at a lofty elevation—that they are not found above an altitude of 500 feet. This was also observed upon this survey, with one exception, the Santa Maria valley.

Everywhere these beds have been observed, they seem to have suffered extensively by denudation. In San Luis valley, towards the south, these strata merge into the San Lucia range, and shut up the valley in that direction. Around the town of San Luis, and north to the ocean, these soft strata have been removed, and have left only the harder conglomerate standing here and there as landmarks to indicate the former position of the strata.

The history of these beds would be incomplete if notice was not taken of their occurrence upon the hills which form the divort between the valleys La Purissima and Santa Inez. In descending this hill slope on the southeastern side, or entering the Santa Inez valley, the upper yellow slate was met, forming the sides of a cañon down which the wagon road led to the valley; on examining these shales, they were found to contain in places the impressions of numerous bodies of small fish—only the marks of the vertebræ and ribs were discernible—the scales of which had only been observed in the San Luis valley and elsewhere; intermingled were some fractured impressions of dorsal spines. In the same locality was found very beautiful impressions of *pecten discus;* lower down the strata became black from asphaltic impregnation.

This description completes the history of these upper strata of the valley San Luis. In noticing them, as occurring in other places, reference is made to this locality for a knowledge of their characters to avoid repetition. They are the most recent of the consolidated rocks of California; they have suffered the most extensively from denudation, and upon them, either on their edges or their slopes, the terraces and the raised beaches are found, and they are constantly associated with outflows of bitumen.

Between the serpentine and trappean upheaval, on the east side of San Luis valley, and the conglomerates of the bituminous group on the west, the valley proper is located; the surface is covered with alluvial clays, the whole depth of which cannot be estimated, as no borings have been made, and not more than twenty feet of reddish yellow clays and light gravel were observed in the river courses. As the centre of the valley has suffered so much from denudation, it is probable that the ancient alluvium is also very deep. The valley, at present, slopes slightly to the northwest, where it opens on to the ocean, the direction doubtless which the denuded matter took when it was being removed from the plain.

A section of the valley is given on plate 7, fig. 2, and plate 1, fig. 2.

In plate 7, the upper strata of the valley are illustrated.

CHAPTER X.

SANTA BARBARA MOUNTAINS.

SITUATION AND EXTENT OF THIS RANGE.—ABSENCE OF PRIMARY ROCK.—REPETITION OF UPHEAVALS.—SECONDARY AXES, THEIR NUMBER AND POSITION.—EASTERN LIMIT OF THE RANGE AT SAN BUENAVENTURA RIVER.—ERRONEOUS VIEWS PUT FORTH BY RECENT WRITERS.—THE SANTA BARBARA MOUNTAINS MUCH MORE RECENT THAN SAN BERNARDINO.—DIFFERENT POSITION OF THE AXES OF THIS CHAIN FROM THAT OF THE OTHER COAST RANGES.—GRANITE OF MATILIHAH.—VOLCANIC ROCKS OF THE CHAIN.—AMPHIBOLE AND FELSPATHIC.—POSITION OF THE AXIAL ROCKS FOUND IN THE PLAIN.—POSITION OF SERPENTINE AS A MASSIVE ROCK.—ASSOCIATED MINERALS.—ELEVATING POWER OF THE IGNEOUS ROCKS.—BEDS OF LIMONITE.—WIDTH OF VOLCANIC VEINS.—SEDIMENTARY BEDS.—DIFFERENT POINTS OF OBSERVATION.—CLASSIFICATION OF THE STRATA.—POSITION OF CAMP XXII.—METAMORPHIC ROCKS.—DIP OF THE SANDSTONES—ENUMERATION OF THE STRATA IN THE SANTA INEZ VALLEY.—GAVIOTE PASS—PECULIAR FEATURES OF.—ELEVATED TERRACE OF THE SANTA BARBARA SHORE.—GEOLOGICAL STRUCTURE OF.—ENUMERATION OF THE STRATA ON THE SOUTH SIDE OF THE RANGE.—PROBABLE THICKNESS OF THE STRATA.—FORAMINIFEROUS AND ASPHALTIC BEDS ALONG SHORE.—DEVIATION OF THE SHORE LINE.—EVIDENCE OF RECENT UPHEAVAL.—UPHEAVAL OF THE STRATA EAST OF TOWN OF SANTA BARBARA.—POINT RINCON.—ANALOGY IN STRUCTURE WITH QUESTA SAN MARCUS—POSITION OF STRATA ALONG SAN BUENAVENTURA RIVER.—SULPHUR SPRING AND BITUMEN BEDS.—TERRACED VALLEY HIGHER UP.—CHARACTER OF THE DISTRICTWHERE THE SOURCES OF THE BUENAVENTURA ARISE.—OF THE FOSSILS CONTAINED IN THE STRATA ON THE NORTH SIDE.—OF THE FOSSILS CONTAINED IN THE STRATA ON THE SOUTH SIDE.—RELATION OF THE BEDS ON EACH SIDE OF THE AXIS TO EACH OTHER, AND TO THE PANZA, SANTA MARGARITA, AND SAN RAFAEL STRATA.

THIS sierra, one of the most important and well defined of the ranges in the State, extends in a direction nearly east and west, forming the prominent crest of hills observed in sailing from Point Concepcion towards San Pedro. The length of the chain is from ninety to one hundred miles, the whole extent of Santa Barbara county, and its greatest width, at any point, is not more than ten miles, and toward its western edge considerably less. Viewed from the sea, it forms a lofty and decided barrier, rising from 1,300 to 2,000 feet above the plain, its naked sandstone summits presenting rugged angular sky outlines of an uniform character throughout its entire length. The chain is almost unbroken in its entire extent, in one or two places only being interrupted, as at Gaviote pass. The Questa San Marcus cannot be deemed, properly, a pass, as there is no gorge through the range, but rather a mountain trail, which takes a smooth summit as a crossing.

There is no primary rock observable in the entire chain, the upheaval being produced by a series of serpentine and volcanic protrusions, repeated at separate intervals between Point Concepcion and the Buenaventura river; at this latter point this chain of hills terminates. Between this river and the point as many as five distinct axes of volcanic force can be distinguished, each of them producing a link or wave in the chain which drops down toward the shore, and is replaced by another which lies close at its back, thus forming distinct ridges without distinct breaks forming passes.

These secondary axes are in order from west to east:

Axis 1. Northern extremity, terminating in Point Arguello and the southern west of the Gaviote pass.

Axis 2. That of Punto Sal and La Purissima, running west of Mission Viejo and east of Gaviote Pass.

Axes 3 and 4. Two small axes occupying the chain along shore from Ortegas ranch to four or five miles north of Santa Barbara; axis 4 terminating at Rincon.

Axis 5. Axis terminating four miles up the San Buenaventura river.

At the San Buenaventura this range may be said to terminate. The hilly country lying east of that river and of the Santa Clara, the sierras Susanna and Monica, have an elevating cause different from that which raised the Santa Inez, neither are the same series of brown and yellow sandstones repeated in them to at all the same extent. The dip of the strata do not correspond, and involving as they do different stratified beds, they should not be included in the Santa Inez range.

It is necessary in this place to insist upon the fact that the Santa Inez range is limited toward the east by the rivers before mentioned, inasmuch as an opposite view has been taken by two writers on Californian geology.

Mr. W. P. Blake* puts forth the view that all these strata from Point Arguello, eastward, have been elevated by the mass of granite forming the San Bernardino mountain, whose influence he believes to spread thus far to the west, and also to have produced the lone hills of the desert and basin upon the east.

It is contrary to good reasoning to adopt a remote cause when a proximate one equally efficacious can be found. The dip of the sandstones forming the sides and slopes of the Santa Inez chain is not that which could be produced by San Bernardino. The general dip is southwest, verging round to south, and occasionally to southeast; the dip should be uniformly west if produced by that mountain range. Again, the strata of Santa Inez range are more vertical than those in immediate contact with the granite of San Bernardino, that is to say, the strata more distant have a greater dip than those in proximity, a circumstance which should lead us to suspect that that enormous mountain mass was not the upheaving cause. Besides which, in several places on the chain, there are anticlinal axes produced by the volcanic upheavals.

It is strange that Mr. Trask should have adopted this view, and expressed himself so decidedly in his report as to class the Santa Inez mountains under the name of the San Bernardino mountains, to the confusion of topography and local names. "The inception," says he, "of this chain on the west was stated to occur a few miles north of Point Concepcion, and to follow the above trend (due east and west) nearly, or perhaps quite, to the Colorado river."† From his description he must have crossed this range in two places, and how he omitted observing the volcanic rocks, producing in places anticlinal axes, it is difficult to imagine. These hills, when viewed from the valley of Santa Inez, have their escarpments boldly looking toward the north, and tilted southward at a high angle, a condition of strata impossible to reconcile with their dependance upon San Bernardino mountain, lying 200 miles due east.

It is much more reasonable to suppose that the elevation of this range is much posterior in time to that of San Bernardino, and was produced by the same forces which elevated the Santa Lucia and San Rafael hills, acting in a direction somewhat more east and west than the other ranges, yet still in a direction more northwest and southeast than due east and west. The shore-line is in the latter direction, while the Santa Inez range deviates considerably; thus, at Rincon and near Santa Barbara it stretches into the sea, while fifteen miles west it is several miles inland. The direction south 70° east, would represent the lines of force which have upheaved the links of the range; the results of these upheavals we will presently consider.

Between the disposition of the Sierra Santa Inez and that of the more easterly coast ranges there is this difference: that while the other ranges are disposed so by virtue of their axial forces running along the direction of that range, the Santa Inez mountains are ridges *en echelon*, interlocking with each other, and running from west to east along a land previously

* Report of a Reconnaisance and Survey in California, in 1853: H. Doc. 129.

† Report on the Geology of the Coast Mountains, (State Document,) Sacramento, 1855.

upraised by the granitic mass which lies between Matilihah and the Santa Lucia mountains; an upheaval through which the Peyrou river has cut its way, forming deep cañons, and which extends west to the head waters of the Santa Inez. It is, in fact, this immense mountain district which gives origin not only to that stream, but to all the larger rivers of the south. From it the Santa Clara derives its larger tributaries; and from it, as a central point, flow the San Buenaventura, Santa Cruz, Sangre de Crista, and not only the Santa Maria itself, but the large tributary which flows east of the San Rafael ridge into that river, in the Cuyama plain. This granitic mass is a branch of that which forms the Cordilleras and the San José range; upheaved about the same time, and having the same character of granitic rock, it drops down very abruptly to the west, as it is not found in the Santa Inez, the San Rafael, or the Santa Lucia mountains, which all appear to radiate from the common centre. That it has not influenced either those mountains or their valleys is evident by its non-appearance in place, by the axes of those several chains being found to be of a different character, and by the general depression of the valleys with the rivers flowing down them.

The rocks of the Santa Barbara chain may be treated under the heads of volcanic rocks and sedimentary rocks.

VOLCANIC ROCKS.

The various species which enter into the composition of the axial rocks are trap, amygdaloidal and scoriaceous lava, talcose and whitish magnesian rock, passing in places (as in the bed of the Santa Inez river, near the Mission) into white tremolite. This latter variety forms the intrusive rock in the western portions of the range, rising up and forming small hills on the left bank of the river in the Santa Inez valley. At the western edge of the valley they pass N. W. and enter a low range of hills, which cut off this valley from that of La Purissima, and which run toward the ocean, forming the headland Punto Sal.

Upon these amphibole rocks lie the mass of sandstones known as the Santa Inez or Santa Barbara Hills. The occurrence of an elevating axis occupying a low position, or, as it were, at one side of the strata upheaved, is of common occurrence in the southern valleys of the State, so that the primary rock is often found occupying the plain, and the sedimentary strata form the mountain mass or elevated land.

Further to the east of this chain serpentine rock is found as the axial rock, either alone or with amygdaloidal trap, sometimes accompanied by trachyte or scoriaceous lava—the former occurring at Questa San Marcus, the latter at Rincon, east of Santa Barbara. Iron pyrites abound in the sandstones at San Marcus, and small masses of free sulphur accompany it when in contiguity with trap. Near Rincon it is also found abundantly, but in this latter place it appears to have been produced by deposit from volcanic exhalations in the gaseous form, rather than by decomposition of the sulphuret.

The igneous rock of the extreme west of the range is serpentine. This rock may be seen in large masses stretching into the sea at Point Arguello. In the extreme east of the range at Buenaventura river the rock is amygdaloidal lava, a reddish rough aluminous rock, the cavities sometimes filled with white magnesian clay, sometimes with carbonate lime, and occasionally altogether empty.

The result of these igneous rocks passing in the S.E. direction, and upheaving the strata, is to present at times the back of the strata, and at times the edge to the shore, and allowing both sides of the axis to be examined. There are several points along the range where the strata may be observed dipping both ways. This occurs at San Marcus pass and east of Santa Barbara, where at two points the chain may be observed to be broken through, and the strata tilted both S.E. and S.W. by the volcanic protrusion; about 4½ miles E. of the town of Santa Barbara this may be as well seen. The same may also be observed in the chain near Carpenteria. Thus, the strata are not only elevated by these magnesian and laval rocks, but they are also inclined in various directions in conformity with the direction and extent of those upheavals, proving that the elevation of the range is due, not to the granite of Bernardino, but to the magnesian rocks and trachytic lavas found in situ.

Accompanying the volcanic rocks are small beds of limonite (bog iron ore) arising from the decomposition of the pyrites found in contact with the trappean lava. The deposits are small and unconnected, and does not warrant the belief that extensive collections could be had of this useful ore.

The space occupied by the intruding rocks is rarely great. The widest veins were those observed in Santa Inez valley, at the point indicated previously, where the tremolite and amphibole rocks might be 150 feet in width. The serpentine has rarely been observed in one single place so thick, though often occurring in several seams parallel and contiguous. On the shore at Rincon the laval vein was 24 feet in width.

SEDIMENTARY STRATA.

The upheaved beds have been observed at several points, with results indicating considerable uniformity; they have been observed on both sides of the axis. In Santa Inez valley at Camp 22. The north side was examined, while the southern dip was observed at the Gaviote pass, and generally along the range to San Buenaventura river.

The various strata may be divided into five distinct groups:

Group 1. Greenish grits and fine conglomerate sandstones.

Group 2. Arenaceous sandstones.

Group 3. Brown and drab colored sandstones, coarse and gypseous.

Group 4. Calcareous sandstones, with veins of calcite.

Group 5. Whitish slaty argillite beds.

All of these beds were fossiliferous. Groups 1, 4, and 5 were best displayed in the Santa Inez valley, south of the river; while beds 2 and 3 constituted the chief mass exposed in the southern slopes, forming the bare and brownish crests and slopes which render the chain so similar along its whole extent, and which has a remarkable resemblance to the appearance of the sandstones on the two Panza hills.

In the order given above, these groups were observed either in passing from the shore into the Santa Inez valley, through the Gaviote pass, or in passing from Camp 22, in the valley, down the creek toward the mission, and the trail leading to the pass; or, finally, by passing over Questa San Marcus,* or up the San Buenaventura river, where a cross section of the range was obtained.

Camp 22 was favorably placed for observing the strata on the northeast slope in the Santa Inez valley, situated on the left bank of the river, two miles up a small creek, and overlooking the valley, above which it might be elevated 100 feet; it lay almost upon the axis of the range, which here crossed in a S.E. direction. Trappean rock, a brownish augitic variety, accom-

* For the geological information of this pass and a few other localities, I am indebted to my friend and fellow traveller A. H. Campbell, C. E.

panied with reddish jaspery sandstone and serpentine in veins, constituted the volcanic and altered rocks of the upheave.

These metamorphic rocks occupied the foot hills of the range which immediately overhung camp, and presented cliff edges or forming bold escarpments. These rise for several hundred feet at such a steep angle that it is difficult to ascend them on foot without deviating considerably; they presented to the eye only a mass of brownish red and yellow sandstones, which, when the ascent was gained, were found to dip south a few degrees east. The mountain here was not a single chain, but presented two crests through the depressions, in the further one of which the ocean was descried. The second range also dipping similarly to the south and east, they appeared to be repetitions of each other. In passing through the Gaviote pass a similar duplicate stratum was observed.

From the camp to the river Santa Inez the strata dipped in the opposite direction—that is, to the N.W.—and thus sections were afforded on each side of the axis, whose course here was N. 76 W., (magnetic.)

The sections on the valley side were:

1st. A little above camp and close to the axis, although not observed in contact with it, a greenish grit passing into conglomerate; where the rock approaches a fine grain it becomes calcareous, containing small grains of crystalline carbonate of lime. The exposed thickness of this bed was 200 feet.

2d. Brownish yellow sandstone, coarse grained, containing layers and seams of gypsum in places, and decomposing irregularly, so as to form cavities—fossiliferous.

3d. Whitish yellow sandstones, with fossil casts injured, followed by brownish flagstones; thickness, 200 feet.

4th. Sandstone grit, calcareous, and having flinty laminæ and veins of calc spar; this bed has layers of ostrea and pecten in great numbers; 160 feet thick.

At this point the bed of the Santa Inez river is reached, on the opposite side of which were observed the layers of the white fissile argillaceous rock already alluded to as found on the hill dividing the valleys Inez and La Purissima.

In figure 1 of plate 3 a section of the northern beds is given.

The section on the south side of the range was afforded by passing down the Gaviote pass. This is a cleft in the range carried down to the level of the surrounding land, and having a small stream traversing it. It is much blocked up by masses of sandstone which have fallen from the overhanging ledges of rock on either side. The mean width of the bottom of the pass might be about 50 feet, divided between the stream and the wagon road; it is in places only 30 feet; the road necessarily very rugged and contested often by the brook. With a little work, however, it might be made a good road, and appears to be the natural route to cross these mountains from the southern counties to reach San Luis Obispo and the north.

The pass occupies the position of a synclinal axis, the strata being bent downward on each side to this point, where, being fissured and broken by the pressure of the uplifting axes on either side, the debris has been removed by the usual actions of weather and running water.

Plate 4, figure 1, gives a view of the pass looking south, and figure 2 represents the ideal condition antecedent to the removal of the ruptured portion.

In the pass the sandstones dip at angles varying from 25° to 40° in the direction S. 15° E. Between the pass and the shore is an elevated plateau, or terrace, perfectly smooth, and with a gentle slope to the ocean, above which it is raised at least 80 feet; the strata on shore dipping at an angle of 40° into the sea and form a bulwark of natural masonry against further encroachments.

This elevated terrace continues the whole way from Point Concepcion to Santa Barbara ; along this distance it is cut into here and there by numerous arroyos running down from the mountains ; these cut their channels 15 to 30 feet down through the soft argillaceous and sandstone rock, not only exposing their layers, but also disclosing a peculiar feature in the geology of this southern coast, namely, that the low terraces and undulating hills close to shore are cut into by talcose and magnesian rocks, which have altered, contorted and tilted up the strata until the angle is almost vertical, and in some places making them incline the other way, or from the shore inland ; this latter direction may be seen wherever the mountain range is more than five miles from shore ; then the volcanic rock may be traced running through the mounds along shore, making the strata incline toward the mountain range. This is visible near Mr. Hill's ranch, a few miles west of Santa Barbara, and is also remarkable in the Los Angeles valley. These elevating forces, though more recent than those which upraised the mountain range, were still antecedent to the elevation of the whole land above the water level, inasmuch as the smooth and denuded surface of the upper edges of the strata which form the floor of the terrace indicate the long continued action of the sea flowing over it.

To return to the sections of strata of the sierra on the shore side of the range, commencing at the water's edge, and passing along the terrace up the pass into the valley of Santa Inez, the following was the superposition of the beds :

1. Whitish yellow argillaceous beds, alternating with thin arenaceous slates ; dip from 30° to 60° S.E., intruded upon by magnesian rock. This is the same rock as that described as occurring on Santa Inez river, and on the road to Purissima ; also, similar to those on the terraces of the Santa Maria river, in Cuyama.

2. Beds of sandstone—grits fine and coarse—brownish in color, weathering irregularly, and containing ostrea in layers ; the stratum containing this bed is 10 feet thick. Then follows greenish brown sand rock, containing impressions of fuci, broken and imperfect—a soft stone, readily crumbling.

3. Brown sand rock, fine grit ; containing a bed of fine grit with *Ostrea Panzana*, 10 feet thick, accompanied by *Natica Inezana*. This bed contains some hard flagging layers lying above the ostrea stratum ; thickness, 150 feet.

4. Greenish sand rock, with calcareous layers, containing *pecten, ostrea, turritella, and pachydesma*. This bed forms one of the loftiest in the pass.

5. Brown sand rock and greenish conglomerate—very similar to bed 2, on the north side ; thickness, 200 feet.

In continuing up the pass beds 2, 3, and 4 were met ; the repetitions of these strata on the 2d ridge. These terminate near the river, in the valley Santa Inez. It is difficult to estimate exactly the total thickness of the strata, inasmuch as those hidden beneath the terrace, whose position is beneath 1 and 2, extending three-fourths of a mile from the sea to the mountain base, may be but repetitions of similar strata contorted by the magnesian rocks. The thickness of the strata in the pass is about 950 feet, and above 200 feet more lies further down outside ; so that, allowing 150 feet for bed 1, the total thickness of the group cannot be less than 1,500 feet.

At the camp situated 5 miles N.W. of Santa Barbara, among the foot hills of the range, the strata containing pecten meekii, with veins of calcite, were found lying behind camp, and were quarried as a source of rough lime. A section of the strata on the south side is given in figure 2, of plate 3.

Upon the terrace, near Ortegas ranch, an arroyo cuts its way through to reach the shore, disclosing the terrace strata tilted up at a high angle and bent, and the whole swept smooth by denudation. This is illustrated in plate 3, figure 3. The intruding mass is a magnesian and ferruginous clay, with seams of gypsum and traces of sulphur, probably separated by decomposition from pyrites. This upheave has occurred beside the foraminiferous bed of the asphaltic group, or the San Luis beds; this, in its elevation, carried before it the soft, white argillaceous beds of San Luis, (stratum 1,) and bent them completely, forming an arch over the intrusive substance, beside which is a gray, dark sandstone rock here seen dipping under it.

Near this ranch, upon the shore, the asphaltic strata again shew themselves; a thickness of about 6 feet is exposed in the edge of the cliff on shore, the beds dipping into and under the sea. The lower layers are dark greenish, with an upper layer two feet thick of yellow sandstone. The layers are fissured, and the cracks filled in with bitumen; the latter is washed ashore here by the tide in masses from ½ pound to 4 and 6 pounds weight. An examination did not discover any deposit of it at this point of the terrace, but there is no doubt that some miles out at sea a dislocation of the strata allows the mineral to escape and to be washed ashore. At times, as when the wind blows on shore, the whole air is impregnated with the bituminous odor, which is thus disseminated for miles over the low lands. The strata, which at this camp (24, on the terrace) are covered up almost entirely by the tide, a little further east are exposed, and form the low hills which lie immediately west of the town of Santa Barbara; the shore line here commencing to deviate near to the south, leaving a larger interval between the base of the mountains and the sea. As this distance widens to six miles, the high terrace drops down, and in its place are undulating swells of land, 100 to 150 feet, lying along shore, and cutting off from the sea a low and fertile valley, very little above the level of high tide, and which is in part occasionally overflowed by it. Mr. Hill's ranch is at this point. Before the last elevation of the land which raised it above sea level, this was an arm of the sea stretching up to the base of the mountains. It is now a fertile valley, and, between grantees and squatters, well filled up.

The asphaltic shales at this point are conformable with the white agillite rock found at the cliff edge, Gaviote pass; as these beds have been fully noticed elsewhere, (see San Luis valley, and the chapter on bituminous effusions,) their further consideration may be dispensed with.

The Santa Inez range sends out a terminating ridge a few miles east of the town of Santa Barbara, produced by one of the protrusions of igneous rock, in a southeast direction, throwing the upraised strata in opposite directions, making the dip vary from northwest to southeast within a few hundred yards. In this part of the chain, the volcanic forces cannot be said to be quiescent as yet. On Dr. Robbins' ranch, which lies near this spur, occasionally fire, smoke, and sulphurous vapor has been emitted, from fissures in the rock, in large quantities within a few years past. A similar volcanic vent exists at Rincon.

This point (Rincon) is interesting as being the termination, along shore, of that link of the range which lies behind Santa Barbara town, and over Questa San Marcus leads. The axial rock is scoriaceous lava, resembling, in some places, furnace clinkers; in others it is a whitish-gray, hard trachytic rock. It is not more than twenty-five feet wide on shore, running into the sea to form a prominent headland. The stratum seen in contact with it is a soft, reddish sand rock of an ochry tint, then whitish clay rock, then green sand rock with layers of bitumen, and then seams of gypsum, the stratum fractured and re-cemented; while veins of pyrites accompany the white clay rock, which is there hard and flinty. The bright red tint of the stratum near the trachyte is very noticeable, and, with the hardening of the strata, is the result of plutonic action decomposing the pyrites. A similar appearance of the strata was observed by Mr Campbell on the San Marcus pass, where he also found a serpentine axis accompanying the trachytic lava; the decomposition of the pyrites was there effected on a much larger scale, considerable deposits of sulphur being found in clefts and chinks of the sandstone strata impinging on the axial rock. Limonite occurred in partial deposits near that locality.

Rincon is the most easterly locality where the axial rock of the Sierra was observed along shore. In passing up the river San Buenaventura, about two miles above its mouth, an anticlinal axis occurs on the right bank of the stream; the sandstone strata form low hills there, and the igneous central rock is not upraised; this low range, which the river cuts through, and has worn into it a wide valley bed, is two and a half miles across in width, from the shore northward; still higher up the river, another range is met six miles north of the first, there reddish amygdaloidal trachyte, having a dull earthy fracture, crosses the river in a line northwest and southeast. On the east side of the river, and contiguous to the igneous rock, a spring, which deposits sulphur, is met, and beside it a large outflow of asphalt, solid along the margin, but toward the centre readily yielding to the pressure of the mule's foot, and in places oozing up in the condition of a syrupy liquid. The rock through which the bitumen is effused is a yellow sand rock.

Above this point the river bed widens and opens into a valley bounded by mesas or terraces given off from the hills, and having an elevation of fifty feet above the river valley; these mesas are of sandstone covered over with its own detritus, the wear of the foot hills. A lofty range bounds this valley on the north and northwest, which may be considered as the eastern continuation of the San Luis Obispo hills, while those to the south may be looked upon as the Santa Inez and San Rafael mountains, the two ranges being here blended thus closely together so as to become intimately one. The elevation of this valley is about 700 feet above tide level, and is called by the Indian name Mat-ili-hah.

The Buenaventura river has its source in this northern range. In the glens between the ridges it courses its way downwards, crossing augitic dykes and metamorphic rocks, over which it forms cascades, until it finds its way into the valley of Matilihah; in this upper course it heads considerably in the west, and finds its source not many miles apart from the sources of the Santa Inez river. The exploration of the upper waters of this river was a fatiguing and difficult performance. The strata met with were hard sandstones, conglomerates, chloritic slates, and augitic trap, with amygdaloidal trachyte. Beds of black shale, accompanied with sulphuret of iron, occur, intercalated with the hard gray sandstone. Sulphur springs are frequent in these strata, which are sometimes elevated, and sometimes only cut through by the trachytic rocks. No developments of serpentine were met in these hills. These strata may be looked upon as very much altered in character, and have little resemblance to those lower down and nearer the coast; they resemble more the beds found flanking San Emilio, and the whole region may be considered as the commencement of that mountainous district which extends north to Tejon and the Sierra Nevada.

From this region the Santa Inez mountains are separated by the little valley Matilihah, and from the sierras Susanna and Monica by the valley of the Santa Clara river. Their eastern and northern termination has been now traced. The whole sierra is made up of sandstones of various degrees of fineness, highly calcareous in a few beds, and fossiliferous in almost all; the fossils included belong to the upper Miocene group, corresponding to the "Faluns" of M. Cordier, which from its great thickness forms one of the most remarkable features in the geology of California. The soil, formed by the debris of the strata, varies with the nature of the stratum decomposed. The green sandstones are calcareous, and form a fertile soil, while the brown and yellow sandstones form only a barren sand by disintegration.

In the strata on the north side of the mountains (in Santa Inez valley) the following fossils were obtained, (for the description of the species *vide* Palæontological Report.)

In the lowest stratum, (nearest camp,) bed 2:

Mytilus Inezensis, *Turritella Variata*,
Pachydesma Inezana,

constituted the only species, but existing in remarkable abundance, in some layers pachydesma predominating, in others turritella.

In the sandstones which lay above this bed, which were of a light yellow tint, bed 3, were:

Tagelus, (*Cultellus*, Conrad,) *Tapes Inezensis*,
Turritella Variata, *Crassatella collina*,
Cyclas permacra,

along with comminuted portions of an Ostrea.

In the upper bed, bed 4, were found:

Turritella Inezana, *Cyclas Estrellana*,
Natica Inezana, *Cyclas permacra*,
Pecten Magnolia, *Pecten* (perhaps young magnolia.)
Balanus Estrellanus,

In the strata on the south side were observed, in the Gaviote pass:

Crassatella collina, *Turritella variata*,
Ostrea Panzana, *Pachydesma Inezana*,
Mactra Gaviotensis, *Tapes Montana*.
Mytilus Inezensis,

Among the foot hills, near Santa Barbara, (Camp 25:)

Pecten Meekii, *Cyclas Estrellana*,
Natica Inezana, *Pecten discus*,
Balanus Estrellanus,

and southeast of the town of Santa Barbara the foot hills contain a layer of *Ostrea Panzana*.

It is highly probable that the brown and yellow sandstones of the Gaviote are the middle beds, and lie between beds 1 and 2 of those on the north side; they possess Turritella and Pachydesma in common with the northern beds, and have the ostrea layers extensively developed. The beds at Camp 25 are the representatives of bed 4 of the north side, but possessing the *Pecten Meekii*, a fossil also present in the foot hills of San Rafael sierra, where it is accompanied by *Balanus E.*, rendering it exceedingly probable that the strata of San Rafael are similar to those of Santa Inez.

The upper beds on the north side, as well as the upper beds on the south side, are distinguished by the abundance of *pecten*, it being the dominant shell.

Mytilus and Pachydesma dominate in the lower beds of the north side, while they are sparing fossils of the Gaviote, where ostrea is the dominant shell. The numbers of species common to this sierra and the slopes of the San José mountains, at Panza, show that similar conditions existed 100 miles further inland, as at Santa Inez, yet the absence of *Asterodapsis*, *Pallium*, and *Ostrea Titan*, show that they may not have been under like circumstances of depth or deposit. It is still further removed from the groups of Santa Margarita, having only *Cyclas* and *Balanus* in common. As both Panza and Margarita now occupy positions several hundred feet above the Gaviote beds, they may, even in the period of deposition, have been on a more elevated base, and as the deposits were from the east and north, they may have so thinned out in the deep waters as to leave but slight representatives. All the strata appear to thin out towards the south; the sandstones, of Santa Inez range at Gaviote are apparently much thicker than at Buenaventura.

CHAPTER XI.

GEOLOGY OF THE SIERRAS SANTA SUSANNA AND MONICA.

Geographical position of these ranges.—External form of the hills.—The two chains separated by Conejo pass and Semee creek.—Analogy of the strata of the Sierra Susanna with those on the San Buenaventura at Matilihah.—Connexion of the range with the Cordilleras.—Sierra Monica.—Trappean rocks.—Slow disintegration.—Effects of.—Absence of timber.—Contrast of Semee plain with the valleys of Encima and Triumpho.—Trachytic upheaves.—Traces of two different volcanic forces.—Trachytic rocks and augitic trap.—Enumeration and order of the sedimentary beds.—Fossiliferous sandstones and limestones.—List of fossils.—Similarity of the Susanna and Monica ranges.—Occurrence of the asphaltic group in the latter range.—Extension into Los Angeles valley.—Thickness of the beds of that group.—Resumé of the structure of these beds.—Probable thickness of the sedimentary strata.

These hills occupy the triangular space comprised between the Santa Clara river, with its valley on the north, the ocean on the south, and the plains of Los Angeles and San Fernando to the east, embracing a district 40 miles long from west to east, and 26 miles from north to south. They constitute distinct ranges of hills, running in a direction nearly east and west, having a slight northeast trend.

They present in outline a series of rugged angular crested hills, which run parallel and rise to an altitude of two to three thousand feet. As many as four of these ridges may be counted in the Sierra Susanna, which lie most northerly, and are first met in passing up the Santa Clara, against which river valley they abut their western edges. Each chain to the north lies a little east of its neighbor, and thus the Santa Clara valley runs northeast until the river finally winds behind the most northern ridge, and separates it from the Sierra Madre or Cordilleras, leaving a communication by a pass between the Santa Clara valley and the plains of San Fernando.

The two sierras are separated from each other by the Conejo pass, a considerably elevated plain rising from the Santa Clara valley and passing in a line N. 30° E., enters the San Fernando valley at its northwest corner; as the pass narrows it loses its plane character, and is cut across in places by ridges of plutonic rock. Down the slope of this pass rolls the Semee creek, a small stream which fertilizes the pass, and finds its way into the ocean at the eastern end of the Santa Clara valley. The ranch Las Posas lies upon this creek, at the point where it leaves the pass to flow through the valley below. To the north of the pass lie the Sierra Susanna; to the south, the Sierra Monica.

The Sierra Susanna, where observed, was made up of the red and yellow sandstones, similar to those observed upon the Buenaventura river, crossing it 12 miles above the Mission. In the most southerly of the ranges the strata dip N.E. about 18° to 20°. No primary rock is observed in this sierra, the intrusive masses being amygdaloidal trachyte and felspathic porphyry rock. Only the southern slopes of these ranges were observed, those upon the north side not having been traversed. This range is connected at its southeast extremity with the Cordilleras by an upheaval of trappean rock, which, starting from these hills, runs northwest toward the shore, carrying upon its flanks the same sandstones, which may be traced from the Cordilleras to San Buenaventura.

Sierra Monica.—These hills lying parallel with the road were better observed; like the foregoing, they are made up of parallel ranges running easterly, and rising to a considerable height in the centre of the range. The volcanic rocks have there elevated the whole mass of the surface considerably, so that even the valleys are several hundred feet above the Santa Clara river.

Semee plain, which lies at one of the most elevated points of this region, having an altitude of 1,400 feet, is a small valley, surrrounded by igneous rocks, which rise a few hundred feet, forming bounding walls. The buttes, which lie east and west, are a reddish felspathic rock full of amygdaloidal cavities, some of which are encrusted with a yellow zeolitic powder. It is not unusually rough to the touch, but is slow of decomposition, forming a thin soil, which does not remain attached to the hill, but is washed down, leaving the sides of the butte naked, and incapable of supporting any growth of timber. The absence of trees of any kind upon these hills strikes the observer at once as a phenomenon very remarkable; where a few miles travel could present him with luxuriant growths; as the hills are unclad, so of course are the vallies, the latitude being too low for arborescent growths, and thus an air of perfect sterility crowns the whole; while, a few miles south, lying upon the calcareous sandstones, the small valleys of the ranches Encima and Triumpho are covered with evergreen oak, loaded with the hanging ramalina, and growing on rounded knolls well covered with grass. South of these valleys a high range runs east and west, cutting them off from the coast, which may be reached by deep cuts or drops in the range, the centre or axis of which is the red felspathic amygdaloid alluded to—a trachytic rock; this upheave tilts the strata to the northwest, (between Camps 34 and 35,) which is the general dip of all the sedimentary rocks of the vicinity, save where they are again broken by dykes of augitic rock. There appear to be two volcanic forces at work in these hills: 1st. The trachytic rocks, including the amygdaloid and the compact red felspathic variety, which encloses small angular crystals of quartz and glassy felspar. These occupy both the small isolated buttes on the plain as well as the centres of the lofty ridges; and 2d, augitic trap, which does not form an axial rock, but partially uplifts, and cutting through the strata forms dykes of more or less thickness; the former of these volcanic rocks runs from east to west, (N. 80° W., S. 80° E.,) the other more north and south; thus they cut across and intersect each other, and coutort the strata considerably.

The sedimentary rocks are brownish, white, and greenish sandstones, including calcareous layers, which are highly fossiliferous. The arenaceous beds of the sandstones are poor in fossils where examined, containing *mytilus Inezensis*, and are either a felspathic sandstone, with angular quartz particles, or they are a soft greenish sand rock, similar to that which is everywhere along shore associated with the bitumen.

The order in which these beds are exposed are north of Semee plain, reckoning from above downward:

1st. Reddish sand rock, 100 feet exposed; 2d. Whitish grit, 80 feet exposed; 3d. Yellow sandstone, with a calcareous layer 14 feet thick, 150 feet exposed. This last rock is in contact with an augitic dyke; in the calcareous layer are found well preserved *natica*, *cardium*, and *turritella*.

The foregoing strata have a general dip to the north, which, in the majority of observations, did not exceed 15°.

In passing from Camp 34 to 35 the road lay over some elevated strata which formed the divort between the plain Semee and the ranch Triumpho. The capping rock of this locality is a soft brown sandstone grit, which readily decays, forming a quartzose sand, which accumulates in hollows. This sandstone corresponds to the third bed, mentioned above as north of Semee; it included a bed of bluish limestone, a compact, and heavy rock. The whole mass of sandstone rises about 600 feet above the plain, has an easterly trend extending to San Fernando plain.

Both this brown sandstone and the included limestones were fossiliferous, the latter abounded in vegetable remains and estuary shells. The sandstone fossils were few and very difficult of preservation. The following species were collected from these strata, the descriptions of which are found in the Palæontological Report appended: *Lutraria transmontana, Axinea Barbarensis, Natica Inezana, Ostrea subjecta, Cyclas permacra, Tapes montana, Perna montana, Tapes Inezensis.*

Except tapes montana, lutraria, and perna, the other fossils were found in the hills bounding the plain of Santa Barbara, and lying at the base of the Santa Inez range.

As the reddish sand rock which forms the base of the Monica hills is also found in the Susanna range, there can be but little doubt that these mountains are but repetitions of each other, and both but the continuations of the strata immediately superimposed upon the Santa Inez range of sandstones lying further west. The existence of mytilus Inezensis in this shows the continuity of the bed, although otherwise not containing many fossils.

Tapes, lutraria, natica, and perna were found in the layer of limestone described as existing in the yellow sandstone, (bed 3.) Ostrea subjecta was not found in place by the writer, but was brought in and described as found in a very loose clay rock; its position must have been superior to any of the other fossils of this section. This limestone was probably of estuary or lacustrine origin, judging from the minute paludinal shell present in it, and from a nodule of it containing some fibres of endogenous wood. The whole nucleus was silicified and of a brownish hue.

Lying above the foregoing series of rocks, but not observed occurring everywhere throughout this range of hills, are the beds of sandstone grit and fine argillite rock which we have described in connection with the bituminous rock almost wherever examined. It is in this range seen at the eastern edge, in the valley of Los Angeles, north of the town, where the asphalt springs exist. It also constitutes the uppermost strata of the hills at the coast near San Pedro. At these two points in this twenty miles apart the dip varies. At San Pedro it is a gentle dip northward. At Los Angeles it is almost vertical. In the latter place the strata are hard, ring to the hammer, and are rendered metamorphic by the volcanic protrusions. At San Pedro they are soft clay and sandstones. These upper beds of the sierra are the same as described under the term of asphaltic and foraminiferous beds when treating of the valley of San Luis. In these hills (Sierra Monica) they appear unaccompanied by the trappean conglomerate reported in that valley as being the inferior stratum; at least this conglomerate was not recognized from Point Concepcion eastward. Here, also, the upper strata are less thick, not more than 175 feet. North of Los Angeles they occur in this order:

Yellow clay rock, shaly	30 feet.
Whitish soft argillite	25 feet.
Yellow sandstone, with quartz layers, bituminous	120 feet.
Total thickness of upper beds	175 feet.

As the lithological and fossil characters of these beds have been already described, it is unnecessary to repeat them here.

Thus the Sierra Monica appears to be made up of strata over 500 feet in thickness, which are susceptible of division into two groups:

1st. The hard sandstones, both red and yellow, which were observed along the Buenaventura river, and which contain calcareous layers that are highly fossiliferous. Similar beds are found on the low hills near the Indian villages, four miles west of Santa Barbara. The thickness of these over 300 feet.

2d. The bituminous and argillitic beds—soft rocks—including foraminiferous beds, found along shore near Arroyo Hondo and at La Purissima, and described under the report on the valley of San Luis. Total thickness nearly 200 feet.

Both of these groups are uplifted, contorted, and altered by the volcanic rocks which elevated them.

The Sierra Susanna was but hastily examined; only the lower beds of the Monica hills (group 1) were observed. It is probable that group 2 would be on its northern flank; but this district was not travelled over.

An outline of the order of position of the strata of Sierra Monica is given in plate 5, figure 2; also in plate 4, figure 5; and plate 7, figure 1.

CHAPTER XII.

PLAINS OF SAN FERNANDO, LOS ANGELES, AND SAN BERNARDINO.

Position and extent of the alluvial plain at the base of the cordilleras.—Subdivision.—Altitude of the plain.—Secondary valleys.—Variable fertility.—Vegetation of the upper plain.—Supply of water by rivers and sequias.—Variety and beauty of the flora.—Grape culture.—Oranges.—Apples and peaches.—Number of vineyards in Los Angeles valley.—Manufacture of brandy.—Mode of cultivating the grape.—Stock supported by the valley.—Stock raised in California in 1854.—Increase of 1855.—Geological structure of the plain.—Different dip of the strata.—Quaternary deposits.—Artesian borings.—Nature of the soft beds.—Origin of the clays and gravel.—Absence of boulders and polar drift.—Boring in Sacramento valley.—Variable depths of beds above blue clay.—Length of periods of deposition.—Conditions of the plain during the deposit.—Partial denudation of the detritus.—Review of the deposit of quaternary clays.

Lying at the base of the Cordilleras, in parallel 34°, is an extensive plain, which slopes gradually from that range to the shore of the ocean in a southwesterly direction, and embraces a vast area, being a hundred and eighty miles long from east to west, measured at the base of the Cordilleras, and narrowing to 30 miles at the shore of the Pacific, presenting a blunt pyramidal form, the flattened apex being to the ocean. Its greatest extent in a line due north and south is 40 miles. This great expanse is broken into by a low range of tertiary hills, which run from west to east, at an average distance of 13 miles from the foot hills of the Cordilleras, and thus divide the area into an upper and a lower plain, which are connected by wide passes in the tertiary hills, the present valley beds of the various streams which roll from the base of the mountains to the sea—as the Rio de los Angeles, Rio San Gabriel, and the Rio Santa Anna.

These have worn their way through the low hills and formed those passes during the present epoch, the whole range of tertiaries having formed one continuous chain previous to the last geological change.

The result of the wearing down of these hills by the rivers is to connect the upper and lower plains together, and thus divide the whole Pacific slope into several smaller valleys, which receive distinct names, as the San Fernando valley, the San Bernardino, and the Los Angeles valleys or plains; strictly speaking, they are not valleys, but ancient alluvial plains.

Between these and the ocean is another low range of tertiary hills, which separates the slope from the present shore, and gives rise to the accumulations of water both on the surface and in extensive deposits beneath. The elevation of the plain varies exceedingly in its upper and lower limits; the following are the altitudes of a few points examined, given in feet:

In the upper portion of the valley—

Kikal Mungo ranch	1307	Mission of San Fernando	1048
Sycamore grove, (Cajon pass)	1900	Jurupa	1000
San Bernardino town	1118		

In the lower portion—

Los Angeles	457	San Pedro	30
San Gabriel	354		

It may be remarked that the base of the Cordilleras along its whole extent presents considerable uniformity of elevation, and the valley at its upper limit has an average level of 1,200 feet. In the extreme east of the valley it becomes more elevated as it approaches the lofty Sierra Bernardino. The whole of this portion of the plain is less continuously level than the western, being broken into by the extremities of the ranges, which are here slightly elevated, and which rise to a considerable height as they approach Temescula mountain, a lofty granitic mass lying midway between San Bernardino mountain and the shore. These narrow the plain at the N.E. extremity at the same time that they elevate it. Those mountains have between them secondary valleys which pour their little streams into the Santa Anna. The plain as a whole may be divided into two: that whose elevation is from 900 upwards, and that which descends from 900 down to the level of San Pedro.

In the former would be included the San Fernando valley and the plains of Kikal Mungo and San Bernardino; in the latter would be the plains of Los Angeles, San Gabriel, and Monte.

This extensive plain is separated from the Santa Clara river valley by the Sierra Susanna, already described, which run into and join the sandstone hills forming the foot hills of the Cordilleras. The elevation of that valley, where it is entered from San Fernando plain, is nearly 1,300 feet, (1,286.)

Along this uniform slope, averaging 14 feet to the mile from the Cordilleras to the shore, a great difference of fertility might be expected, a diversity of soil and a variety of vegetation; but it is not so. The diversity of growth is more evinced by the appearance of timber on the streams than by the growth of grass; and with regard to the soil, it is an uniform mixture of clay and rolled pebbles, forming a light brown loam, with a considerable growth of vegetable mold in its superficial portion. The soil of the lower plains is finer and more clayey, but one common statement might comprise the soil of the whole plain in its utmost extent, namely: local and defined beds of clay, (modern alluvium,) resting upon a bed of fine conglomerate clay and gravel, (ancient alluvium.)

In the upper plain, about the town of San Bernardino, near Jurupa, and on the Cajon creek, near the pass, sycamores grow abundantly, near water, with oaks, alders, and cotton-wood; there the oaks, button-wood, and sycamores increase with the altitude, and are found plentifully on the foot hills, both of Kikal Mungo and San Bernardino.

The upper plains are much better watered than the lower, partly from more rain falling on the more elevated surface, but chiefly because the rivers as they roll down the valley are gradually absorbed by the porous and sandy nature of the soil, which in places is of great depth. Thus a few hundred yards below the town of Los Angeles, the river, in summer time, ceases to flow, it being mostly removed by infiltration into the subsoil, and partly by evaporation from the heat, which, for a few months in the year, is very intense. Indeed, everywhere over the whole region the rain fall, which does not exceed 16 inches yearly, is not sufficient to support vegetation, and hence, in the upper valleys at San Fernando and at Kikal Mungo, irrigation by sequias is had recourse to; and without this system the plains of Los Angeles could not produce the excessive crops of grape vines which they do. In the spring and early summer there is abundant water derived from the melting of snows on the Kikal Mungo and the San Bernardino ranges, which are occasionally retained on their summits to the middle of summer, and supply the numerous arroyos and creeks that find their way into the San Gabriel or Santa Anna rivers; besides which, the dews which fall nightly in spring are very heavy and are equivalent to a mild rain fall.

A very fine meadow grass grows in portions of the valley, and the wild oat is common over the whole extent. East of Los Angeles, and between Monte and the Cajon, hundreds of acres were occupied with sunflower, (*Helianthus petiolaris*,) of unusual height, 10—12 feet, in blossom and often disputing the road by their numbers. A hundred other species of more humble growth, but exceeding it in beauty, covered the whole surface of the plain, rendering it a beautiful object to behold: among these were the species Calendrina viola, (pedunculata,) Gilia, (five varieties,) Eritrichium, (fulvum,) Nemophylla, mimulus, orthocarpus, pentstemon, erodium, and salvia.* Above all were conspicuous the Escholtzia, (Californica,) and the salvia, which by their scarlet and red flowers gave to the base of the hills the appearance of a finely dotted carpet. Nor should the wild mustard and the clover be forgotten. Under the latter name come the "alfalfa," which is extensively spread over the valley and ripens its fruit in autumn ; the stalk then dies and scatters its capsuled seeds on the ground, where they form so thick a layer as to mask the ordinary growth below and give an air of barrenness, from their brown color, to a soil essentially fertile. A prickly burred capsular surface invests the seed, whence it has derived the common name of *burr clover.* It is highly nutritious, and much sought after by the domestic cattle, who devour it with avidity, and upon which they fatten when other leguminous plants and grasses fail from drought.

That portion of the plains which do not much exceed 1,000 feet in elevation are admirably adapted to the culture of grape and other kinds of fruit which require a warm and constant temperature. The vineyards of Los Angeles have been long famed for their productiveness in supplying the more northern sections of the State with the grape, the pear, apricot, peach, apple, and fig. During fruit season the steamers from San Pedro go up laden with grapes, peaches, and pears, which are delivered at San Francisco and Sacramento. The apple does not grow to any great perfection, owing to the climate and latitude being too near the intertropical zone, but the pear, the peach, and the fig trees, bear very abundantly.

The orange has not of late been extensively cultivated, although it grows remarkably well. At the mission San Gabriel are large orchards of this tree growing in the open air, and ripening their fruit at the close of the month of May. Its cultivation can be made as profitable as any other fruit production, owing to its luxuriant growth, and, as already a few small orchards have been planted around the pueblo of Los Angeles, there is little doubt that in a few years this fruit will form a staple article indigenous to the plains. The climate and soil appear both to have united in favoring the growth of the grape in California. Commencing with a few cuttings which 150 years ago were transported from Malaga to this country, it has spread with remarkable rapidity and rendered itself almost a native in its quick growth. The number of vineyards in Los Angeles county are (1855) 125, each producing seventy thousand pounds of grapes annually, or making an aggregate of above nine millions of pounds. The value of the grapes varies according to the time they ripen and are in condition to be shipped, ranging from three to twenty cents per pound. It is estimated that two-thirds of the whole amount shipped would not exceed three and a half cents. Under the present culture there is much loss from neglect and inattention, not harvesting them sometimes until heavy rains come, when they are rendered worthless.

The rough estimate made of this growth sets down one-half of the entire crop as being manufactured into wine and brandy, one-quarter sold for shipping, and one-quarter for domestic use, including waste and loss ; very nearly 100,000 gallons of wine and brandy are manufactured in the county annually, which is valued at $2 per gallon. In 1854 it was calculated that $50,000

* *Vide* Botanical Report and synopsis.

was paid out by shippers for grapes during that season, which was much beyond that of any preceding year.

Most of the fine graperies near the pueblo Los Angeles extend along the river side. One proprietor, Don Luis Vigné, had 42 acres under his vineyard, the largest in the county. The vines are planted in rows of hills, the plants being about 6 feet apart each way. They are watered by sequias or open drains from the river, which roll in a channel down one side of an allotment with side sluices for allowing small streams to flow in between the rows and irrigate the ground. The water is allowed to lie on the surface from 4 to 6 days, and then shut off, and this process of irrigation repeated several times during the early growth of the fruit.

But little attention was bestowed upon the manufacture of the wine, and the article, until within the last few years, was not what either the climate or the variety of vine would warrant. A Mr. B. Wilson has commenced the manufacture of a sparkling wine, which is said to be equal to if not superior to the Catawba.

The natural gramineous and leguminous plants indigenous to these plain support an immense number of stock of a wild, shy and intractable character. But little attention has been bestowed upon the rearing of cattle, and no cultivation of dairy produce has yet been attempted. These plains are the headquarters for the supply of stock to the northern parts of the State, and since the number of cattle driven over the plains into California has sensibly diminished, it is to these extensive prairies that the supply of Sacramento and San Francisco is due.

A local paper of credit* places the amount of beef stock then (1855) in California, exclusive of arrivals during that year, as follows:

Counties.	No. of cattle.
Los Angeles	101,800
San Bernardino	27,000
San Diego	8,100
San Luis Obispo	12,500
Santa Barbara	40,050
Monterey	32,900
Alameda	8,200
Contra Costa	4,000
	234,550
Add three tenths for other counties	67,365
Total of native stock	301,915

The natural increase of 1855 was large; in San Bernardino it was, over and above sales, 21,000; in Santa Barbara 7,000, and in Monterey 3,000.

The cattle brought over land during the same year was calculated at 100,000 head; one third of those sent from the east usually perish on the way.

The geological structure of this plain is somewhat different from that of any region which has been described. Its northern boundary are the sandstones which lie on the flanks of the granitic axis of Kikal Mungo mountains. As these sandstones extend westward in a continuous

* California Times and Transcript, 1855.

line to form the Sierra Susanna, and as they have there been recognized as similar to those on the Rio San Buanaventura, which are certainly Miocene, it may, perhaps, without error, be asserted that here they are of a similar age. They constitute lofty hills which have suffered very much from denudation, and which are daily losing by the effluent streams which carry down their detritus to the plain. The low ranges which intersect the plain and divide it into two are the outliers of the Sierra Monica, which stretch toward Jurupa, and have suffered by the fluviatile erosion already alluded to, and belong to a later period of the same group. These strata dip north, while the Susanna sandstones dip south on the north side of San Fernando plain. The low ranges of San Pedro, which extend along shore, are a repetition of these beds further inland. These strata also dip to the north. Thus two basins are formed by the dipping of the strata. In the San Fernando and San Bernardino valleys the strata dip toward each other, while in the Los Angeles plain it is only the southern ridge of San Pedro whose strata dip north. The hollows formed by the slope of the strata is filled up by Quaternary clays and gravels, the depth of which can only be estimated approximately; in the Los Angeles valley more exact information has been gleaned, owing to the sinkings made for an artesian well a little outside and west of the town. The selection of the spot was most unfortunate for success and might have been avoided by a little geological knowledge. During the period of visiting these plains boring operations had been suspended until the arrival of fresh apparatus from San Francisco.* The augur had already perforated 540 feet without meeting with water; a heap of bluish plaster clay with yellow gravel of granitic pebbles were the only indications of the subterranean constituents. Messrs. Butt and Wheeler stated that, after passing through 30 feet of clay, sand and gravel were the chief beds met with; solid rock, however, had not been reached when the labors were suspended, so that these incoherent Quaternary beds were over 500 feet in thickness.

Dr. Trask, who examined this locality during the period of artesian boring, gives the following as the thickness and nature of these beds to the point at which the sinking had then reached, (400 feet.)†

1. Alluvium, 6 feet.
2. Blue clay, 30 feet.
3. Drift gravel, 22 feet.
4. Arenaceous clay, 16 feet.
5. Tenaceous blue clay, 160 feet.

This catalogue only embraces 234 feet; further enquiry at the pueblo only showed that nothing but blue clays of various degrees of coherence were met with. This would give to the lower bed a thickness of above 300 feet. Such a thickness of deposit might be attributable to the local circumstances, namely, a deep trough in the sandstone strata under an elevation almost vertical, close by; yet that these incoherent beds are usually of great depth is evident from the smooth surface of the whole plain, which preserves its gradual slope from the Cordilleras to the ocean, independent of the dip or upheaval of the strata beneath. Again, when looking from the south entrance of the Cajon pass towards San Bernardino, at an altitude of 2,000 feet, there may be perceived a broad terrace at the base of the mountain, consisting of loose conglomerates, gravel and clay beds, lying at an elevation nearly 200 feet above the present

* Rep. Geol. of Coast Mountains; Doc. 14, sess. 1855; Cal.

† Since his visit a further sinking of 140 feet was made, and then the operation was abandoned from ill success.
T. A.

level of the plain in its neighborhood, and which are the only remains of a series of beds which have been removed from the lower and more exposed parts of the plain. Its average thickness perhaps might be about 200 feet; the other beds would preserve throughout a pretty uniform thickness; of these, bed 4, an arenaceous yellow clay is described as containing small marine shells. The brownish loamy clay (bed 1) is exposed by every creek, and in the sections produced by the Los Angeles river several feet of the bluish clay (2) are exposed; the beds are deposited almost perfectly horizontal, and are therefore unconformable to the soft sandstones of the San Pedro hills and the Sierra Monica, which in the former case have a dip of 20°, and in the latter are in places almost vertical; they have, therefore, been deposited posterior to the upheaval of these soft tertiary sandstones, and the surfaces have undergone no material alteration of contour since, the only change being that of elevation of the whole region out of the bed of the sea.

An investigation into the mineral nature of these various deposits shows that the alluvial covering, to the depth of six or seven feet, is aluminous in its finer parts and granitic pebble in its coarser, and has been the result of the degradation of granitic and felspathic rocks. The soil of the plain is rarely quartzose, except when close to some of the low tertiary hills, which alteration may therefore be due to the wash of these latter.

The blue clay is generally assigned by geologists to a slow deposit of mud produced by the sifting action of the tide in estuaries or gulfs where matter is not transported by current actions; it is the evidence of a calm condition of the waters during the period of deposit, and a cessation of upheavals of the land contiguous; the two beds of bluish clay are separated by nearly 40 feet of gravel and sand.

The drift gravel (bed 3) consists not only of rounded granitic pebbles, but also those of syenite, hornblende schists, metamorphic brown sandstones, trap and amygdaloid; and the underlying sandy bed is chiefly quartzose, and probably is the detritus of the sandstones at the base of the Cordilleras.

There have been no very large stones seen in the drift beds, there are no loose boulders or erratic blocks, nor is there, either on the surface or in the deposits, any stone which cannot be traced to masses of similar mineral constitution in the ranges bordering the plain. The period of *general* or polar *drift*, therefore, which was one of the earliest in the Quaternary epoch, passed by without affecting California—and it was during the later periods of drift that the processes of wearing down continents and depositing them in the seas around took place, and were carried out on an immense scale and over an immensely extended period of time.

Los Angeles plain is not the only one in California where these deposits of clays and gravels are of great depth. The borings which have been made in Sacramento and San Joaquin plains have revealed a similar structure of basin, while that in Santa Clara valley, Santa Clara county, shows that the deposit has not been to so great a depth in that plain.

Thus, at the Stockton well boring, after passing through red clays, sands, and gravel, the blue clay was met with at the depth of 400 feet.

On the Sacramento valley, observed exposed between the city and Pit river, the lava clays and sands covered the blue clay to the depth of (Dr. Trask) 358 feet.

In the Santa Clara valley, the covering of clay and light sand above blue clay was from 80 to 115 feet, averaging 90 feet.

The depth at which the blue clay is reached in Los Angeles plain (234 feet) stands intermediate between the Santa Clara valley and the great plain between the Coast Range and the Sierra Nevada. The bottom of the Santa Clara blue clay has been reached, and has been found not more than 100 feet in the deepest boring; the depths of blue clay in the other valleys far exceeds that, and has not yet been determined.

If the periods of clay deposits be assumed (as generally admitted) to be those of repose, and the deposits of gravel and sand as the indications of periods of elevation or depression of the land, we have in this history of the Quaternary period, derived from the evidence afforded by the artesian boring in the plain, two periods of repose and three periods of elevations, the rapidity and extent of which may be estimated, in some degree, by the textural condition of the gravel.

Of the duration of these periods of upheaval but little can be safely affirmed; they throw but little light on the total length of the Quaternary epoch. As the deposit of fine mud out of water has been examined under various conditions, a distant approach to truth may be obtained from a consideration of the blue clays.

These are found 465 feet below the surface at Los Angeles, and, therefore, below the present sea level; while the surface of the terrace on San Bernardino is somewhat above 2,000 feet in altitude, and as the beds are horizontal or nearly so, it follows that near Los Angeles the deposit took place when the water was over 2,000 feet deep at that point. All the low tertiary hills were ledges of rock several hundred feet below low water. The ocean then rolled up east of the Cordilleras, occupying the Colorado desert and the Mohave valley; and the Cordilleras stood up like a peninsula in the great mass of waters, with its crests from 3,000 to 5,000 feet above the surface, and with a breadth not more than 60 miles from S. W. to N. E. From the wearing down of the felspathic rocks, the granitic porphyries, and the dark colored shales, arose the blue clays, while the trappean and hornblende rocks formed the material of the coarser drift, transported by currents produced by the elevations. The carriage of such coarse matters would inevitably remove large portions of the tertiary hills of the plain and form the breaks which now occur in what was once a continuous chain, the denuded matter itself going to form the bed of arenaceous clay.

It has been calculated that the deposit going on at present in the Gulf of Mexico, produced both by the alluvium of the Mississippi and the transported mud of the Amazon, does not exceed more than half an inch yearly. There is nothing in the topographical condition of southern California to warrant the belief that the slow deposit could have occurred to a greater depth in the same space of time; for there is no evidence of the double influence of a large river and a strong current of sea water coinciding. Admitting, however, that the same rate of deposit occurred then as now in the two localities, the period of deposit of the lower blue clay bed would be 7,200 years, and of the upper blue clay and gravels above 1,600 years, making a total of 8,800 years of perfect repose. If to this we add the periods of elevation, both rapid and slow, the total period occupied by the deposit of Quaternary beds would equal the period occupied by some deposits of the secondary age. Yet such a calculation would scarcely give the total period accurately, since neither has the base of the lower blue clay bed yet been reached, nor should the present alluvial surface be looked upon as the last deposit of that epoch, or the prelude of the modern period; since, as has been already stated, the slopes of San Bernardino display a series of conglomerates and gravels 200 feet above the level of the nearest stream, (Cajon creek.) These are coarse accumulations of primary pebbles and granitic clays which have been removed from every portion of the plain where it is exposed. In the gorges and cañons it still remains; and wherever a pass has been travelled, there it is found, as the superficial covering, between 200 and 300 feet deep; this, the last evidence of deposit of the Quaternary period, has not been considered in calculation of duration. Yet such a deposit must have existed over the plain, and must have been removed afterwards; so that two additional periods would still require to be added to make the calculation complete, namely, the period occupied by the last deposit, and the period occupied by its removal.

From a review of the physical structure of these drifts, it would appear that the upper blue clay bed was deposited after the first or lowest bed had been lowered by a gradual subsidence of the whole, and this subsidence was probably repeated. The denudation of the upper conglomerates may have been effected by the later upheavals, at which time the base of the sierra may have been at the water's edge. During the greater portion of this period the waters east of the Cordilleras communicated with the ocean on the west through various channels, of which the chief were the present passes—the Cajon, San Gorgoño, and New pass.

Sections of these plains are given in fig. 3, plate 5, and fig. 1, plate 7.

CHAPTER XIII.

GEOLOGY OF THE CORDILLERAS.

Chain known by the name of cordilleras.—Direction.—Repetitions of the chain.—Passes.—Character of the cajon pass and san gorgoño.—Altitude of the passes.—Conglomerate of the slopes.—Strata in the cajon pass.—Cause of the dip of the strata.—Different aspect of the cordilleras viewed from the western and eastern sides.—Axial rocks of the cordilleras.—Structure at warner's and the cajon.—The sedimentary strata on the west slopes.—Period of elevation of the chain.—San emilio mountain.—Geology of the district surrounding.—The most elevated land in southern california.—Peru river.—Cañons of, through granitic rock.—Segregation of minerals of the granite.—Cestek plain.—Sandstones of, conformable to the cordilleras but not to the sierra nevada.—Relative modern appearance of the former range.—Continuity of san emilio with point pinos range.—Radiation of the chains from san emilio district.—Santa barbara chain elevated independent of the cordilleras.—Direction of the volcanic fissures of the coast ranges.

Under this term is included the mountain range which extends from the point of junction of the Sierra Nevada and the coast ranges to the Mexican boundary line, and thence southward into Lower California, of which it forms the spine. It is not, by any means, a continuous chain, but a series of disjointed masses running in a nearly parallel direction, the intervals in the chain being the passes from California proper into the desert.

The direction of the Cordilleras is uniform. If a line be extended from San Emilio mountain in a direction south 50° east to parallel 34°, it will be found to cover the great mass of the range lying between these two points, the southern termination being the great mountain San Bernardino. The length of this range is about 150 miles.

Temecula mountain, in 33° 30′, commences another range, which extends south 45° east, and passes into the peninsula of Lower California. The observed length of this range was 80 miles. The continuity of these two ranges is preserved by the San Jacinto mountain, which lies between San Bernardino and Temecula mountains.

The passes which occur in these two ranges, leading from the coast into the Great Basin and the Colorado desert, are—

1. San Francisquito pass, (also called Turner's pass.)
2. New pass.
3. Cajon pass.
4. San Gorgoño pass.
5. Warner's pass.

Of these, only passes 1, 3 and 5 will be noticed here, as they alone were subjects of observation. It may be doubted if passes 1 and 2 are true arrests of the upheaving power; they might be more properly considered as alterations of denudation and fracture, produced in a continuous range by actions occurring long posterior to the elevation; while in the Cajon pass there is a wide separation of several miles between the lofty mountain masses of Kikal Mungo and the range prolonged northwest from San Bernardino, a separation so wide that, looking from the plain at any point south of the pass—as from the Mormon town—a wide passage can be plainly discerned between the ranges. The ranges are really connected by the stratified sandstones of the Great Basin, which, like a curtain, stretch across and close up the natural hiatus in the upheave of primary rock. Similarly is it with San Gorgoño pass; like the Cajon, its direction is south a little east; and, instead of crossing the mountain mass, it takes a low valley between San Jacinto and San Gorgoño mountains, and leads into the Colorado desert.

The elevation of these passes varies considerably. Thus the altitude of each summit above the sea is, in feet—

Of Pass San Francisquito, 3,437.

Of New pass, 3,164.

Of Cajon pass, 4,676.

Of San Gorgoño, 2,808.

On reaching the summit of any of these passes the strata of the basin and desert (sandstones and conglomerates) are immediately encountered; showing not only the increased elevation of the Great Basin above the Pacific slope, but proving the fact of the communication of the waters on both sides of the sierra during the period of the deposition of the coarse sandstone (Eocene) found forming the rim of the basin.

In fact, these strata reach the summit of the range in many places, as in Pass San Francisquito, and within a few hundred feet of it, at Cajon pass, and still less at New pass. This is so remarkably the case at the Cajon pass as to form the peculiarity whence it has derived its name. In ascending this pass from San Bernardino valley, at the level of 2,000 feet, the pass commences through primary rocks which rise up to no great altitude in the vicinity of the pass; further up dislocated sandstones and alluvial beds, occupying small basins, are met until the head of the creek is reached. The primary rocks now no longer appear, yet the summit of the pass has not been reached. The valley, if it may be so termed, in which the creek heads, faces the south with its only opening, hemmed in on every other side by loose and not very well defined stratified sandstone and conglomerate, which rise almost abruptly 700 or 800 feet above the creek bed. The edges of the strata, which are almost horizontal, form the walls of this cajon, or box, and once no doubt occupied the whole pass to the granitic rim at its southern edge; the fluviatile action during the modern period having worn out the present bed and valley in this intramontane locality. The vast amount of rounded driftstones carried down into the San Bernardino valley attest how much can be done by a single small stream acting during a prolonged period. When it is stated that the Eocene desert beds are found rising to the level of all the mountain passes, it is not inferred that the waters on either side of the primitive axis were of the depth indicated by the altitude of the passes; there is abundant evidence of the reverse. One circumstance alone would render this unlikely. These desert strata at the Cajon are deposited unconformably upon a granite which drops very abruptly, and upon which originally it never could have received any marked inclination at the time of deposit. The slope is about 7° toward the basin, which is due to the elevation of the Kikal Mungo and San Bernardino hills, which, in their final uplift, carried these (once) horizontal beds along with them, and thus gave them the dip they at present possess. That this dip is due to this cause is apparent by examining the same strata at San Francisquito and about Lake Elizabeth, where they appear almost perfectly horizontal, and perhaps have a dip less than 3° towards the basin. In other words, the difference of elevation between New pass and Cajon pass (1,500 feet) would account for the variable dip of the strata at the two points. In this case, it is supposed that the whole chain was of a pretty uniform height throughout its whole extent at the time of deposition of these beds, since when, the whole has been elevated slowly—not only the mountain axis, but the desert basin also—yet unequally, so that while one arm of the lever at the north rose 3,100 feet, that at the south was uplifted nearly 4,700 feet.

Standing on the margin of the desert sandstones and looking at the Cordilleras, they appear only small hills a few hundred feet in height, while viewed from San Bernardino valley they are lofty mountains of an altitude of as many thousands; so great is the difference of level of the upper edges of the strata on the Pacific and the basin sides of the range. The south entrance of the Cajon, being 1,932 feet above sea level, is the highest point of the conglomerate terrace which skirts the western base of Kikal Mungo and Bernardino mountains. This conglomerate terrace (which has been already described when treating of the plains of San Bernardino) has been removed to the depth of two hundred feet, and the lower beds now constitute the level plains. This denudation is shown in figure 3, plate 6.

The axial rocks of the Cordilleras are granitic, varying in type from the western to the eastern side, being mostly felspathic (orthose) on the Pacific side, and passing into hornblendic and magnesian species on the desert side. This is the order of appearance, whether observed at Cajon pass or at Warner's pass. The breadth occupied by these rocks is very different, however, in the two situations: in the northern range—the Kikal Mungo hills—the strata, if the term can properly be applied to gneiss and hornblende schists, are lifted to a high angle and form the lofty sharp-pointed crest of the higher hills, the porphyritic granite having been injected through a comparatively narrow rent or fissure of the crust. In the pass (the Cajon) the primary rocks do not occupy a surface breadth of more than ten miles. In the southern range, south of San Jacinto mountain, the schists and gneissose rocks are not elevated at so high an angle, while the primary rock occupies a much greater breadth of ground, at Warner's pass the breadth being over thirty miles. In the passes, of course, the appearance of primary rock is always of less amount than in the chain itself, and therefore these figures do not express the full extent occupied by the igneous rocks in their average width—at the Kikal Mungo hills it would be about sixteen miles, and in San Diego county forty miles.

As a detailed description of the varieties of igneous rock met in passing over the axis of the chain is given when describing the Cajon and Warner's passes, it is only necessary to contrast the species found in both situations.

Cajon pass.	*Warner's pass.*
West.	West.
Felspar rock, with veins of porphyritic granite.	Felspathic granite.
Mica slate and gneiss.	Granitic porphyry.
Hornblende schist.	Granite, including gneiss in broken masses.
Hornblende and felspar.	Gneiss.
Gneiss.	Mica slate.
Talcose schists	Granite, with hornblende and mica crystals.
Felspathic granite, with wide veins of quartz.	Hornblende and albite, with a paste containing carbonate of lime.
Gneiss, with hornblende.	Syenite.
East.	East.

Thus, in both instances, the felspathic rocks are accumulated with micaceous granites on the west; and the porphyries—gneiss and schists—rocks on the east, all contain amphibole, either as hornblende, actynolite, with tourmalines, or occasionally epidote and talc granite, (protogine.)

Plate 6, fig. 1, gives an illustration of the strata met with in Cajon pass.

Upon these axial rocks the sedimentary strata are disposed, unconformably, on the eastern slope of the great basin, (Mohave valley,) and lapping round the southern margin of the Sierra

Nevada. Further south, on the slope of the Colorado desert, gypseous and arenaceous beds of the Miocene group are found ; these beds probably overlie the unconformable sandstone of the Mojave valley.

On the western slope the deposits appear to be all conformable ; but, as along the range extending from Temecula to San Diego the strata have been intruded upon by erupted trappean rocks, it is difficult to connect the slope of the sandstones with the granite. In San Diego county these strata are Miocene ; in Los Angeles and San Bernardino counties the sandstones which flank the granitic axis of Kikal Mungo are certainly conformable, and owe their elevation to the upheaval of that range ; the actual age of these strata was not determined in these counties, but the continuity of the strata was traced to positions where the age was well known—thus, the Sierra Susanna is an offset from the Cordilleras, produced by a lateral upheave in a more westerly direction from the main chain ; this upheave carries on its sides (and, indeed, is almost concealed by) the same sedimentary beds ; these are again uplifted in the Sierra Monica, are found at San Buenaventura, and finally at Santa Inez and Santa Barbara, where these sandstones were perfectly examined, and the examinations of the fossils of which, (by Mr. Conrad,) show them to be Miocene strata. It is the lower beds of the Miocene group, the brown and red sandstones, which are displayed on the Pacific slope of the Cordilleras, the upper beds being much contorted, so as often to assume a vertical position, and so much abraded as to lie several hundred feet below the present level of the valley, the denuded trough being filled up by the deep deposits of blue clays and sand treated of when describing Los Angeles valley.

The Cordilleras, therefore, have been upraised since the deposit of the Miocene beds of California, and are thus coeval with the Coast Ranges, with the sierras Santa Inez, San Rafael, and San José ; indeed, perhaps, the latter are the true continuation of the same chain toward the northwest. Both have the same direction, both have the same sedimentary beds flanking them, the nature of the axial rock similar, and the volcanic rocks erupted on its sides very similar ; and, lastly, both are connected by an intervening mass of mountain, the San Emilio region ; this district has been only alluded to heretofore by name, and deserves now a more enlarged notice. The name of San Emilio mountain has been applied to a lofty district which lies west of the Cañada de las Uvas, between the termination of the Sierra Nevada and the southern extension of the Santa Lucia range. Viewed from a distance, as from the northern end of the Santa Maria valley, it appears a large well-defined mountain, which stretches east and west, and rises to an altitude between 7,000 and 8,000 feet ; but on travelling up the Cuyama valley to the upper waters of the Santa Maria, and ascending to the sources of this stream, it becomes evident that what was apparent as a single mountain is an immense tract of elevated country, which is chiefly granitic and porphyritic on its eastern edge, where it is loftiest, and further west is made up of the yellow sandstones and overlying beds which, towards the north, constitute the slopes of Panza and San José ; these constitute the divort between the Santa Maria and the Santa Clara waters, and form the most extensively elevated land of south California. Both volcanic dykes and veins of porphyritic granite are given off from each side, the former from Santa Lucia and the latter from San Emilio. The strata on the north side of this divort dip northeast into Cuyama valley, and the beds on the south into or toward the bed of the Santa Clara. The Peyrou, a tributary of that river, finds its sources here, and carves its way down through deep chasms in the granitoid rock, which lie between its sources and its debouche ; the same mode of segregation of the granitic mass observed at the Cajon and at Warner's passes were noticed here. The order of segregation of the minerals observed in the granite of the cañon of the Peyrou was as follows:

Felspar (orthose) white and reddish.
Hornblende crystals in felspar paste.
Syenite, highly quartzose.
Hornblende slate.
Hornblende porphyry.
Gneiss.

The felspathic rock, a crystalline porphyry, being found on the west side, and as the river cuts its way further down it revealed the introduction of amphibole, until the whole rock assumed the appearance of a coarse gneiss or a hornblende porphyry. The granitoid rocks of San Emilio, of which those cut through by the Peyrou are the more depressed portions, cannot be less than from eight to ten miles thick upon the surface, and yields an immense amount of detritus to the Peyrou and other smaller streams which roll into the Santa Clara on its western side.

The strata on the western slope of this upheaved region are those of San Buenaventura, which have been traced, as described, running into the Cordilleras. The strata on the eastern slope form the hilly country called Cestek, which, in appearance and vegetation, is the repetition of the strata which cover the east side of the Cordilleras at San Francisquita and Cajon pass. The grass, the oak, the pine, the sycamore, and the cotton-wood disappear, and in its place are tule, yucca, palmetto, dwarf cedar, and the worthless vegetation of the desert slope. The sandstones described as peculiar to the eastern slope stretch in and occupy the angle formed by the termination of the Sierra Nevada at the Cañada de las Uvas and the San Emilio mountain, which lies fifteen miles west; this re-entering angle of the desert is crossed in the trail from Los Angeles to Fort Tejon. These sandstones dip away from the granitoid rocks of the Cordilleras at San Emilio, and so on toward Cajon pass, while they run abruptly up to, and lie unconformably upon the Tejon granites. This may be observed in the Cestek plain. It would thus appear that this sandstone was deposited originally upon both ranges, the Nevada and the Cordilleras, but that since the deposition the former was not upraised, while the latter was. Should this observation prove correct, it follows that the Cordilleras are of a later age than the Sierra Nevada; a view which I think the correct one, although opposite to that taken by Mr. Marcou. Both ranges may be post-Miocene in appearance, and to some extent arose together, but the latest elevations have been in the Cordilleras and the Coast Ranges, and the general order of upheaval, in point of time, from the east toward the west.

Nothing appears easier to trace than the relations of connexion and continuity between the middle of the Coast Ranges (San José and Point Pinos) and San Emilio, and between San Emilio and the Cordilleras, a fact now, for the first time, stated and brought to light by the explorations of this survey, by which there has been traced a continuous granitic chain from Point Pinos, at Monterey bay, to the northwestern edge of the Cajon pass, terminating at the Kikal Mungo mountain; a range alike distinct in direction from the Sierra Nevada or the San Bernardino and Temecula ranges.

The ranges which lie west of the San José sierra do not always run parallel with it. The Santa Lucia range gradually approaches it toward the south; the San Rafael hills, a small chain to the southwest, run in a trend somewhat more to the east, and the Santa Inez, the last of the coast ranges, has a still greater deviation to the east; thus, by a gradual radiation, they all meet near one focus, the San Emilio district, and conspire to form this elevated region; or rather, as has been advanced before in this report, the radiation of the lesser ranges is from the south, diverging more to the west as they proceed north, each range a little more west than its predecessor, until the direction of the Santa Barbara hills are obtained.

In alluding to the Santa Inez mountains it has been shown that they are uplifts of volcanic rocks upon an already elevated land; land previously upraised by granitic masses, and the elevation of which originally lay northwest; hence the range is a series of short links which lie in "echelon" to the whole range, the dip being southwest and northeast, and occasionally southeast and northwest, according to the position of the volcanic rock. The influence of the Cordilleras, therefore, as an elevating agent, does not extend to the Santa Inez range; it has neither the axial rock nor the dip to correspond to such a supposed cause. The true termination of the Santa Inez mountains is on the Santa Clara valley, and the upheaving causes come from the northwest, and not from the southeast, as is supposed by the State geologist of California; and to call the Santa Inez mountain the San Bernardino range is to confound things that have no necessary connexion.*

The volcanic rocks which have elevated the Santa Lucia, San Rafael and Santa Inez mountains run in a direction which would enter the Cordilleras in the southern portion of San Diego county, near the boundary line, and from that north to San Bernardino. This range they appear to traverse along its western edge, and do not in any place cross over to the eastern side; they can be traced at some distance from shore near San Juan Capistrano, San Luis Rey, and San Pasquale, at positions from 300 to 500 feet above sea level.

*Dr. Trask, Rep. on Geol. of Calif., 1855.

CHAPTER XIV.

ESTRELLA RIVER, PANZA, AND CARRIZO.

SOURCE AND COURSE OF THE SAN JUAN RIVER.—CARRIZO CREEK.—PANZA VALLEY.—FLATTENING OUT OF THE SAN JOSE GRANITE TO THE WEST, AND ELEVATION OF PANZA AND CARRIZO SANDSTONES.—STRUCTURE OF PANZA HILLS.—PROXIMITY TO TULARE VALLEY.—EXTENSION OF THE GAVILAN RANGE SEPARATING THEM.—EFFECT OF PROXIMITY OF THE SAN JOSE AND GAVILAN.—ESTERO PLAIN FORMED BY THEIR DIVERGENCE.—RESEMBLANCE OF ESTERO PLAIN TO TULARE VALLEY.—STREAMS WHICH SUPPLY THE PLAIN.—LITTLE KNOWN OF ITS GEOLOGY.—THE EASTERN SLOPE OF THE SAN JOSE ASSISTS IN FORMING PANZA AND CARRIZO, AND HAS THE SAME STRATIGRAPHICAL RELATIONS.—INFERIOR ROCK OF PANZA SIMILAR TO THE BROWN SANDSTONES OF SANTA BARBARA.—GYPSEOUS SANDSTONES.—OSTREA AND PECTEN LAYERS.—UPPER BEDS ARENACEOUS, WITH ARCA.—SLOPE OF THE STRATA.—TOTAL THICKNESS.—TERRACES ALONG THE VALLEY.—FOSSILIFEROUS STRATA BENEATH.—COMPARISON OF THE STRATA AT PANZA WITH THOSE OF SANTA MARGARITA AND SANTA BARBARA.—TABULAR LIST OF THE STRATA.—ENUMERATION OF THE FAUNA OF THAT PERIOD.

THE San Jose mountains separate the Salinas and Santa Maria valleys from those lying further east. When this range is crossed east of Santa Margarita, or of Cuyama, a valley country is entered whose elevation is considerably above that of those on the west; but the nature of the valleys north and south are very different in character. At the point where the San José chain crosses the Salinas to pass south, the San Juan or Estrella river enters the Salinas. This, which is hardly a tributary, since it is much longer than the upper Salinas, takes its rise forty miles further southeast in a series of high valleys on the eastern base of the San José mountains. The stream, there small, receives the name of Carrizo creek, where its elevation is more than 1,600 feet above the sea; as it passes south, it leaves the open rolling sandstone land and enters a narrow valley wonderfully disturbed since its deposition, and denuded during its elevation. This receives the name of Panza valley from the ranch of that name. South of this it receives the name Estrella, and from thence southwards the river retains its place at the base of the range until it reaches the Salinas valley and river.

The region of Carrizo was but little examined; but few fossils were found in the upper sandstones; in an upper layer of these, before reaching the valley of Panza, two small shells were picked out of the soft sand rock. These were *pecten deserti* (*Conrad*) and *anomia subcostata*, the latter doubtful. The former is a shell found on the western limit of the Colorado desert; it is here found 250 miles northwest, and separated by two valleys and three mountain ridges. The stratum does not correspond lithologically with that of the desert in which it is found.

The granitic axis of the San José range spreads out westward underneath the strata elevating the whole plain, and carrying the sandstones to a level several hundred feet above the western valleys. Nor does it merely elevate; it is also itself protruded in several places, not in a chain, but separately, producing the local disturbances and flexions of strata alluded to. Panza hills, lesser and greater, are two mountains which display these phenomena well, being masses of granitic rock at their southeast end, which have tilted up the strata, and causes them to dip toward the San José, from which they are not distant further than six miles in an airline eastward. Further south the country still rises with rolling hills of sandstone, presenting their worn edges to the west and south. The granite appears more constantly as a surface rock, and along the head of Carrizo creek gneiss is traced for several miles accompanying the stream. This elevated rolling plain stretches several miles to the east, when it drops down into Tulare valley. This lofty district owes its elevation to Gavilan range coming in at this point in its southern course, and intermingling its strata with those of San José. The result of this union of two parallel ranges not only produces the highly elevated country, but perhaps also the increased elevation of the San José range itself, which at this point (the head of Carrizo creek) sustains a loftier crest than elsewhere in its course. South of this point the two ranges separate and pursue different courses, forming, by their divergence, Estero plain, a wide trough plain, with a gentle descent to the south-southeast, where it opens into Tulare valley by the subsidence of the Monte Diablo range at the extreme south.

Estero plain is a miniature of Tulare. The hills bounding it on either side supply it with water, small in quantity, which collects in lagoons or ponds in the centre, and thence flows sluggishly south, forming the Agua de Paleta, which rolls into Buena Vista lake, in Tulare valley. The northern edge of the plain near Carrizo and Panza hills furnish the largest amount of water, as many as three distinct streams being observed to roll down to the lake in the centre of the plain, which is uninhabited by man, and occupied only by herds of deer, antelope, and wild horses, with which it abounds. It is about forty miles long, and averages twelve broad. Nothing exact is known of the geology of this plain. Its geography was comprehended exactly by looking from the summit of Panza hill, which overlooked the whole country south and east as far as the eye could reach. The southern portion of the plain was again observed in crossing from Tulare to Cuyama plain; of its structure nothing more is known than that its eastern ridge is the Monte Diablo range, terminating south at the head of Tulare plain—its western the San José range; the sandstones slope into Estero from either side. Two slight elevations cross the plain above and below the lake, as if a dyke crossed in these places. The plain itself was not entered.

In treating of the San José mountain range, allusion was made to the axial and sedimentary rocks; the textural character, dip, and thickness of the strata on its eastern side are there given, and need not again be repeated. Hornblendic gneiss appears here upon the east side of the range along the bed of Carrizo creek for some miles down below its source; it presented the appearance of a stratified rock dipping away to the northeast. Although the granitic rock was exposed at a few points east of the range, yet nowhere was the gneiss rock observed in contact with it there. Panza hills are sandstones, elevated by felspathic granite, which occupies low bosses on the southeastern edge of the hills, and have no gneissose rock nor any appearance of the limestones found at Gavilan; the point of contact of the sedimentary and upheaving rocks was not, however, observed; the lowest rock was a series of brown sandstones, with sharp angular outlines, and serrated and triangular shaped crests, in every respect similar to the lower beds of the Santa Inez chain at Santa Barbara; above these were coarse conglomerates and grits with saline (gypseous) veins, and thin layers of limonite. These represent the beds on the east of Santa Margarita valley, immediately below the ostrea and scutella beds; these also line the Santa Lucia mountains; then follow fine-grained sandstones with ostrea and pecten; and, finally, where the hill drops down to the creek bottom, fine arenaceous clay beds consolidated, containing arca obispoana. Both the northern and southern Panza hills have a similar structure, and dip southwest from 25° to 35°. The total thickness of these beds approached eleven hundred feet; the dip is towards the San José range, from which it is separated by the valley intervening; this valley, (Panza) like that of Santa Maria, is also one of denudation, presenting terraces one hundred feet high on the east side of the San José range, where the foot hills run out into promontories, which, before the denudation, stretched across the present valley to the Panza hills; these promontories come off from the main ridge, like the teeth of a comb, and are themselves merely fragments denuded. On examining the strata of these terraced promontories near the edge of this valley, they are found to dip away from the valley and toward the range of which they seem to be a part; from one of these was obtained some of the finest specimens of the *asterodapsis* of a larger size than those found in Santa Margarita valley; accompanying it was the *scutella subrotunda*, the *pecten*, and *ostrea;* the dip of these layers was 15° southwest. On another promontory, about a half a mile up from the valley, yellow clay rock containing the same fossil scale impressions as that found on the shore at the Gaviote, and also found on the west side of the San José. The green agatic quartz riband layers found in Santa Margarita valley were not found here.

The exploration of the Panza hills proved to be very interesting; their sandstone, less inclined than either those of Santa Margarita or Santa Inez, allowed of a comparison not admitted by the others. The continuity and relative position of these beds could be better studied there than in any other locality. Here was first observed the angular crested gypseous sandstones repeated at Santa Inez, and here was observed the relative position of the ostrea and echinoderm beds similar to those of Santa Margarita, with the softer clays and beds associated with bitumen along shore, and including polythalamous layers. Much that was doubtful was thus removed, and the relative position of these tertiary beds was thus determined to stand in this order from above downwards:

A. Fine yellow slates; soft argillitic layers, with *arca* obispoana; bituminous sand rock, with polythalamous layers.

B. Yellow sandstones, with pallium, ostrea, hinnites, and echinoderm.

C. Brown and yellow grits; sandstones, conglomerates, gypsiferous and ferruginous; the upper beds including the dosinia of San Antonio.

D. Coarse grits and green conglomerates of serpentine and jaspery quartz.

The last bed, so distinctly marked on the San José and Santa Lucia ranges, was not observed represented on Panza hills, in which circumstance it resembled Santa Inez range.

A section of Panza hill is given in fig. 3, plate 2, and the fossiliferous beds on plate 2, fig. 5.

South of the larger Panza hill, a few miles along the valley, a dyke of augitic rock of a dark green compact structure was observed running north 80° east, and converting the sandstone into a hard micaceous rock in its neighborhood; the strata dipped in every direction near it, and even the gneiss rock was slightly disturbed from its usual easterly dip. A folding together of the sandstones was observed not far from this on the river side, causing a partial synclinal axis, which may, perhaps, have been produced by the upheaval of the Panza granite at a date subsequent to the elevation of the San José rock.

The bed of the Estrella river, at Panza, displays a series of terraces on the hills on either side precisely similar to those on the Santa Maria, although necessarily on a much smaller scale.

The fossils found in the strata on the sides of the valley were the following, the names and descriptions of which have been supplied by Mr. Conrad:

1. *Ostrea Titan*
2. *Ostrea Panzana.*
3. *Pecten discus.*
4. *Pecten Heermani.*
5. *Pallium Estrellensis.*
6. *Spondylus Estrellensis.*
7. *Cyclas permacra.*
8. *Cyclas Estrellensis.*
9. *Glycimeris Estrellensis.*
10. *Balanus Estrellensis.*
11. *Astrodapsis Antiselli.*
12. *Scutella Subrotunda.*

The ostrea, astrodapsis, balanus, scutella, and pecten, were found in the same strata and accompanying each other; the other fossils occupied the sandstones lying below the upper calcareous layers, having the comminuted shells and other points of resemblance with the beds containing ostrea and hinnites of Santa Margarita. The Panza beds are thicker than those of Santa Margarita, and more variety in the animal life contained in them. Like the latter beds, the Panza strata lie upon the slope of the San José range, and have suffered extensively from denudation.

CHAPTER XV.

MOJAVE RIVER VALLEY.

Santa Fe trail to salt lake.—Mojave river and valley.—Cajon pass.—Primary rocks of.—Mica slate and porphyry.—Pink sandstones.—Local drift.—Limestone in.—Thick conglomerate and sandstone of the eastern slope.—Second axis in the pass.—Probable thickness of the conglomerate.—Distinction between them and the pink sandstones.—Slope towards the mojave.—Nature of the soil upon.—Vegetation of.—Yucca, cedar, artemisia.—Soakage of the rain water through the sandstones.—Wells near the river.—Course of the river where first reached.—Different temperatures of air, wells, and the river.—Hills east of the mojave.—Fertility of mojave valley.—Heat of the soil during the day.—Similarity of the flora with those of Los Angeles valley.—Amygdaloid range along the mojave sixty-six miles down.—Metamorphic action exerted on the sandstones.—Variety in the volcanic rock.—Felspar dykes.—Accompanied by gypseous veins.—Granitic chain crossing the river further down.—Soda lake, its length and form.—Appearance of the surface.—Saline coating of the surface.—Quicksand bottom.—Subsoil soaked with water.—Intrusion of a dyke upon the playa.—Primary limestone.—Aspect of the playa.—Mirage.—Origin of the saline incrustation of the playa.—Freshness of the river water.—Recapitulation.—Characters of the country east of the Sierra Nevada.—Appearance of the valleys.—Slopes of the conglomerate.—Different level of soda lake and the colorado river.—Direction and nature of the mountain ranges.—Number of ranges between soda lake and the sierra.—Intervals between the chains.—Fall of rain.—Limited fertility of the district.—Number of animals sacrificed from drought.—Exposure of the high plain to winds.—Cold of nights.—Dew.—Thunder storms without rain.—Parallelism of the geological forces.—Plain reaching across the colorado to the pimas villages.—Saline incrustations at soda lake.—Chemical examination of.—Incrustation at navajo camp.

The old Spanish trail from Los Angeles valley to Santa Fé entered the great basin from the Pacific slope by the Cajon Pass, followed the course of the Mojave river for several miles to the northeast, and then left its bed to take a more northerly direction toward Salt Lake. This trail is now followed to the latter place by the mail carriers in their fortnightly journey to Salt Lake City, and by the Mormons in their intercourse between that city and the Mormon settlement in San Bernardino valley.

The Mojave river is first struck by the trail not far below its sources—its further course from the point where the trail leaves it was but partially known; to clear this obscurity was the object in crossing the Cordilleras to enter this, the second lowest steppe of the Great Basin, to ascertain whether the river emptied itself into the Colorado or was lost in the basin; a very hasty reconnaissance was made by striking the river at the east slope of the Cordilleras, and travelling down its bed until it was lost in the alluvial sands of the small basin of Soda lake.

While crossing the Cordilleras through Cajon pass its geology was observed, and is noted in this section rather than in the chapter on the Cordilleras, to understand the constitution of which it may be necessary to refer to this description of the pass.

Cajon pass lies behind (eastward of) Kikal Mungo hill, and between it and an elevated flat-topped range, which is the northern extension of the San Bernardino mountain.

The general direction of the pass is north by west and south by east, and as the strike or axis of the range is here about south 70° east a good section is obtained in ascending the pass. Here, also, as in many other mountain ranges, it may be observed that the geological axis itself is not situated at the most elevated point of the pass, for while the axis is on the south and west extremity, the greatest elevation lying north is occupied by the sedimentary beds on the north end upraised by the axis.

In ascending the pass from the Pacific slope primitive rocks only occur along the first three miles. The depressed axis of the Kikal Mungo hills is there met with at an elevation not exceeding 2,000 feet, consisting of a nucleus of granitic porphyry, hornblende, and mica slate, intercalated with beds of crystalline felspathic rock, gneiss, and talcose slate.

The stream which flows down the pass (Cajon creek) winds its way through and between these metamorphic and primary rocks, and enabled a thorough section to be obtained.

In ascending the pass, as soon as the upper drift beds, which are continued into the valley of the Santa Anna river, are passed over, and which are here cut through by the Cajon creek, the first rock in situ exposed is mica slate, forming a hill about 900 feet high above the pass, with a dip of 30° northeast. A couple of hundred yards higher up granitic porphyry and hornblende slate appeared on both sides of the stream ; one mile further up, the creek bed traversed a small flat, with well marked terrace banks, composed of the detritus of the primary rocks around, varying in depth from three to 10 feet, and lying upon mica slate, dipping northeast 50°, accompanied by gneiss, talcose slate, and felspathic rock. These erupted and metamorphic beds were much contorted, the gneiss and slates lying at a high angle.

Ascending the creek, which here flows almost south, a series of pink colored strata occur, dipping 25° south 10° west, lying on the right bank of the stream; three hundred yards higher up the same beds dipped in the opposite direction, or to the northeast; both series presenting a prominent feature in the landscape by the peculiar tint and conical shape of the edges of the strata ; being very friable they weather readily, and have their caps rounded, the degraded material being either washed down by the creek, which carries in its current vast quantities of fine and course debris, or accumulates in the little valleys between the upraised strata. These beds might be at first sight mistaken for a granitic rock, were not its sedimentary character and the lines of stratification so well marked, for it is wholly felspathic in its constitution, presenting small rhomboidal crystals of pink colored felspar, imbedded in a felspar paste of the same color loosely cemented, so that the mass can be readily cut with the penknife, or even removed by impressing it with the shoe ; each crystal of felspar being complete in its form, and showing no sign of having been transported any distance before it was consolidated. No trace of fossils was observed in these strata.

These strata are repeated several miles up the pass, almost to the head of the creek, which rises in a depressed area, surrounded on all sides (save at its southern outlet) by bluff walls of steep ascent, varying from 150 to 500 feet, which, when gained, are not hills, as they appear from below, but merely the summit of the sandstone sloping eastward to the Great Basin.

This peculiar local configuration has given rise to the name of the pass, (Cajon,) the origin of the creek being enclosed, as it were, in a box.

The rounded drift stones, some of which are of large size, carried down by the creek during freshets are not to any extent derived from the immediate wearing away of the primary rocks of the axis alluded to, but are mostly derived from the drift covering of the little valleys of the pass, and from the terraces alluded to. They are gneiss, hornblende, porphyry, felspar rock, a few mica slate specimens, and white crystalline limestone. This latter rock, though an abundant constituent of the drift, has nowhere in this pass been observed in situ. That it exists in the pass in place there can be little doubt, near its summit. It is a constituent rock of the chain, being found extensively in place at Tejon, and having been observed in situ by Mr.

Blake in the San Gorgoño pass. About four miles below the summit, on each side of the pass, are high hills, with sharp outlines and ragged crests of crystalline felspar, intersected by quartz veins of a brownish red color, and hardly deserving the name of granite. These occurring on both sides of the pass must also cross it and produce a second axis eastward of the one lower down. To this axis may be attributed the dislocation and tilting of the pink strata, and in this axis the crystalline limestone may belong.

In ascending the last five miles of the pass, and especially the last three, thick beds of conglomerate and sandstone appear, which form the bluffs referred to. Sections afforded by the creek often exhibit 100 feet of thickness, and as all the beds were not exposed at one place, I think 300 feet to be the approximate thickness of these conglomerates in this place. From the lines of deposition they appear to be horizontal; but viewing the slope to the Great Basin as merely the upper surface of these strata, the true dip may be about 6° northeast. They are yellow colored and very friable, being in some beds wholly unconsolidated. They contain angular felspathic crystals and paste similar to the pink beds alluded to, with the addition of gneiss, mica slate, and quartz pebbles, both rounded and square fragments of all being freely mingled in the mass. This addition serves in part to distinguish these conglomerate beds from the pink sandstones. They are still further recognized by their want of consolidation, and by their unconformability to the strata on which they rest. The pink sandstones repose on the axis, have been upraised and contorted by the elevating force, while, on the contrary, the upper conglomerates are almost horizontal, and are undisturbed by any cause. Derived in a great degree from the same sources, (primary granitoid rocks,) they mark successive periods of deposition.

The descent from the summit of the Cajon pass to the Mojave river, where the trail strikes it, is over the back of the pink sandstones referred to in the description of the pass, and capped by the conglomerates. The slope of the surface of the strata towards the river is 20°, a slope greater than that of the beds themselves, inasmuch as the inferior fourth of the slope is very much worn into ravines and cañons by the water draining from off so large a level surface higher up. The true dip of the strata is northeast. The soil on this slope is a mixture of quartz and felspar, granitic detritus in fine powder, with pebbles of quartz, gneiss, and mica slate, derived from the degradation of the conglomerates.

The tree yucca, of every possible form and size, was the predominant vegetation. Cedar trees of small size in the valleys near the summit, immediately below the pass. Dwarf pine, chemisal, and artemisia were the other shrub growths. The herbaceous vegetation was similar to that of the San Gabriel and Los Angeles valley; but the individuals on a dwarf scale. The whole vegetable growth is that of a desert region, and contrasts wonderfully with the luxuriance on the west side of the mountain range, the difference being due to the deficient supply of water on the east side of the Cordilleras.

The rains falling upon the eastern summits of the sandstone strata and the melting of the winter snows form a body of water which sinks between the laminæ and finds a subterranean course toward the valley of the Mojave, where, by their oozing out from the worn edges of the strata, they form springs, and go to swell the volume of the river itself.

The Mojave river, where first struck, has a course north by west—lies several feet below the level of the sandstone in a small channel about thirty yards wide, worn in the strata; by cutting its way across the dip of the sandstones, and to some depth downwards, it has tapped some of the subterranean water courses alluded to. Along the whole course of the river it is very common to find, here and there water holes, of great depth, and from which, for a few miles down, the river has a body of running water, which ultimately sinks into the sands and disappears, until a new series of water, in holes, is met with lower down. These water holes are true springs, oozing up and overflowing to form the river bed. The temperature of these springs is much more uniform than that of the running water, which, passing over a heated soil, becomes, in a short time, nearly as warm as the atmosphere; while the water holes or springs, on the contrary, have a much lower temperature in summer time, and are warmer in winter. These water holes are surrounded by a dense growth of willow, and occasional cotton-woods.

The difference of temperature observed at camp, fourteen miles below where the trail strikes the river, was—

Temperature of the air, in shade	82° F.,	at 2 p. m.
Temperature of running water	74° F.,	do.
Temperature of water holes	56° F.,	do.

At the first crossing of the Mojave, at the foot of the slope from the Cajon pass, is a spring of this character. The water is hard, clear, and of good taste.

Immediately east of the Mojave, where it is first struck, there extends a low-crested hill running north and south. This hill is not more than three miles from the river, and is approached by a more rapid ascent than that of the left bank. The beds of conglomerate are traceable a short distance up this slope, then terraces of detritus, chiefly of quartz and volcanic rock; then a compact quartz rock in situ, and the main body of the hill of red amygdaloidal lava and greenstone porphyry. Fragments of these rocks are scattered along the terraces.

The valley of the Mojave is fertile only on the immediate banks of the river; there, where the moisture infiltrates through the soil, cotton-woods, willows, grass, and composite flowers grow luxuriantly; at some distance from the bank, (three or four hundred yards,) the flowers were in clusters, with intervals of bare, dry, and pulverulent soil, which is chiefly of a sandy character, though occasional clay beds occur.

On the same day (April 7) on which the foregoing thermometrical readings of the water were taken, the sandy soil was examined for its temperature, six inches below the surface, which, at 4 p. m., was found to be 92° F. The hottest part of the day is about 2 p. m., so that the temperature ascertained was that which for five, or perhaps six, hours of the day the soil had attained to. This great warmth of soil starts the vegetation forward early in spring, and from the absence of rain in this region in summer, the plants are burned up by the intense heat of the soil. Perhaps for the same reason they are stunted in height, do not put out branch or leaf, and flower early. The plants not having time to live long enough to increase in size, and then flower, appear to devote all their energies to the propagation of the species. Species similar to those of Los Angeles valley were found in flower on the Mojave; at Los Angeles some species were eighteen inches and two feet high; their congeners of the Mojave were two and three inches.

From the first crossing, the course of the Mojave, fourteen miles down, is north a few degrees west; then, for more than twenty miles, it is north a little (10°) east; and then, generally, in a true easterly direction, until it terminates in Soda lake. In this course it follows, to a great extent, the dip of the conglomerates, north 10° east. This dip determines the slope and configuration of the valley of the Mojave until it disappears; but here and there the sandstones are broken through, upheaved and contorted by small ranges of hills generally isolated, and running in direction or trend pretty uniformly northwest and southeast. Occasionally a small range runs north and south, forming with the others a series of triangles, enclosing valleys, or rather playas, between the hills. In its course eastward the river either cañons through or passes round these ranges to reach the lower level; hence its occasional deviation to the westward.

The intruding rock forming the axis of these isolated ranges and lone hills is chiefly amygdaloid, a reddish felspathic rock, approaching trachyte in texture, the cavities filled with chalcedonic geodes. Masses of pure felspar rock occur occasionally. Greenstone and greenstone porphyry are the chief varieties of volcanic rock. Jasper and compact quartz rock, of various hues, lie in contact with the foregoing. These rocks, flanked by the conglomerates, constitute the bulk of the hills of the Mojave valley.

At the third camp on the Mojave, sixty-six miles down the river from the first crossing, the amygdaloid rock rises abruptly from the plain beside the river on its south side; at some distance on the north side it rises up again. In their elevation they have uplifted a stratified sandstone which, in some places, is converted into a compact quartz rock; in others, it puts on a jaspery and opal appearance in the fractures, while at a distance it preserves its laminated and sandy texture. The amygdaloid is reddish, but less pyritiferous than usually met with. A great variety in the appearance of the volcanic rock prevails over this district, being sometimes highly cellular, the cavities filled with chalcedony; again it is a compact rock, with defined quartz crystals interspersed—in some places pyritiferous, in others not—the felspar generally approaching a red brick color; in a few instances becoming grayish, and resembling trachyte. A yellowish green clay forms on the surface of some of these volcanic hills, arising from the decay of the iron and copper pyrites present. This tint is sometimes communicated to the soil in such a quantity as to render it visible at a distance of several miles.

Dykes of a green felspar porphyry cut through the amygdaloid in some places; one well marked instance is on a hill north of this (3d) camp. The amygdaloid is fissured in several places, and the fissures filled with seams of carbonate and sulphate of lime; these seams run in the same direction with the upheaval of the hill—that is, east and west. The carbonate is crystallized in the rhomboidal form. North from this the ground rises with a gentle slope, thence northeast. The highest hills of the neighborhood are in that direction; they have the same porphyritic outline as the hills close by, and run 50 or 60 miles northward, constituting a well marked chain of hills, whose southern prolongation, about 10 or 12 miles from here, is a mass of porphyritic hills heaped together.

Seventy-one miles down the river (from the first crossing) a range of granitoid and porphyry hills cross the course of the stream, and through which the river cañons; loose fragments of serpentine and epidote were scattered about, with jaspers, chabasite, red and yellow porphyry. A bed of unconformable conglomerate lies in contact with the axis rock; it is 60 to 80 feet thick, and the pebbles made up of jasper, porphyry, and epidote, with a fine paste of sand and clay, the fragmentary scattered pebbles derived from this conglomerate being denuded.

This chain runs northwest and southeast, as do many of the lesser ranges, but it cannot be spoken with certainty of many of them; the district being so disturbed, some of the low ranges running north and south, and inclosing triangular valleys, as before described.

The same stratified sandstone which caps the eastern flank of the sierra to the Mojave river is also found here, and inclined also at a small angle to the east, (4°,) and sloping eastward for 12 miles, when it terminates in Soda lake.

Soda lake is a flat, dry lake bed, or playa, about 20 miles long and 12 broad, of an elliptical form ; bounded on the east by the elevated and mountain range formed of granitic and porphyry uplifts which separate the Mojave valley from that of the Colorado, and on the west by the conglomerate slopes of the ridge just described. The surface of the playa is perfectly level and without vegetation, save on the margin, where some coarse salt grass flourished in the loose sands ; on the edge of these sands could be traced a beach—heaped water-worn pebbles, pieces of drift wood, and vegetation—and for miles the eye could trace this dark line at the base of the small sand hills accumulated by the winds ; yet at the time of the visit (April 14) there was no water over the surface, nor has it ever been known as a permanent lake. For several hundred yards from the margin the soil, a sandy clay, was hard and ripple-marked, and coated from 2 to 4 inches deep with a saline incrustation which crackled under the feet like frozen snow ; examined by the eye it contained cubes of common salt, had an alkaline taste, and deliquesced in the fingers ; it raised bread indifferently well, and was therefore a mixture of cloride of sodium and carbonate of soda; an analysis of this efflorescence is subjoined. Further in, towards the centre of the playa, dry stream beds exist 2½ to 3 feet below the general level, and about 5 yards wide ; and in the neighborhood of these the soil is a quicksand, which, though supporting a man who shifts his position occasionally, renders it very unsafe for a mule to keep its foot, the animal frequently sinking to its belly. In this playa the Mojave river is finally received ; its course down the conglomerate being visible for some miles, when it gradually sinks down and disappears in toto. The whole under stratum is soaked with its waters. Digging at the edge, 18 inches deep, allowed abundance of water to ooze in, sufficient for culinary purposes, but which requires to be used fresh, as, after it has lain some hours, it becomes intolerably saline; at the best it is mawkish and alkaline, and only to be drank on necessity. Occasionally the playa is overflowed with water and forms a small lake, whose margin or beach has just been described ; it is never more than a few inches deep, and drying off again leaves the alkaline incrustation on the surface.

The playa is nearly divided into two portions by a projecting ledge of trachytic porphyry, which has in immediate contact with it a mass of primary limestone, forming a hill about 500 feet high ; at the foot of this is a small fresh water spring of remarkably pure hard water. The limestone is metamorphosed, and presents no trace of fossils ; it probably is geologically connected with the limestones of the Sierra Nevada, and that in the vicinity of the bay of San Francisco, along the Santa Cruz valley.

The aspect of the playa is remarkably forbidding ; a wide expanse, unclad with herbage, bounded by lurid purplish hills without timber, smooth as a bowling green, and glittering in the sun like a snow field, dry brown slopes rising to the margin of the rocks, forms a most dismal picture, and gives an idea of incompleteness and desolation.

The mirages on this playa were constant, and on a very large scale.

The formation of so large a crust of salt and alkaline carbonate from the capillary evaporation of the soil of the playa shows how large a quantity of mineral matters may be abstracted by running water percolating through porous sandstones and the debris of albitic granite ; for the waters of the Mojave were, in the first instance, merely the melted snows of San Bernardino ; all the mineral matter, therefore, in its volume, were derived from the strata along which it rolled, concentrated by accumulation in Soda lake ; for in no part of its course was the flowing river at all saline, or unpalatable to the taste.

RECAPITULATION.

The Mojave valley is composed of beds of conglomerate and sandstone, of very loose texture and easy of degradation, through which the river and streams have worn their way, exposing in some places 100 feet in thickness of these beds reposing unconformably upon the igneous rock.

Beds of clay, sand, and gravel, 20 to 150 feet in thickness, are deposited over these sandstones, and in many cases appear to be formed out of these materials.

A few shells of anodonta, similar to those found near New river, at Alamo Mocho, on the Colorado desert, were found west of the range bounding Soda lake and on the alluvium within 100 yards of the river.

The upheaving plutonic rock is chiefly felspathic, red quartzose, porphyry, red amygdaloid, with the cavities filled with chalcedony, and occasionally serpentine, epidote and trap.

Felspathic (orthose) granite was not found; albitic granite formed the mountain range east of Navajo camp; porphyritic rock, resembling it, constitutes the hills separating the Mojave from the Colorado; the axial rock is thus assimilated in mineral character to that of the Sierra Nevada.

The conglomerate and solidified sandstones may be looked on as tertiary and of the same age as those at Carrizo creek, of the Colorado desert, perhaps Eocene. The clay and gravel beds belong to a much later period. It is these loose beds which give the peculiar and characteristic features to this region east of the sierra; everywhere the mountain ranges are approached from either side by a gentle slope which runs direct up to the edge of the hill, so that it appears as if the level of the valley and the slope of the mountain could be defined by an exact line, the local drift bed running close up. Thus every valley presents a central depression, rarely filled by a river bed; thence on each side a gentle slope until the mountain base is suddenly reached. This appearance, which is very striking, is also observed in the western Alps, (Europe,) where an individual may set one foot on the plain, and the other on the mountain slope—so decided is the line of demarcation. These loose and deep beds are related to those west of the sierra, and to those east of the Colorado and on the Sonoranian desert south of the Gila. They are, no doubt, of Quaternary age, and to some extent of local origin.

In parallel 34° short ranges of hills, running northwest and northeast, divide the country between the Sierra Nevada and the Colorado into a series of ridges and plains, or valleys, which character continues as far as 35° 30′, or 20 miles north of Soda lake. This mountain belt of country is much more elevated than the Colorado desert further south, its lowest level, Soda lake, being 1,116 feet above the sea. The Colorado level (from which it is separated by a lofty though short range, over 4,900 feet high,) being, almost in the same parallel, 350.4 feet.

Assuming the Colorado as lying at the lowest point of the district between the Cerbat range and the Sierra Nevada, the country to the west would consist of a series of ranges of albitic granite and porphyry hills running N. 60° W., occasionally interlocking, forming isolated valleys, but more usually unconnected ones, giving rise to extensive plains passing round the edges of the ridges and connecting. As many as five of these parallel ridges lie between the Cajon pass of the sierra and the eastern boundary of Soda lake, and Lieutenant Whipple describes as many as nine between the Colorado and the sierra.—(H. Doc. 129, p. 29.)

The intervals between these chains vary from 5 to 15 miles; are in places composed of loose drifting sand, which cover the surface and check vegetation, or in places of a hard sandstone pebble formation, and occasionally clay beds. The river bottom (Mojave) is alluvium. On account of its greater elevation above the desert to the south, and the number of ridges which rise 1,000 and 1,500 feet above the valley at their base, the fall of rain must be greater than in the latter place ; but this mountainous belt of country must still be looked upon as, to a great extent, a desert region. It is only where water is abundant that vegetation luxuriates, and hence, where the river bottom is left, sterility commences. Along the immediate bed of the Mojave, from the foot of the Cajon pass to where it sinks in Soda lake, cotton-woods, willows, and mesquite, are abundant; they are the only trees, except those upon the San Bernardino slope. There is no tree growth upon the sides of these short ranges, and grass is only found on their slopes in the immediate vicinity of springs, or upon those level terraces for a few weeks after the fall of rain in spring. Then a sweet though scanty herbage rises in April and May, which is all burnt up and withered in June for want of moisture ; a second vegetation springs up in the fall, which is of an inferior character. The scarcity of water and the general dryness of the district is testified by the dead carcases lying beside the Salt Lake trail ; the cattle having foundered from fatigue and thirst, and their hides preserved from decay by the aridity of the climate ; the dropped saddles, harness, and wagons attest the same, and give to this trail, as well as that across the Colorado desert, the character of a Golgotha ; the whole district producing in the dry valleys only larrea, artemisia, fouquieria, yucca, and cactuses.

Such is the country through which the Mojave flows, and into the soft sands of one of which valleys it ultimately empties itself. In its course it crosses some of those ranges through wild cañons, and rounds others to avoid them. Its course being distinctly visible by the bright green of the foliage of the cotton-woods, so remarkable from the upland generally : over these plains above the river, in spring, was scattered a profusion of vernal flowers, composite plants, many of them in full bloom, and resembling those of the Los Angeles and San Bernardino valleys, but of a more diminutive form. Upon no part of the Mojave river were there any traces of cultivation, although where it enters the valleys between ranges and widens its bed it is capable of producing fine growths; and as it occasionally rises and falls in its bed, dependent upon rains or snow-meltings on the San Bernardino mountains, irrigation might be adopted with success. The Indians who travel along these trails and live in the mountains, 60 miles down the Mojave, are the Cucoomphers, not speaking the same tongue as the Mojaves or Pay-utes, nor apparently so advanced in civilization—lizards, rabbits, and roots, constituting their chief fare.

The winds blow with great violence along these plains and smooth slopes of the mountains, drifting the sands and accumulating it in small hillocks at the base of the hills. In summer the thunder and lightning storms are frequent and severe, although but little rain falls with these phenomena. At night time the air cools down so as to feel chilly before sunrise, and even deposits a dew upon the blanket and hair of the exposed sleeper. This radiation and production of dew is, no doubt, beneficial to vegetation, and enables animal and plant to support for a longer time, without injury, the high temperature of the midday.

Of the parallelism of the geological forces exerted over this district, there is an evidence in the existence of an extensive plain which is crossed by the Mojave, about 62 miles below the first crossing—the eastern boundary of this plain is a chain of granitic and porphyry hills, alluded to in Chapter XIX, which runs S. 60° E. to the Colorado river. In this direction the plain extends, crosses the river, and continues the same southeastly direction until the Gila is reached, a little west of the Coco-maricopas villages.

Upon the portion of the plain near the Colorado the Chemi-huevas have their cultivated grounds. The Mojave Indians are on the opposite bank of the river, and occasionally these latter travel south along this plain to make incursions upon the peaceable Maricopas.

Along its whole extent it is said to exhibit the same character—sterile where the soil is dry, fertile where it can be irrigated, and without timber throughout.

Saline incrustations.—During the period of visit many of the small basin beds were dried up, and presented a rippled sandy surface, easily impressed with the foot, but yet sufficiently coherent to resist the action of light winds. Upon the surface a dry whitish efflorescence was spread, which tasted alkaline and unpleasantly. Two such efflorescent incrustations were collected—one at a spot on the Mojave river known as Navajo camp, (Camp 3;) the other was collected from the surface of the dry playa called Soda lake. Portions of each of these were subjected to chemical examination, with the following results:

Incrustation of dry playa called Soda lake.—In mammillary bunches and botryoidal masses, efflorescent, readily crumbling under the finger, dull white externally, purer white and semi-crystalline internally; readily and completely soluble in cold water. Solution is colorless and transparent, and possesses a very faint alkaline reaction.

While crystallizing under the microscope, two forms of crystals are observable—needle prisms and cubes.

The solution tested with a barium salt gave a light precipitate, and a copious white with a silver solution, which is soluble in ammonia.

The solution was not affected by solutions of oxalate of ammonia or carbonate of soda, and did not effervesce on the addition of an acid.

The salt mass fused readily before the blow pipe and gave a deep yellow tinge to the flame.

From the foregoing it is evident that both sulphuric acid and chlorine are present, with the base sodium, and the crystalizations shows that only two salts are contained in the solution. The cubes are therefore chloride of sodium and the needles sulphate of soda. There is a mere trace of carbonate of soda, and not any lime salt present. The solution on standing deposits traces of silica. The amount of sulphuric acid present was determined in the usual way, and calculated for sulphate of soda; the difference was set down as chloride of sodium. The mass is not homogeneous; the centre of the nucleus containing the greatest amount of chloride, while the sulphate was round the periphery of the crust. Thus, one portion differed a little centesimally from another; but the following is an average of these estimations:

Chloride of sodium	85.	
Sulphate of soda	14.6	
Carbonate of soda, silica	.4	
	100.0	parts.

The very small quantity of carbonate present in this crust is singular, since an alkaline carbonate exists in the well waters at the margin of the playa. The water of the wells at the bivouac distintly effervesced and was very unpleasantly alkaline to the taste; the crust was taken one mile out in the middle of the playa which may account for its small quantity of carbonate.

Incrustation of soil at Navajo Camp.—An earthy powder of a light yellow brown color, and without trace of crystallization, of a dull white color, discolored by the surface soil; efflorescent, partially soluble in water; solution transparent, of an amber tint, owing to vegetable matter; highly alkaline reaction to test paper; strong effervescence on addition of nitric acid to solution.

On examination under the microscope, the same crystals were observed as in the former case, mixed up with amorphous powder.

Salts of silver and baryta gave abundant precipitates ; oxalate of ammonia gave no precipitate, nor was the solution troubled by carbonate of soda, or ammonia phosphate.

The sulphuric acid and the chlorine were determined by the usual methods, and the absence of potass proved : a small quantity of nitric acid was detected.

The portion which was insoluble was made up of fine felspathic clay and rounded grains of silica. These amounted to more than one-fourth of the whole.

By quantitive analysis the following results were obtained in 100 parts:

Insoluble clay and quartz	28.
Moisture and a trace of nitric acid	7.
Sulphate soda	19.5
Chloride sodium	38.
Carbonate of soda	6.
Sulphate of lime	1.5
	100.0

In plate 6, fig. 1, the structure of Cajon pass is shown ; in the same plate, fig. 2, the course of the Mojave river is shown, with the character of the ranges it crosses, the whole number of which, however, are not inserted.

CHAPTER XVI.

BITUMINOUS EFFUSIONS.

Localities where bitumen exists.—Proximity to the coast.—Submarine exudations.—Bitumen found in all stages of consistence.—Its abundance.—Santa cruz bitumen, particulars of.—Bitumen of San Luis valley.—Nature of the asphaltic rock, and details.—Fluidity of the bitumen.—Subterranean cavities.—Bitumen of Napoma.—Of La Purissima.—Nature of the strata through which it leaks.—Bitumen of Santa Barbara, locality, and extent of the bed.—A solid bitumen, no fluid outpouring.—Exposure along the shore cliff.—Estimate of the quantity which this locality affords.—Proprietorship of the land.—Enumeration of the strata at the cliff.—Upraised beach along the terrace.—Evidence of time afforded by a consideration of the cliff strata.—Bitumen of Rincon and San Buenaventura river.—Curve of the shore line.—Enumeration and thickness of the asphaltic rocks.—Bitumen spring twelve miles up Buenaventura river.—Sulphur spring, its temperature.—Liquid overflow of bitumen.—Strata of the neighborhood.—Deposits on the Santa Clara river.—Bitumen of Los Angeles valley.—Locality of.—Extent of outflow.—Liquid nature of.—Strata of the locality, amount of the bitumen, and cost at the spring.—Contrast between the supply at Los Angeles and at Santa Barbara.—Different estimates of the value of asphaltum.—Pecuniary wealth of Los Angeles valley in this mineral.—Bitumen of San Pedro, of San Juan Capistrano, and San Diego.—Remarks on the occurrence of bitumen in the strata of California.—Speculation on the probable origin of bitumen.

Bitumen is *par excellence* the mineral of southern California, being found in almost every county south of San Francisco. The localities in which it has been observed hitherto are as follows:

1. Santa Cruz mountains, southeast spur, Santa Clara county.
2. San Luis Obispo valley, San Luis Obispo county.
3. Napoma ranche, San Luis Obispo county.
4. La Purissima, Santa Barbara county.
5. Santa Barbara, 6 miles west of Pueblo, Santa Barbara county.
6. Rincon and San Buenaventura, Santa Barbara county.
7. Buenaventura river, 12 miles up, Santa Barbara county.
8. Santa Clara river, 18 miles up, Santa Barbara county.
9. Sierra Susanna, Los Angeles county.
10. Los Angeles valley, Los Angeles county.
11. San Pedro hills, Los Angeles county.
12. San Juan Capistrano, San Diego county.
13. San Diego, off shore, San Diego county.

The survey has traced the mineral in its course from the extremity of the Santa Clara valley to San Diego, a distance of more than four degrees and one-half, or about 300 miles by the travelled roads. It is remarked of most of these deposits that they are situated close to the sea, the most distant being that near Santa Clara river, (No. 8,) being not more than 25 miles inland; the next most remote is Los Angeles, and then that of the Santa Cruz mountains, being less than 15 miles; still closer are those of Napoma, Santa Inez, and Susanna hills, while those of San Luis valley, Rincon, and Santa Barbara are on the shore edge and dip under the sea. On the shore at San Diego and at False Bay, north of Point Loma, masses of asphalt are washed ashore by the tidal action. The submarine exudation cannot lie far out, as the asphaltic rocks lie beneath high water mark, and are visible at low water; nor is the effusion of bitumen from submarine localities confined to this district. The waters of the Santa Barbara channel are frequently covered with a thin layer of liquid bitumen, which is gradually inspissated by the evaporation and effect of solar heat, and then washed ashore in solid masses by the tide; the whole atmosphere of the sea, many miles out, being highly impregnated with the bituminous odor. These phenomena (the odor and surface film) were observed by the writer on two several occasions in sailing between San Diego and San Luis Obispo. It has also been observed still further out at sea by Lieut. Trowbridge,* U. S. A. It has not, however, been observed along the route of the Panama mail steamers, whose track lies considerably west of the islands off Santa Barbara shore, so that it may be inferred that the greater amount of upheaving action which evolves bitumen lies between these islands and the coast.

This substance exists in all the stages of consistence, from that of a thin syrup to that of ordinary coal. In some deposits, as along the Buenaventura river, all of these are found together; also along Tar creek, a tributary of the Santa Clara; in fact, wherever the bitumen is oozing at the present moment there the substance is fluid and thin. The quantity of the mineral is incalculably great in the several deposits, and the supply appears to be steady, although not abundant in the majority of the localities. The characteristics of each locality will be briefly alluded to in detail.

1. *The bitumen of the Santa Cruz mountains, near the Pajaro river.*—It is here found on the banks of the Arroyos La Brae and Pescadero. As many as six springs were found close to the banks of these two creeks, which cut their way through soft brown fossiliferous sandstone. The ground for several yards round each spring was covered with the solidified mineral, and, perhaps, twenty-five acres in all were occupied by the overflow. The fluidity of the bitumen at the immediate spring was not very great; not far distant from these is the igneous rock of the Santa Cruz range, serpentine and trap, (greenstone,) which is directly in contact with the tertiary sandstone, the latter is metamorphic near the point of contact.

2. *Bitumen of San Luis valley.*—This deposit is situated about four miles southwest of the village of San Luis Obispo, along the road leading down the river to the port. The road, as it leaves the valley, passes between a series of low hills, which cut off the valley from the shore. About half a mile below the ranch Corral de Piedras, which is located close to the edge of the valley, the asphalt is met with in situ. The rock is a fine quartzose sandstone of a brownish color, and decaying under the finger, darker on the surface than inside, and forming a pepper-gray colored soil; this bed is not fossiliferous. The strike, north 70° west, crosses the road, the rock dipping southwest 20°. The bitumen here oozes out from the rock fissures, and is spread over a space of 350 yards from the creek; one opening has a basin diameter of 30 inches; 8 inches below the surface is the well of bitumen, which rises and flows over the edge, coursing down toward the creek in a small stream, which solidifies some distance below, forming a layer of pitchy hardness, over which the fresher outflow wends its way. Another spring, 20 inches in diameter, resembles the former, being a hole in the superficial sand rock. This well has the bitumen in a more fluid condition; a six foot pole was pushed down through the centre of this fluid mass, and found its way readily until, from its pliancy, it no longer resisted pressure. The liquid hardens readily at the edges of the spring and on the soil around, which is partially liquified by the mid-day sun, rendering it plastic, but not fluid. A third spring close by gave off carburetted hydrogen gas, which was inflamed and burned brilliantly

* On the authority of Dr. Trask's "Report on Geology of Coast Mountains."

but unsteadily, owing to the insufficient supply. During its combustion a distinct gurgling sound was heard, noticeable twenty yards off, showing that the superficial spring was in communication with underground chambers, partly filled with air and partly with fluid, through which the gas, bubbling in its passage through to the external air, produced those gurgling noises. In this well the bitumen appeared to have varying levels; thus, upon one day it was found within three inches of the edge of the well; in visiting two days afterwards it was found five inches lower down. Probably the gaseous pressure of the lower chamber made the fluid assume a higher level. These springs, four in number, are all found on the north side of the creek; on the south side the same sandstone rises in a hill nearly 400 feet high, at the base of which the creek cuts a channel 40 feet long, 20 feet deep, and 6 feet wide, forming a natural lock. Still further to the north, in the dry bed of a small creek, a large accumulation of solid asphalt is found, in places 4 feet in depth by 12 feet wide. On following these up 120 paces, the upper limit was reached, but no spring or well appeared. A thin shelf of sandstone stretched from this to the creek; on following the exposed edges of which, the bitumen was observed to ooze from between the lamina of deposition of the rock, which here is of a darker tint than the beds higher up or lower down. There is no tilt or apparent rupture of the strata at this point, nor any evidence of igneous rock in the vicinity. The whole area of the surface occupied by the spring and overflowed by the deposits might be about thirty acres. The springs are collected together in an area of 200 yards, close to the road and the creek.

3. *Bitumen of Napoma ranch.*—This ranch is built upon a terrace of white sand, from 12 to 15 feet deep, below which is the white clay rock, a stratum superior to that described as the asphaltic rock of San Luis valley. Trappean rock is found northeast of the ranch, about 500 yards distant, toward the foot hills of the Coast Range. The overflow of asphalt is very limited; there are no distinct wells or springs, the mineral appearing to be forced up through the seams of the strata. The strata dip southwest.

4. *Bitumen of La Purissima.*—Evidences of this deposit were found in the low range which divides the valley of La Purissima from that of Santa Inez. The wagon road to Santa Barbara crosses these hills, which are all tertiary strata. On the Santa Inez valley slope of these strata the white argillite was found. In these were found the minute vertebrate casts alluded to in describing the argillite, which contains the casts of *arca obispoensis.*

These layers were of a light fawn color; lower down they were blackish, and had a bituminous odor. Thin crusts of bitumen lay between the layers, and where the rocks were fissured they were cemented together by the asphalt. These dark layers contain the impressions of the fish skeletons equally with the fawn colored layers. Although no distinct deposit of bitumen was found here, yet it is highly probable, had time been devoted to it, that it would have been found in this locality.

5. *The bitumen of Santa Barbara.*—This bed is one of the most extensive and best defined in the State, lying 6 miles west of the town of Santa Barbara, among the low hills along shore. The terrace land of the shore further west has here almost disappeared, and in its place are low, flat-topped hills, or swelling land, forming a small terrace at the shore edge, with vertical cliffs 70 feet high, at the foot of which is the sea beach. Along this cliff, for 1½ mile to the west, the asphalt may be traced. Eight distinct veins are found to pass up and overflow above, so as to form a coating of solid bitumen on the surface of the terraces, in places 8 feet deep. Occasionally grass grows over it, owing to a slight sprinkling of clay overlying the bitumen; but in most places the bitumen is uncovered, and destitute of vegetation on its surface. Several

exposures of this stratum have been made in various spots, in order to determine the extent of the deposit. Its greatest thickness appears to be at the cliff edge; in some spots, 600 yards inland, it is not thicker than three feet. The veins of supply rise at angles nearly vertical, varying from 3 inches to 4 feet in thickness. The mineral in the seam has a brown lustre; melts readily when heated; when cold, has a brittle conchoidal fracture. At the western edge of the cliff is a small cape stretching into the breakers some 80 yards, the extremity of which appeared to be made up of asphalt. Masses of bitumen were washed ashore containing mussel and other shore shells. The beach deepens so rapidly as to allow of no observations at ebb tide. Following this cape back to the cliff, the strata are found to dip away from it on either side, giving a curved form to the beds along the cliff edge. In crevices of the lamina of this curve the asphalt has infiltrated laterally. The veins must have once poured out their mineral on what was once a shore, on which are found the same shells of the present seas as were met at San Luis Obispo upon the terrace.

It is difficult to estimate the total quantity of bitumen here, but it must be very great; perhaps 300 acres of ground were occupied by the overflow, varying from 2 to 8 feet in thickness. It is easy of access, because lying along the cliff, down which it would only require to be sent by a "chute," and load a vessel with it below. Accurate search was made for some spot where it was at present being forced up, but there did not appear to be any traces of present action.

The land is claimed by Mr. Hill, owner of a ranch in the vicinity, but squatting has taken place close to these beds in the valley. Some claim is also made to it by Messrs. Palmer, Cook & Co., of San Francisco. As the bitumen here is wholly solid, it is better adapted for shipping, and some cargoes have been sent to San Francisco, where it can be delivered for seven dollars per ton, total charges. The upper portion of the bed is mixed with alluvial clay and beach shells, but the great mass of the bitumen is pure; it has a brownish-black color, without the glossy black of the Cuban variety, and dissolves readily in spirits of turpentine. It is, however, equally valuable for all purposes of manufacture, except that of varnish making, with the Chapapote mineral. Considering its purity, abundance, and facility of transport, this bed of asphalt may be looked upon as the most important one in the State.

The strata found at the cliff edge are as follows, from above downwards:

1. Bed of hard gray sand, including a calcareous layer filled with beach shells, 6 to 8 feet thick, and is unconformable to the strata below.

2. Whitish clay rock, with threads of asphalt between the laminæ; dip, 55° south 40° east; strike, north 50° west, (magnetic.) Owing to its softness, this rock is worn by the tide into small caves along the beach; the inferior beds are darker colored, and in belts, a dark layer two feet thick intercalating with the whitish layers, and repeated five times; total thickness, about 200 feet.

3. Greenish arenaceous rock—a fine-grained rock, containing small round fragments of quartz; the bed exposed did not display any fossils; has the same dip as the overlying white rock; not more than 60 feet thick was exposed when the valley bottom was reached, making the total thickness of the exposed rocks 260 feet.

On the surface cliff, near the cape or headland alluded to, is a collection of shells, of the same species as those lying on the shore below, mixed in with the gray sand of the cliff, showing hat, at the time of this outflow of asphalt, and for some time subsequent, this was the beach level. The calcareous layer which underlies this, generally four feet down, is a continuous seam of shells of both fresh and brackish water, among which voluta, melania, natica, and helix, are prominent species. Here, then, is an anterior epoch before the upheaval of the asphalt, when the surface was the bottom of an estuary similar to that which rolls up the flat land behind the present terrace; so that three distinct periods are chronicled in this cliff, viz:

1. The deposition of these soft clay beds.
2. The estuary action and deposition of the brackish water shells.
3. The elevation of this to its present height, 60 to 80 feet; this was most probably accompanied by the effusion of asphalt, the elevation being at intervals so as to allow of the formation of the beach on the upper surface.

6. The localities of the Rincon, and the mouth of San Buenaventura river, are more remarkable as geological displays of the strata in which asphalt is found, than as actual deposits of practical value. A magnesian and trachytic axis runs into the sea at the Rincon, forming the headland. Minor protrusive rocks occur, within a few hundred yards of each other, between these points, which give the shore line a crescentic form, repeated three times, the concavities being towards the sea. This excavation is formed by the sea, owing to the soft nature of the strata along shore, being the same white and brownish clay rocks, overlying greenish sandy beds, through which the asphalt leaks up. The strata dip inland or under the shore, and are nearly vertical on the beach. In one of these indentations of the shore, the strata, as they crop out on the beach and under the water, are commencing with that nearest the axis.

1. Dark greenish sandy clay rock, colored with bitumen. Two hundred feet of this could be measured along its edges until the water became too deep for further examination.
2. Coarse grit clay, with whitish quartz, seventy feet; fossiliferous.
3. Fine grit, with bitumen, forty feet; making a total thickness of bituminous rocks = 310 feet. The bitumen is here washed ashore in small masses; along shore the bitumen is only found in threads leaking through the strata, which are cleared off by the tide, so that no deposit occurs.

7. *Bitumen of Buenaventura river.*—This is found 12 miles above the mission, along the left bank of the river, the ascent of which is unusual. Passing the range of hills which abuts upon shore at this point, the river opens into a small terraced valley, and thence cuts its way through an undulating country which lies between the back of the shore range and the little valley of Matilihah. This is occupied by coarse brown and reddish grits, such as form the lower beds of the Santa Inez range; here they dip northeast and southwest, within a narrow compass, owing to the intrusion of trachyte, whitish felspar rock, and porphyritic felspar with orthose crystals. This rock crosses the river and does not exhibit an exposed breadth of more than 60 yards; in proximity with it and on its northern edge near the left bank of the river, is a spring which deposits a large quantity of sulphur; its temperature was 64° Fahrenheit, the air being 55° Fahrenheit. Along with the spring is an overflow of bitumen, which has covered up the soil 20 feet around and 2 feet deep; it oozed up not from one point but apparently from crevices extending some yards and wide enough to allow a 2-inch pole to be inserted, which could be pushed down 4 feet, but was then arrested by the tenacious character of the bitumen. The strata are not the clay rocks usually accompanying the bitumen, but are the brownish sandstones of Santa Inez. Here, too, as in other places where sand rock is close to trachyte, it is colored red, by oxide of iron, of a vermilion tint, and in riband strata. The deposit of bitumen at this

point is limited, appearing to be the commencement of a series of outflows which are found occurring at intervals eastward beyond the Los Angeles river; with this deposit may be classed—

8 and 9. *The deposits on the Santa Clara river tributaries and among the Susanna hills.*—These are but the eastward continuation of the foregoing outflow. If a line be drawn from the deposit upon the banks of the Buenaventura river in a southeast direction it will touch in its course several disturbed districts containing deposits of bitumen, until it reaches the low hills north of the Pueblo Los Angeles, where the largest overflow has occurred. The small stream which rises in the low ranges between the Buenaventura and Santa Clara rivers, and finds its way down to the latter stream, about 12 miles up its valley, received the provisional name of Tar creek, from its passing through a small valley in which several very extensive outpourings of the bitumen were observed. Several small wells or springs were found here delivering small quantities which had consolidated further down on the slope. The bitumen occasionally pours into the creek, and is washed down into the Santa Clara river. It was detected here at the point of debouche by the main party travelling up the Santa Clara, and observed by Mr. Campbell along the line of the creek in a cross trail made by him from Matilihah to the Santa Clara river. From these deposits occurring in a rocky district troublesome to reach they are not available sources of bitumen. They occur in the brown sandstones last described. Deposit No. 8 has already been alluded to as most distant from the shore.

A deposit occurs on the Santa Clara river, about 8 miles up the valley; it occurs in one of the ranges of the Sierra Susanna, is in close proximity to whitish amygdaloid trachyte, met with in brown sandstones accompanied by a sulphur spring, and is on the right bank of the river. Report speaks of other deposits occurring more easterly along the chain of hills which run toward the Cordilleras.

10. *Deposit of Los Angeles valley.*—This occurs between one and two miles north of the pueblo in an air-line, but as the low range of the Sierra Monica, in which it is found, runs east and west, the road winds round northwards to reach it. These hills are a brownish yellow sandstone, 120 feet thick, passing into a hard shale lower down, which is covered up by a bed of soft white argillite, 20 feet thick, in turn covered up by a thin brownish fissile slate, 30 feet thick; above all is a capping of porphyry and granitoid drift gravel. The strata are tilted at a high angle dipping northwest from 40° to 75°; upon their upturned edges the drift rests. Whitish trachyte and greenstone are the upheaving rocks which run north 60° west, and alter the sandstones in contact, rendering them hard, sonorous, and giving them a line of cleavage nearly vertical to the plane of deposition. The asphalt is protruded through these strata near its contact with the argillite, forming distinct wells or springs, which overflow. The land where they lie is owned by Captain Dryden, who, at the time of visit, was sinking a pumping apparatus for hoisting up the bitumen, which is very liquid at this locality, where it forms a small pond a fourth of a mile in circumference, thinner in the centre than at the edges. Like the other varieties, it readily dries, and forms a solid pavement some yards around the edge of the wells. A large quantity is occasionally raised and sold at the rate of 40 gallons for $5 = $1 for 8 gallons. It is in some demand for flooring and roofing. The quantity drawn at present seems to have no effect in diminishing the supply; but as intervals of rest occur, owing to the limited demand, it is difficult to say what continuous supply could be derived from this source. Mr. Trask, in his report, (Doc. No. 14, Calif., session 1855,) calculates the amount of asphaltum in the counties Santa Barbara and Los Angeles as not less than 4,000 tons. As

he only mentions two localities, that near the village Santa Barbara, and this at the Pueblo Los Angeles, it is presumed he reckons these as the only sources of his estimate. He does not state what the data of the calculations are. The actual quantity already poured out on the Santa Barbara shore is vastly greater than at Los Angeles—perhaps 6,000 tons would be an under estimate for Santa Barbara; but as a *source* of asphaltum it is extinct, while that at Los Angeles is actively pouring out, although the accumulated overflow is much smaller. As a locality of asphaltum available for the present time, Santa Barbara is pre-eminent; as a source for future wants, Los Angeles is preferable. By following the line of upheaval on these hills, and making borings in the sandstone strata, the bitumen might be reached, and thus other sources than the natural well might be drawn upon. Dr. Trask values the asphaltum delivered in San Francisco at $16 per ton; but this is an excessive valuation according to the price at the well, or according to the calculations of freight from Santa Barbara northward; allowing the value to be $7 per ton, and in Los Angeles valley about 2,500 tons to be at present available, the actual present wealth of the valley in bitumen would be $17,500. This, of course, does not take into account the future supply.

11. *Bitumen of San Pedro hills.*—This locality, south of Los Angeles valley, is a soft argillite, similar to those found further north in the Monica hills; in these strata the bitumen leaks out in small quantity as at Rincon and San Buenaventura rivers; no actual deposit has been met with as yet upon these hills.

Further east, in the valley of San Gabriel mission, the asphalt again occurs in small quantity on the low hills nearest the mission.

12. *Bitumen of San Juan Capistrano.*—This is taken for granted on mere report, as no observation was made; it is said to occur a few miles inland above the mission in considerable amount.

18. *Bitumen of San Diego.*—Here, as was stated at the commencement of this chapter, the asphaltum is observed on the seashore, washed up by the tide; as the strata in the immediate vicinity of high water is the greenish arenaceous rock, in which it is elsewhere usually found associated along the Santa Barbara shore, the point of exudation cannot be far out under water. The strata dip toward the sea at False Bay and Point Loma, it is probable that its true position is not far distant from the shore.

From the foregoing notice of the occurrence of bitumen at various points in the State, and of the accompanying strata, it appears evident that the beds in which it is found are accidental and not constant. From the outpouring being close to shore, it has happened more frequently that the softer and more recent of the deposits are those in which it is found; but that where it occurs inland it is met with infiltrated in a brownish yellow sandstone, which lies below the softer rocks along shore; in other words, it is sometimes met in the Santa Inez brownish sandstones, at others in the softer argillites of the San Luis series. The immediate cause of the outpouring is the upheaval of trachyte and amygdaloidal greenstone, and almost in contact with this rock it is *at present* oozing out; showing that this elevating force is not yet quiescent. At Santa Barbara, east of Point Rincon, and a few other localities, where magnesian talcose rock or scoriaceous lava is the upheaving cause, the action has ceased and the deposit is limited; lastly, it may be remarked that numerous as are the serpentine protrusions among the mountain ranges, constituting some of the most powerful uplifts in the Coast mountains, and occupying a breadth of surface which is not equalled by any other volcanic rock, yet nowhere is bitumen found close to it.

It is idle to speculate on the ultimate source of the asphaltum. The generally attributed source, namely, a deposit of fossil vegetable matter, overheated by volcanic rock, does not occur here apparently. The strata through which it escapes are, where observed, almost destitute of vegetable matter; the brown sandstone wholly, and the greenish having a few traces of fucoids scattered sparingly throughout their structure. The tertiary rocks are in contact with the granite. The sedimentary strata are but a few hundred feet thick before primary rock is met with. There are no palæozoic strata, no extensive beds of metamorphic shale, no carboniferous strata, to fall back upon to hypothecate its formation. There are no excessive fish remains whose decomposition could be supposed, even by a chemical imagination, capable of producing this mineral.

Illustrations of the relation of asphaltic effusions to the contiguous strata are given in plate 1, figure 2, plate 4, figures 3, 4, and 6, and plate 5, figures 2 and 3.

CHAPTER XVII.

OF THE QUATERNARY PERIOD IN CALIFORNIA.

Observations on the condition of California, from the time of the deposition of the blue clay downwards.—Removal of the upper local drift of the Pacific slope, its persistence in the basin and region east of the Sierra Nevada.—Ancient terraces.—Height of the waters of that period.—Detailed notice of the terraces on the Salinas and San Bonito.—Santa Margarita.—Terraces of Santa Maria valley, Panza valley, and Carrizo.—Terrace levels of Santa Inez valley.—Terrace along Santa Barbara shore.—Terraces of Los Angeles valley.—Synopsis of localities of terraces, with their altitudes.—Upraised beaches of San Luis Obispo.—At San Pedro.—Section of cliff along shore.—Recent shells in.

An interesting portion of the physical history of California is that which relates to the period immediately preceding the existing state of things; a period subsequent to the deposition of the blue clays, the sands and gravels, with the coarser local drift, (the chief portion of which latter has since been removed,) and anterior to the present physical configuration of the coast line. This period, when the present surface of California was an ocean, studded over with elliptical shaped islands, which ran in linear meridional directions, with currents flowing between them and the main land, was one of elevation with perhaps occasional depression, and is one the history of which there are not materials sufficient to transcribe.

In the geological history of this coast, depression of the land does not appear to have entered largely as an element. There are no records of a continued slow depression, as evidenced elsewhere, by the carboniferous limestone of the Rocky mountains or of the Jurassic beds further east; at those epochs it does not appear that this portion of the continent even skirted the main land—far away out to the westward it formed the depressed bottom of an ocean whose shores were no nearer than latitude 110°, if, indeed, at that epoch, there were any summits of the continent from latitude 30° to 37° north, above the surface of the sea. So far out at sea was it that it does not appear that the granitic bottom received much current deposits until the commencement of the tertiary era, when, by the elevation of the land, basins, estuaries, and rivers of greater magnitude aided in the formation of those sand and clay beds which have accumulated to so remarkable a thickness.

At the close of the tertiary period commenced the deposition of the thick blue clays with broken shells; then the yellow clays and gravel, and, lastly, a bed of conglomerate drift, of mixed material, granitic and volcanic materials, which upon one valley plain at least has been wholly removed. This drift is derived wholly from the degradation of the neighboring sierras, and contains no masses of rock which cannot be traced to the hills in proximity. The removal of this upper bed from the vallies of California has materially increased its fertility by diminishing the depth of the porous unconsolidated strata. East of the Sierra Nevada, in the Mojave valley, the same unconsolidated strata are met with; also of granitic and volcanic conglomerate in the upper bed; but there it has not been removed, and, like the Sonoranian desert, it is a barren plain which appears to have undergone but little physical alteration since its final upheaval.

With the deposition of these Quaternary beds, especially of the upper ones, and with the corresponding periods of upheaval, are connected the system of ancient terraces which are met with everywhere in California. Every mountain side, every river bed, and every valley of that State, presents the unmistakable evidence of a state of quiescence of the land with that of a gentle flow of water over its surface during the latter portions of the Quaternary period; a period of deep estuaries and bays or straits, whose waters then reached points now nearly 2,000 feet above sea level; or, in other words, when the land was so much depressed.

Notice has been made incidentally, throughout this report, of the occurrence of these terraces, in describing the localities where they exist, and it is only necessary here to collect the observations together so as to form a connected series.

Commencing at the Salinas valley. Three terraces have been noticed on its bed, and one on the sides of the San Antonio hills, near the mission San Miguel. On the Arroyo San Bonito, a tributary of the Pajaro, which it joins near the village of San Juan, a little south of that village both sides of the stream have continued terraces for four miles; that on the east side, or right bank, being 40 feet above the present valley level; that of the west side almost as high, differing only in a few feet from the other; the valley is not a mile across. This valley is one which leads out from Tulare valley through the high range (Gavilan) separating them.

The pass leading from the Salinas valley to Monterey is formed of the sandstones overlying the Point Pinos granite; at an elevation of 140 feet the summits of the low hills are flattened and covered with oaks; the terrace flat extends 100 yards back on each slope. This may have some connexion with the terrace on the valley side of the San Antonio hills, which are about 20 feet above the level of the stream. South of the mission San Miguel, terraces again are found on each side of the river bank, 70 feet above the river level.

On the west side of the valley Santa Margarita a small terrace is found, 12 feet above the valley; on this eminence the old mission Santa Margarita is placed. There were no terraces observed on the east side of this valley.

In the valley of the Santa Maria river some of the most extensive systems of terraces were found. These have already been noticed in full; they stood on the sides of the San José range, at the heights of 30 and 150 feet, respectively; a terrace flat existed on the central insular elevation and a high terrace on the Santa Lucia hills, above 150 feet high. Besides the hill terraces, the river bottom was cut down so as to form a well marked terrace, the ancient or upper bed of the river.

On the east side of the San José mountains, in the Panza valley, and the elevated land of Carrizo along the banks of the Estrella river, two sets of terraces were found, the lowest at 12 feet, and the upper 70 feet above the river level. It is remarkable how nearly the levels of the upper terrace here and that of Santa Maria valley assimilate, the one being 1,650 feet above the sea and the other 1,670. The difference might, perhaps, be placed to an error of observation. In Santa Inez valley the river flows in a narrow bottom, 25 feet below the ancient valley, in a direction toward the west; north of the ancient bottom, a terraced land spreads along its margin 20 feet above it; upon this the mission Viejo is placed, behind which (N. W.) another terrace rises 100 feet above the last. These different levels are not distinctly repeated on the south side. The different ancient water levels are, then,—

25 feet—ancient river bed, above which, at
20 feet—1st terrace,
100 feet—2d terrace,

above the present river level.

Leaving the inland valleys and taking the line of travel along shore, the whole base of the Santa Barbara range, coastward, will be found to be one great terrace from Point Concepcion to Santa Barbara. As the latter place is approached, the terrace at the immediate base of the range is scooped out, forming a valley, in which Mr. Hill's ranch and the Indian village are situated. This terrace, in its whole length, averages 80 feet above the ocean level, toward which it presents cliff edges.

At the mouth of San Buenaventura river the foot hills of the Santa Inez chain approach the shore; on the shore edge of these, terraces are found 150 feet above the mesa land below; in the valley of this stream terraces of small elevation are found; in the valley of Matilihah, which lies near the head of this stream, surrounded by the converging ranges of the coast, terraces exist on the hills on each side of the valley at an elevation of 60 feet above that of camp, which was 2,000 feet above the sea.

On the sides of the hills, the continuation of the Sierra Monica, extending into the Los Angeles plain, terraces of small extent are found; their elevation does not anywhere exceed 100 feet above the level of the plain.

The following synopsis of the localities where terraces have been found, with their relative and absolute height, may serve as a conclusion to this brief notice of the evidences of rising land:

	Relative level above valley or river.	Absolute level above sea.
Salinas river valley		
2 river bottoms — 1	6	about 30
2 river bottoms — 2	7	
Terrace 70 miles up	20	180
Pass to Monterey	140	170
San Bonito river	40	
Santa Margarita	12	962
Santa Maria valley		1,500
on San José mountains, No. 1	30	1,530
No. 2	150	1,680
Santa Lucia range	150	1,680
Altitude of terrace at Quatre Domingo		1,530
Panza—1st terrace	12	1,612
2d terrace	70	1,682
Santa Inez—ancient valley	25	425
1st terrace	20	445
2d terrace	100	545
Santa Barbara shore		80
San Buenaventura mission	150	230
Matilihah	60	2,060
Los Angeles valley	100	400
Mojave valley	50	2,050

The terraces of the Salinas are illustrated in plate 1, fig. 1; of the Santa Maria, plate 2, fig. 4; of Santa Inez, plate 3, fig. 1; of Santa Barbara, plate 3, figs. 2 and 4; and of Buenaventura, plate 4, fig. 6.

Ancient sea beaches have been observed at a few points in or near the shore. In San Luis Obispo county one well marked sea beach is found on the summit of a conglomerate hill which overhangs the west side of the valley a little south of Corral de Piedras ; the summit height, 300 feet above the plain, was covered with fine quartz sand, mingled with broken and perfect shells such as exist on the shore a little west, as the *Saxidomus Nuttali*, a common shell along the coast. Another beach was found on the summit of a small hill which lies directly at the mouth of the San Luis river on its southern side, with similar shells ; this hill had not an altitude much exceeding 150 feet. The shells found on it were precisely similar to those found along the present shore at the base.

On the terrace, a few miles north of Santa Barbara, deposits of fine quartzose sand with the broken shells indicated the existence of an ancient beach along its line, and similarly at the port of San Pedro along shore, where the cliff has been cut down for the improvement of the wharfage ; besides the terraced flat above, which may be 40 feet high, the cliff itself presents the following section, from above downward:

Alluvial clay and sand, 10 feet.

Calcareous bed, (beach,) 8 feet.

Arenaceous clay with modiolus, cardium, and small univalves, 22 feet.

The strata dipping southwest. At another point north of the custom-house, a section slightly different was obtained ; the distances between the two points might be 500 yards along shore, the strata dipping north-northwest.

Alluvium, 8 to 11 feet.

Raised beach, with shells, 4 feet.

Argillaceous rock, 6 feet.

Yellow and blue clays stratified, 30 feet.

Accompanying the *Venus Nuttali* is a *trochita*, also very common along shore ; these two shells form the mass of the perfect as well as of the comminuted shells of every raised beach along shore.

CHAPTER XVIII.

GEOLOGY OF THE DISTRICT FROM SAN DIEGO TO FORT YUMA.

Tertiaries of san diego.—Volcanic rocks near san pasquale.—San ysabel.—Axis of the cordilleras.—Warner's rancho.—Agua caliente.—Minerals in the granites of san felipe.—Springs of.—Porphyritic rocks between san felipe and vallecitas.—Springs at latter place.—The cordilleras —Their breadth, altitude, and structure.—Volcanic intrusions in.—Included gneiss.—Probable age of the range.—The colorado desert.—Tertiaries and alluvium.—Curved beds.—Excessive temperature.—Physical appearance of the margin.—Sackett's wells, soil at water of.—Igneous rocks of desert.—Lagoons.—Alamo mocho.—Wells at, and supply of water.—Slope of the desert.—Its vegetation.—Climatal phenomena.—Trail to cook's well.—Drift sands.—On new river, and the present fluviatile action of the colorado.—Algodones.—Colorado river —Fort yuma.—Of the climate and water supply of the desert.

The low hills which surround the mission of San Diego, and which form the headlands along the extremities of the harbor, are of the tertiary period, and are similar in character to those existing at Los Angeles and further north to the San Buenaventura river.

These tertiaries stretch inland, forming a high terraced country, which continues to ranchos Solidad and Peñascitas. Trappean and augitic dykes commence to show themselves east of this, and the character of the country changes, becoming more rugged and elevated, until San Pasquale is reached, where the underlying rock is a soft felspathic granite. The direction of the granitic ranges here is south 70° west, cut through by a finer grained porphyry granite running east and west; here and there the granite contains hornblende crystals, but never for any distance, returning again to the micaceous variety; further east, at "Lagoons," (11 miles,) it becomes coarser, with well defined crystals of orthose; these hills enclose small valleys between them, well supplied with springs, some of which, coming from deep sources, are warmer than the atmosphere in winter time.

San Ysabel mission is situated among the fertile valleys near the summit of the sierra. Granite constitutes the only rock visible; it is a coarse felspathic variety, and has masses of gneiss and mica slate imbedded in it.

From San Ysabel the trail leads through a granitic cañon, the hills on each side of which cannot be less than 2,000 feet high. Near Warner's rancho is a hot spring, "agua caliente," which issues out of a cleft in the granite, and has a temperature of 135° Fahr. The granite between the rancho and San Felipe is soft and felspathic, with brownish mica in moderate sized plates, and, as at San Ysabel, is not homogeneous, but contains masses of gneiss imbedded in it; here also occur veins of quartz with imperfect crystals of dark tourmaline, (schorl.)

The valley in which Warner's rancho is situated has a slight slope to the southeast. On the western side, at the base of the hills, are some marks of terrace action.

At San Felipe, the river, which a few miles higher up was flowing, had disappeared, and its course was indicated by the growth of salt grass, rushes, and a saline efflorescence of common salt, gypsum, and carbonate of potass. The soil is composed of the debris of the felspathic granite. The massive rock here is syenite, composed of lamellar hornblende, and white felspar, with, here and there, occasional plates of mica, and some quartz. Through this a vein of brownish granitized rock (protogine?) cuts, running north and south, and dipping 50° east. It is made up of light brown orthose, rhomboidal, and hexahedral mica, with talc; crystals of schorl intersect the felspar crystals, and traverse them completely. The syenitic rock is very felspathic, and has two series of divisional planes.

The coarse salt grass and reeds growing along the river course indicate the character of the water, which is hard, brackish, and curdles soap readily. Behind the new adobe house erected by an American settler, a mile south of camp, (May 31,) there is a fine spring of fresh water, and there is but little doubt that deep wells would supply good water in abundance, but the surface water and the current immediately beneath are saline.

Between San Felipe and Vallecitas the trail returns somewhat to the west, and traverses the gneissose belt, with porphyry veins, already alluded to, at a point several miles south of where they were noticed, between Warner's and San Felipe. Indeed, from Warner's rancho to Carrizo is parallel to the trend of the Cordilleras. Six miles below San Felipe the veins of whitish porphyry granite are seen cutting through the igneous rock, (coarse, dark brown, quartzose granite,) dipping 28° west by north. Nine miles below camp, at San Felipe, there is a distinct intrusion of the finer grained granite (protogine) observed through the coarser rock, which has tilted a mass of gneiss rock, one thousand feet in thickness, to an angle of 30°, presenting a large anticlinal axis, the gneiss and mica slate dipping away from it both to the east and west. The hills on the west, at Vallecitas are granitic, while those on the east are gradually merging into porphyry, or trachyte porphyry, becoming reddish brown and felspathic. These hills are terminated by beds of clay and gravel. They have a slight inclination to the southeast, and have a thickness, in some parts of the valley, ranging from 10 to 15 feet. The lower hills of clay are terraced.

The water at Vallecitas is hard and sulphurous, but not unpleasant to the taste. As many as twenty springs are concentrated near the camping ground; these ooze out gently, flow down a few yards as a small stream, and then sink into the soil.

The descent from Vallecitas to Carrizo creek is easy, being down the slope of a valley. Having arrived at Vallecitas, the Sierra may be said to be crossed, and its characters in the mass may be better comprehended.

The granitic upheave which constitutes the great bulk of the chain cannot be less than 40 or 45 miles wide from San Pasquale to nine miles east of San Felipe; many of its summits within these limits reach 7,000 feet, and much of the elevated land has an altitude of 4,000 feet. Throughout this great extent it does not appear to have undergone any subsequent alterations by upheaval or intrusion—at least, in its central portions; but, upon the flanks of the chain, both eastern and western, volcanic rocks of a different date are exposed.

Between Peñascitas and San Pasquale are found intrusions of trappean rock of an uncrystalline augitic character, which occurred posterior to the deposit of the tertiary beds which lie in contact with them. These beds lie in close proximity with the granitic rock, although in no place were they observed in contact; they dip gently (speaking generally) northeast at a small angle. Although, therefore, the great mass of the sierra has been upraised since the period of their deposition, yet there must have been a granitic chain in existence previously, upon the slope of which these tertiaries were disposed, and the maximum elevation may have occurred on the eastern or desert border of the sierra. There, as at San Felipe, the granite may be observed upraised, fractured, and injected by a latter granite; and beds of gneiss and mica slate tilted up, and even separated into small basins. At more elevated portions of the range the gneiss has been observed included in large masses within the granitic rock, as if in the upheaval, the fractured gneiss bed became imbedded in the yet pasty magma of the granite. The chemical character of the granite changes from west to east as it crosses, so that the predominating mineral apparent in it is as follows:

West.—1. Granite, (micaceous;) 2. Gneiss; 3. Syenite and hornblendic rocks, with protogine; 4. Felspathic porphyry; 5. Trachyte.—East

The eastern flank of the sierra is lined by a range of volcanic hills, made up at the base of reddish felspar, porphyry, and trachyte, upon which is superimposed a rough conglomerate of primary pebbles.

With our present knowledge it may be difficult to fix the exact geological age of the sierra. As the Miocene tertiaries of San Diego rest unconformably upon the granite west of San Pasquale, the elevation of the great mass of the granitic axis is post-Miocene; but during, and perhaps before, that period a submarine and partially elevated axis was already in existence, at which time was probably formed the terraced summits in the valley of Warner's ranch. Since then the later granites and porphyries forced their way through the eastern sides of the chain, and may have contributed to raise the whole range very much higher; yet, between that elevation and its present height, an interval of considerable time occurred to produce the unconsolidated sands and clays of the desert; and as this last elevation of the basin has been uniform over its whole breadth, (100 miles at this point,) such an upheaval could not have occurred without also lifting the whole mass of the sierra to some additional higher level. There are thus three periods of elevation of these mountains, the latter two of which are *post-Tertiary,* (post-Miocene.)

Carrizo creek runs over a series of stratified clays and gravels, derived from the decomposition of the primary rocks, chiefly syenite, loose drifted pebbles of which cover up the sand beds of the valley. Through this sand the Carrizo, in places, cuts its way very deeply. At the camp (June 3) on the river, the sand is deposited unconformable to the primitive rocks, upon whose side it reposes. It is mainly composed of disintegrated syenitic rock.

Having travelled seven miles down the Carrizo, from the point where it is first struck on the descent, the trail leaves the river and rises a terrace of stratified clay gravel, with interlaced layers of gypsum.

This is the rim or margin of the desert, and constitutes the edge of a terrace, the uppermost of two. The level of this terrace is 430 feet above the sea, and slopes gently south and east, until it meets with the beds of fine clay constituting the desert bottom. Coarse gravel pebbles are strewed plentifully along the trail, with volcanic debris, broken fragments of basalt, porphyry, purple felspathic rock, and loose blocks of syenite; through this the creek cuts its way. This heavy deposit of sand is denuded in places by pluvial and fluviatile action, posterior to its deposit, and before its elevation above the sea, the wearing of the porphyritic and igneous rocks occurred, whose pebbles are loose, upon its surface, and which cannot be classed with results of causes at present at work. Between the river and the volcanic rocks at the east, the stratification of the sands are well marked; and while they are unconformable, they have a slightly arched line of deposit, giving an apparent dip east and west of the river, which may be due to its having been deposited in an estuary mouth, or in the manner in which tidal bars are formed.

The storekeeper inhabiting the adobe house, newly built at camp, informed us that, for the eight months previous to our visit, it had not rained but once, and then for eight hours heavily;

at the foot of such lofty, rough crested hills, rain, indeed, must be scarce, yet the evidences of running water are displayed in the base of the triangular valleys leading out from the range, where large stones are washed out of the clay and sand and heaped together, the result of existing causes.

The temperature at Carrizo on the 3d June at noon was 100° Fahrenheit, and rose to 102° later in the day. The effect of this heat was visible on the stream, which ceased flowing about 11 o'clock, and did not recommence until near 4 p. m., being absorbed or evaporated during the interval ; two miles below it completely disappears in the sand. Five miles below camp is the high terrace mesa, on gaining which may be seen the desert, as far eastward as the eye can reach. To gain this the river bed was travelled down and its direction followed, for a few miles, where the valley widened into a flat water bottom, the reservoir of the Carrizo ; in front, was the denuded wall of the sands and clays, forming the terrace alluded to, and on the west lay the volcanic rocks, which we were leaving behind, and which stretch out eastward in isolated mountains, forming an unconnected chain, and by contrast to the even surface of the desert resembling, what no doubt they were at one time, headlands and promontories of a bold shore jutting out seaward.

From the edge of the terrace to Sackett's wells is about twelve miles. The soil along the trail is made up of rounded quartz pebbles, grains of felspar, and larger pieces of the minerals mixed ; a yellowish brown fine sand, with some plates of mica, and occasionally small masses of purplish felspar porphyry, all rounded and well polished. Mr. Wm. P. Blake, in Lieut. Williamson's Report, 1853, (H. Doc. 129,) no doubt gives the true explanation of the polishing of these pebbles by the attrition of the loose sands, drifted by the winds.

The unconnected chain of igneous rocks, referred to above, run out about forty-five miles into the desert. One of these lies north of the trail, and one to the south, separating it from the Gulf of California. One of the most remarkable of these is "Signal mountain," which serves as a landmark to travellers from Fort Yuma to San Diego. These hills, judging from their outline, are granitic and porphyritic, with trachyte. Although at a distance they appear like a connected range, yet, when examined carefully, it may be seen that many of them drop down at their extremities, and can be travelled round. Indeed, there cannot be truly said to be any distinct range running eastward from the Sierra Nevada, the general character of the country being a series of extended plains, separated from each other by isolated ridges or lone hills, whose general direction is north 40° west, and south 40° east.

The water supply at Sackett's wells consists of three wells sunk in an arroyo bed, which itself lies four feet below the general level ; the wells are about six feet deep, and the water oozes in about five feet down, flowing through a thin stratum of sand which overlies the clay bed constituting the bottom of the wells. Should this last be cut through, the water sinks, and it would be necessary to go several feet down to meet another clay layer. A fourth well was dug at this time by a Mexican party travelling along. The water is good, not saline, and agreeable to the taste ; it oozes out of the sand layer slowly but steadily, requiring six minutes to fill a two-gallon pail. In one of the wells a barrel has been sunk, which should be done with all, and an adobe building should be raised around them. The clay at the bottom of the wells is a yellow, tenacious argil, and advantage might be made of it for brick manufacture, or using it merely puddled as a material for the sides of the wells.

From Sackett's wells to Alamo Mocho is thirty-five miles, passing by Lagoons, the trail lying along a heavy sand road. The sand is fine, white, rounded quartz, like beach sand ; the clay gradually disappearing the greater the distance from Sackett's wells. In the proximity of the Lagoons the trail was on hard clay, and thence to Alamo Mocho it was mostly sand. This may be looked upon as the most sterile part of the whole desert, on many thousand acres there not being a blade of any vegetable growth. In several places a thin pellicle of clay, two to three inches deep, covers the surface, over which are scattered thin and worn specimens of Anodonta, and some small univalve Gasteropods.

The southeast wind, rising in the afternoon, and blowing with considerable force, carries quantities of the fine sand with it, rendering it intolerably hot and scorching to the eyes; raising the temperature often to 115° Fah.

The "Lagoons," which are occasionally filled by overflows of the Colorado river, (distant 52 miles,) were, at the period of visit, perfectly dry at Alamo Mocho, so called from the stunted and deformed cotton-wood tree near the springs;* the water is in the bed of the New river, so called, as being the new course which the Colorado took in its overflow of 1849. The channel bends at this point, and is considerably below the level of its bank upon one side, where yellowish red stratified sand, 35 feet high, abut upon its edge. A new well has been sunk lately by the United States goverment, which is 22 feet deep, and yields an ample supply of water, not less than 500 gallons being removed in 2½ or 3 hours; which, though it had an evident effect in lowering the well, yet its place was quickly supplied by a fresh influx of water. The well is defended by a wooden shaft and plank work to keep the sand from caving in, which is carried up 4½ feet above the level of the surface; a bucket and windlass would be a great boon to this spot, although found difficult to keep them. Two older wells are at a few yards distance along the same line. In one, the timbers have yielded and decayed, and the well is useless; the other is in good order, but does not yield so large a supply as the new well.

The whole level plain of the desert at Alamos slopes gently to the south, and in this direction also runs New river bed to meet the Colorado. The line of the bed can be traced by the cotton-woods and mesquite, which are only found growing there. On the level of the desert there is nothing but obione and larrea, the absence of vegetation being thus shown to be due, not to any infertility of the ingredients of the soil, but to the absence of sufficient moisture at the time when vegetable growth requires it.

There is much more moisture in the air at this part of the desert than further west, at Carrizo. Hills 8 and 10 miles off were indistinct and hazy in outline, neither were the stars so distinctly visible; but no dew falls at night, the earth not cooling down sufficient to deposit the moisture from the atmosphere, consequently vegetation suffers almost as much as if the air were wholly deprived of it. Low clouds form in the north, near the horizon, and interchange sheet lightning in distant flashes.†

The gravel pebbles of the desert are made up of volcanic and silicious material, chiefly the former, of which the reddish porphyry is most abundant; hyalitic quartz pebbles are common, with hornstone, chalcedony, phrenite, and chabasite, all rounded and polished by attrition so as to be perfectly smooth to the touch; small fragments are also scattered about there.

The trail from Alamo Mocho to Cook's well is along the bank of the New river. The surface of the trail between these two waters (22 miles) is more undulating than the former portions of

* "Mocho," Sp. lopped, maimed—by many this word has been mistaken as being "mucho"—plentiful—but cotton-woods are not abundant here; it is too dry a situation for them, while the disfigured tree is not many yards distant from the well.

† These phenomena occurred during the prevalence of the south wind, which, blowing from the Gulf, may have produced a condition of atmosphere not often found in this region.

the road, and is alternately a sandy and clayey floor. The sand along this route appears to have drifted in heaps over raised clay mounds; these, at first sight, appear to be sand banks, 3 to 5 feet high, which have drifted and collected round the stems of mesquite; but observation shows that those shrubs have grown there when the bank was at that upper level, or nearly so, and while these banks are sand above they are mainly clay below; their formation is more due to water than to wind. At Cook's well the terrace bank is 30 feet above the well, which is here in a bed similar to that at Alamo; there is but one well or spring, 4 feet across, and having water in it about 3 feet deep; its taste is clayey and slightly hard; the well does not refill readily and requires to be deepened. As the soil is more moist here than at Alamo, a shaft sunk to a depth of 20 feet ought to afford a bountiful supply of water.

The mesquite between these two waters was flourishing, and, about Cook's well, in pod and very abundant. Yet there were passed groves of cotton-wood trees which were standing, but dead; some few had fallen, but were, owing to the dryness of the air, but little decayed. The scene presented the curious anomaly of one class of trees flourishing in the immediate vicinity of the dead trunks of another species. To what change of local conditions could this be due? Some have believed in the elevation of the soil, by which it became too dry to sustain these water-loving trees. But while the proofs of elevation are general, there is no local evidence to support this view; besides, at higher levels at present, that is, at Alamo Mocho, a few flourishing cotton-wood trees exist. The cause, like the effect, is no doubt local, and may be attributed to the lessened supply of water from the Colorado river reaching this point.

The belief that the waters of the Colorado have only recently flowed into and formed New river is evidently an erroneous one; a single fluviatile eruption could not have formed the deep and well worn trough which is displayed at the Alamo. At the present time, the lower stratified sands of the desert are water-soaked by the Colorado river; the wells at Indian wells, (not visited,) at Alamo, and Cook's well, are the waters of the Colorado filtered through, and at no remote period that river may have, at the time of freshets, annually rolled its waters through New river bed. The Colorado, from the point where it leaves Fort Yuma until it debouches into the Gulf, resembles, to some extent, the Mississippi; it changes its banks by washing them away, and it forms levees for itself, so as to become higher than the vicinity; an increased freshet, or an obstruction to the flow of the water by a south wind in the Gulf, may so raise the river level as to overflow or remove its banks and flood the adjacent lands. Cook's wells may have been from some such cause, until very lately, supplied with a much larger amount of moisture, which enabled the cotton-wood trees to grow on the desert level, and the sudden withdrawal of which may have been the cause of their death.

By such occasional overflows of the river upon this district may have been formed the rounded patches of clay, covered with sand, resembling "domes" in miniature, to which reference has been made.

From Cook's well to the Colorado the trail slowly descends off the terrace bank to the river edge. At Algodones is an Indian built village beside some low sand hills, which here lie at the margin of the river; along this trail an elevated terrace continues on the left hand (or north-east) the whole distance to Fort Yuma; it is more than 30 feet high, is covered up by drifted sands which round its outline, but it presents very much the appearance of an ancient river line or bank.

At Algodones, a slight elevation of porphyry pebbles, cemented by argillaceous and calcareous paste, occurs; it forms in places a compact rock, and, lying upon the tertiary clays of the desert, may belong to the modern period.

From Algodones to Fort Yuma the trail is along the river bank, (right,) which yields a dense growth of willow and cotton-wood. Continual inroads were being made by the river sweeping away the right bank, destroying the old trail; as much as six feet of the bank has been removed during one night, (June 8.) The river waters were very turbid with (red) mud, high, though declining, and flowed at a rate of five to six miles an hour, ten feet below the level of the bank, two miles below the fort.

It is to be regretted that the rapid transit over the desert, and the period of the year (June) in which it occurred, rendered it, from the insupportable heat, impossible to make a more detailed examination than that contained in these pages. Owing to the excessive heat the marches were made in the evening and night time, and the day was passed in tent to seek repose and avoid the temperature, which, commencing at sunrise with 85° or 90° Fah., would reach 100° at noon, and 117° at 3 o'clock p. m. A hasty and necessarily imperfect survey was all which could be made under such circumstances. The increased temperature of the desert may be due to two causes: one, the level and low surface of the region, causing reverberation of the rays of heat from the lofty hills on the west side, and from the occasional covering of fine, bright sand on its surface; the other, the chief one, is the presence of the sand in the air, which, as so much solid matter in a heated fluid, conveys the warmth more readily to those surfaces which it touches. The southeast wind, which springs up in the afternoon, always carries with it large quantities of sand, blinding the eyes and scorching the skin. The highest ascertained temperature of air alone, examined under circumstances free from the effects of radiation or convection, has been that of 110°.6 Fah., determined by Ruppel at Ambokul, Abyssinia; while on the great African desert the fine grains of sand floating in the air form centres of radiant heat, elevating the temperature to 122°, and even 133° Fah., in the shade, in the oasis of Mourzouk. The horizontal tabular masses of granite and syenite which form flat expanses of naked rock—expanses some thousand feet in diameter, may serve to aggravate the temperature.

Of the injurious effect of the excessive heat and long marches, without water, upon cattle and sheep, there are abundant evidences in the Colorado desert. Skulls, limbs, and whole skeletons of animals lie strewed about along the trail near the watering places. Most of these were on the way to California from Santa Fé and the plains of New Mexico and Sonora, and, overcome by the fatigue and drought, succumbed to nature. Their bleached bones and preserved skins have rendered their last remains unpalatable to the coyote and wolf, and are a valuable, though melancholy, testimony of the dryness of the air.

The Colorado desert, where crossed by this trail, must be looked upon as a deep trough, scooped out at the western side of the continent; its boundary on the west is the only well defined one. There the Cordilleras rise abruptly like a wall; to the north the line of demarcation may be drawn by the termination southwards of these isolated ranges and lone hills, which dot over the surface northeast of Carrizo; these extend northward into a hill country not yet explored, but which can differ but little from the districts south and north of it; more north of this hill country is the Mojave valley, a region of small ranges and isolated valleys, whose general character, during the greater portion of the year, is sterility; and such is the whole character of the country to Salt Lake valley, the only difference in climate and vegetation being due to the gradual ascent from 100 feet above sea level to nearly 4,000 feet.

On the east the desert is considered to terminate at the Colorado, but for 100 miles east of that river the general sterile aspect still remains, except in situations where water abounds or irrigation is practised; this slope is a very gradual one. Southwards the desert continues into Sonora, and embraces the apex of the Gulf of California. The whole area embraced within these limits bears unmistakable evidence of having been an extensive sea bottom at a comparatively recent geological epoch—an extensive gulf, whose only representative now is that of California. The only present evidences of volcanic force are the frequent earthquakes, and the existence of the mud volcanoes south of New river.

Into this sea rolled the Gila, the Colorado, Santa Maria, and Virgin rivers, and it is to the wash of these rivers, delivering their fine matters to be drifted and deposited, that the extensive and numerous beds of clay (alluvium) may be attributed; while from the western shores of the bay, the Cordilleras, were derived the immensely thick deposits of rolled and stratified loose material, gravels and sand, which underlie the alluvium. At this time were formed the fawn-colored unconsolidated sandstone of the Mojave slope of the Cordilleras. The granitic conglomerates at Carrizo belong to this period also, as may also be included the loose conglomerates of the Mojave, near Soda lake. The Cordilleras rose by successive elevations. The first upheave being the protrusion of the mass of granite which carried before it the gneiss and metamorphic rock lying above it; these it broke up, contorted, and, in part, even included in its not yet fully solidified mass. Then followed the period of rest, in which were deposited the Miocene tertiaries of the west flanks of the sierra, no corresponding beds of which are found to the east. This period of rest was followed by the upheaval of the felspar, porphyry, protogine, and trachytic rocks. Then a second calm, in which a conglomerate, including these volcanic rocks with syenite, occurred. Then a third uplift, raising these conglomerates at an angle. The trappean rocks at San Pasquale and on the west of sierra may be connected with this uplift. Previous to the last uplift were deposited the sands and gravels of the desert, with the loose conglomerates, and, posterior to it, when as yet the sea water had not wholly retired, the clay silt beds of the surface subsided. At this period, likewise, may have been formed the terrace extending from Fort Yuma to Pilot Knob. The elevation of the red felspar, porphyry, and trachytic rocks of the Mojave valley are, judging from their lithological character, coeval with the most western uplifts of the Coast Ranges of California, and, therefore, much later than the mass of the Cordilleras, which may be looked upon as occurring at the close of the Miocene period. That any portion of this country was under water recently, or within traditional record, is unlikely. The old Spanish belief that Alta (?) California was an island, is but an instance of erroneous information, rather than a proof; and the tradition of the Cohuilla Indians, who relate the expulsion of their ancestors from off the plains by the rising of the waters, can scarcely be credited, since such irruption should destroy all traces of the water, now cut so deeply in the sands and gravels; recent falls of rain in a dry country cannot account for excavations made so deeply within so short a period as a few centuries, for tradition can go no higher. Some shadow of support has been afforded these conjectures by the barometrical readings on Lieutenant Williamson's survey, which shows that Cohuilla springs and Salt creek are, respectively, 90 and 42 feet below sea level; but the correctness of the inference derived from these readings may be doubted. The comparison of thermometers, one of which was at Benicia, and the other some hundred miles distant, is liable to grave errors. The altitude of Fort Yuma is found to be nearly 130 feet above former calculations, and a like error may vitiate the readings on the desert. While, then, assuming the general level of the desert to be unusually depressed, we are scarcely warranted in saying that extensive levels are lower than the surface of the sea.

The Colorado desert is an extended plain, unbroken by an eminence of any great height, (save the lone hills,) and may be considered as an ancient sea bottom, with raised terraces here and there, loose sand hills, 30 feet high in some places, fine moving sand, 2 inches deep, strewed over a flat, clay bottom, with here and there aggregations of small drift stones, granite, porphyry, trachyte, and quartz, polished smooth by the sand; acres without a bush or blade of grass, and, elsewhere, a scattered growth of greasewood, creosote tree, wild sage, mesquite, and fouquieria. It might be interesting, though hardly in place here, to enter into all the causes which have rendered and keep this still a desert.

It is notorious that a desert tends to propagate itself by its shifting sands covering up good soil, and by the destruction of the humus or organic matter so needful for vegetation. When humus is absent from a soil, it becomes too much heated or too much cooled by absorption and radiation, and all moisture is effectually removed. Shade and moisture are necessary to reproduce humus from vegetation, but as these do not exist on the desert, it is eternally perpetuated a naked sand or clay.

An elevated mountain range to the west, a basin nearly at sea level, and an almost intertropical latitude, are the circumstances which conspire to form a desert there. The first, by its height, effectually drains the clouds, so that but little rain falls eastward—hardly ever more than two inches in the year.

The second, by its configuration and depression, favor the concentration of the solar rays, making it the focus of a large area.

The last has an influence not less than the others; in parallel 32 there are no large timber trees found in low situations; it is also too warm for the growth of the ordinary grasses, so that shade and the protection of the ground necessary for the production of humus do not exist; additional moisture is required; irrigation and the cultivation of trees, shrubs and fruits of the continent further south, which would bear transplantation, would convert portions of this desert into a fertile country.

OF THE CLIMATE AND WATER SUPPLY OF THE DESERT.

The following is a tabular statement of the principal water stations between the eastern slope of the Sierra and Fort Yuma, with the intermediate distances and the character of the water at each station. Having touched at Sackett's wells, makes the distance from station to station somewhat different from the table given by Mr. Williamson.

Stations.	Total distance from San Diego.	Distance intermediate.	Remarks.
San Felipe	79	....	Brackish and sulphurous.
Vallecitas	97	18	Sulphurous, saline, hard.
Carrizo creek	113.5	16.5	Good river water.
Sackett's well	131.5	18	Saline; muddy, with white clay.
Big Lagoons	127	11	Dry.
Little Lagoons	139.9	10.25	Dry.
Indian wells	141	2.70	Not examined.
Alamo Mocho	164.39	12	Sulphurous, saline, muddy, with white clay.
Cook's well	185.50	21	Clayey.
Algodones	196.68	11.18	Colorado river.
Fort Yuma	208.25	11.5	Colorado river.

The mode of obtaining water, and the amount of supply, from each of these points has been already alluded to. There is a melancholy neglect for the comfort and safety of men and animals passing over these trails exhibited both by the State of California and the federal government. Where United States troops are constantly moving to and fro, and where mail deliveries occur fortnightly, it would appear as if something more might be done to obtain a larger supply of water. If two parties be approaching the same well, one strives to anticipate the other, knowing or fearing the supply is not sufficient for both, and the carcases on the trail show how the animals suffer by the deficiency. It would require but a small sum at the outset, and a small annual grant, to form efficient wells, and to keep them so; to widen and deepen those already in use; to sink additional ones at Cook's well, Alamos, and Sackett's well; to raise an adobe structure round them; the travel over the desert would then be safe and comparatively pleasant even in mid-year. Where the sinking does not require to be made of great depth, as at Cook's and Sackett's wells, the well might be made of large diameter, so that the delay from the slow infiltration might be lessened; and in such case, as in western Asia, the approach to the well might be by stairs in the inside.

The statement has already been made that many of these wells, as in the central and lower parts of the route, are fed by the Colorado infiltrating its waters through the loose sands and clays. On which account it appears desirable that the number of wells be increased at Alamo and Cook's well, and that new ones be made at Big and Little Lagoons, as there is a large supply to draw from, though obtained slowly. Sackett's wells, on a higher elevation, does not owe its water to this source, deriving it from a small under current between clay strata, which may be the remains of small streams rolling from the sierra, and losing themselves in the porous sands. This supply is, however, so sparing, the original stream so trifling and so uncertain in its flow, and the annual fall of rain almost nothing, that, to make deep sinkings, or *artesian borings*, on the desert, along the line of trail, would be likely to be a complete failure. It is true that the conglomerate and sandstone of the sierra foot dip east under the sands and clays, and form a trough or bottom; but that bottom itself is porous and little retentive, and so long as the fall of rain is small, the geological conformation is a secondary matter in the forming artesian springs. The following abstract, taken from the meteorological register kept at Fort Yuma, (for which I am indebted to the kindness of Dr. Abbott, U. S. A.,) embracing seventeen months of the years 1854 and 1855, show the temperature and fall of rain during that period at the fort.

Fort Yuma.—Long. 114° 37′ 29″ W.; Lat. 32° 42′ 27″ N.

Months.	Temperature.	Rain fall.	Direction of wind.	Months.	Temperature.	Rain fall.	Direction of wind.
1854.				1854.			
January	55.5	....	N.W.	October	77.74	....	N.
February	59.11	.28	W. and N.	November	66.50	....	N.N.E. and N.W.
March	61.72	.80	W., variable.	December	60.62	.51	N.W. and N.
April	73.55	....	N.	1855.			
May	73.85	....	S.	January	59.25	.12	N.W.
June	84.90	....	W.	February	62.7	.63	N. and N.W.
July	94.54	.01	E., variable.	March	69.90	....	N.W.
August	91.32	2.37	Easterly.	April	73.33	....	W.
September	85.66	.17	E., N.E., and S.E.	May	78.22	....	N.E.
						4.89	

This, the climate of Fort Yuma, for nearly one year and a half, may be taken as representing much of that of the desert. Certainly the latter has no greater rain fall, whatever less it may be from increased proximity to the lofty sierra.

In the Army Meteorological Register, (published Washington, 1855,) page 675, a table is given of the mean monthly and annual fall of rain at Fort Yuma, of which the following is an abstract:

1851, first 4 months	.28
1852, in summer	.61
1852, in autumn	1.80
1853, whole year	1.78
1854, whole year	4.50

and the mean given of the four years of observation is 3.24 inches of rain; but, inasmuch as there were only two full years of observation, and one of those the quantity of rain was unusual, (1854,) it would appear as if the annual estimate given in the report was much too high. Two inches or 2½ inches would be a nearer approximation to the usual rain fall. Admitting, even, the large estimate, the quantity which would be soaked into the ground below the level of evaporation, to be drawn upon by an artesian well, is small. Further observations upon the subject of artesian borings may be found at the close of the report.

Sectional views of the structure of the desert are given on plate VIII, figures 1 and 2.

CHAPTER XIX.

FORT YUMA TO THE PIMAS VILLAGES.

Fort yuma.—Colorado.—Ancient terrace and river bed.—Aspect of gila river near its mouth.—Occasional overflows.—Vegetation of river bottom.—Soil, limits, and constitution of the sonora desert.—Big horn mountains.—Geology of.—Native copper ore—Remarks on.—Basalt overflow, its great extent.—Pimas jornada, geological structure of.—Granitic axis.—Quartz veins.—Titanium ore.—Plain at the Maricopas wells.—Water of.—Influence of subterranean springs upon vegetation.—Pimas villages.—Cultivated lands.—Character of the soil.—Necessity of irrigation.—Recapitulation.

Fort Yuma is situated on a granitoid porphyry hill, 75 feet above low water, on the Colorado river, which, running south to this point, turns abruptly westward, rounding the eminence on which the camp is placed, the southern base of which is denuded and partly removed by the force of the current that here, meeting with the Gila, flows in an united stream to the Gulf of California.

The Colorado, north of the fort, spreads out into a wide stream, with low swampy banks, for some miles, when it is narrowed again by the proximity of volcanic rocks through which it cañons.

In its course through the lowlands below the fort it is constantly changing its banks and altering the course of the stream; indeed, its present channel, and the confluence of the two rivers at the fort, is at such an unusual angle, that it is certain its present course is but a recent and a temporary one.

The terrace which extends from Cook's well to Pilot Knob, and thence to the fort, is about 35 feet high, and is capped by rounded drift pebbles of granitoid and amygdaloid rock, cemented by a tufaceous deposit. This bank, which is remarkably uniform in its height, would appear to indicate the former course of the Colorado when it flowed more southwesterly into an open sea, (the present Colorado desert,) and when the Gila, instead of turning abruptly north to flow into the Colorado, took a course west and south of the granitoid mass on which the fort is now placed, converting it either into an island, or else leaving it on the east side of the two rivers.

The waters of the Gila mingle with those of the Colorado coming from an opposite point of the compass. South of the present course of the former river is a low terrace facing the south and touching the low erupted range opposite to that on which the fort lies. Between this and some bluffs lower down on the Colorado is a deep alluvial bottom, in which, it is highly probable, lay the ancient course of the Gila; in other words, from the appearance of the district it is evident that these two rivers united about one-fourth of a mile west of their present junction at some not very remote period, and that the fort hill lay east of the two rivers and not west, as its situation now is.

Plate V, fig. 5 illustrates this alteration. The porphyry of Fort Yuma may be looked upon as an amphibolic granite, made up of brownish felspar, with small crystals of hornblende disseminated in bundles through the mass. Epidote is in places substituted for felspar, and sometimes increases in amount until the whole mass becomes of an uniform greenish tint from its predominance. This variety of granite is a very common rock at the base of the isolated hills immediately east of the fort, and lying between it and Big Horn mountains. It forms the base of the dome hills which lie northeast of the fort, and cross the river higher up.

GEOLOGY OF THE GILA RIVER.

This river in its course westward has formed its channel by wearing its way through the softer strata and more recent deposits. Like some of the large rivers of the west of this continent, its course is across the strike of the mountain ranges, and seems to occupy the line of a great depression or fault lying at the southern termination of the Sierra Blanca and Mogollon ranges. In this respect it resembles the Humboldt and Columbia rivers further north, and differs from the streams of California, which, almost without exception, roll in the valleys corresponding with the trends of the mountain axis.

For the last 60 miles of its course the Gila has escaped from this fault, and traverses the great sloping plain constituting the northeastern boundary of the desert land—the Colorado and Sonora desert. In its passage toward the Colorado river it crosses the line of several isolated hills, whose general trend is northwest and southeast. Round and between these hills it winds its way, having worn itself a channel or bottom several feet below the general level, producing well marked terraces or mesas upon the sides of the hills upon which it impinges. The river bottom within ten miles of its junction varies from $\frac{1}{8}$ to $\frac{1}{2}$ mile in width; and by the height of the drift shows that the overflow is occasionally 12 feet in depth. The growth is obione, willow, and acacia, and upon the terraces an occasional cereus, which commences to appear about 14 miles east of the fort. The soil of the bottom land the first 12 miles up the Gila is brownish clay, mixed with pebbles of quartz, felspar and jaspery silicious rock. The impalpable soil is calcareous, effervescing very strongly. Below this alluvium, which in many places is not more than three feet deep, is a bed of sand, blackened by a layer of mica crystals, which are deposited in horizontal strata.

Dome hills, the first series of hills east of Camp Yuma met with ascending the Gila, are of a blackish and red brown color, and rugged outline, destitute of vegetation, and composed of jaspery metamorphic quartz, having very little trace of sedimentary origin, cut up by veins of translucent quartz and dolerite, and passing gradually into amygdaloid, with imbedded glassy quartz crystals, a felspathic trachytic rock.

The strike of this range is north 65° west, and can be traced by the eye fifty miles (or further) to the north, where it reaches the Colorado, and crossing that river forms the turretted hills on the Colorado desert. The summits scarcely attain a thousand feet of elevation. At the base, forming the terrace over which the trail runs, is granitic rock, very friable, containing small hexagonal mica and albite. Between these porphyritic hills, which lie 14 miles east of Fort Yuma, and the next series of hills, (Big Horn or Goat mountains,) a distance of 45 miles, lies an extended level plain, slightly sloping to the southwest, unbroken in its level, except by the river, where it has worn its way through it; this is the northern limit of the Sonora desert. The material of the surface is granitic or felspatic, modified by the addition of a few minerals, derived from the occasional elevations or low hills which rise abruptly out of the plain to the height of 300 or 500 feet, composed of quartz, conglomerate and micaceous sandstone of a dark red or brown color, and without any traces of lamination or deposit, intersected by veins of jasper and layers (strata) of silicious jaspery rock. The base of these hills, and the plain close to the base, is covered with jaspery pebbles, but they disappear rapidly on leaving the hill.*

At this locality, the first camp on the Gila, there were found growing some trees, which, at first, were taken for the ordinary mesquite tree. By accident, looking closely at one, the older branches and upper part of the stem was found incrusted over with tears of gum, of which there was such an abundance that in fifteen minutes one pound was collected by one hand; the gum was not found adherent to the young shoots but below, where several branchlets had been given off and were cemented longitudinally in fissures, which the growth of the tree had formed in the bark; some of the tears were moist and tenacious, but the majority was brittle and hard, and easy of removal; as the tree is beset with spines from half inch to one inch long growing on the old as well as the new branches, and, as the tree droops over like a willow, it was a difficult matter to approach sufficiently near to pick the gum off; thus only a small portion of the whole was removed—there could not have been less than seven or eight pounds upon the whole tree, which was about fifteen feet high, dividing at five feet from the ground into numerous drooping branches, altogether a very ungraceful "mesquite." The gum thus collected had all the appearance and character of gum arabic, insipid, soluble in water and weak alcohol, but not soluble in strong alcohol, and yielding to chemical tests the same reaction as the gum of the acacia. Portions of the tears collected were brownish, like gum senegal, but the larger portions were colorless, and by care in picking a very pure gum could be selected. Four of these gum trees were observed here, and from the purity and value of the gum, it is to be hoped that, at no distant period, these trees may be cultivated along the margins of the Gila bottom, and that gum gila may become one of the staple commodities of the district.

Eighteen miles east of the first camp lie a series of isolated ridges, trending northwest and southeast, the most northerly approaching the river, and being about three miles long; it is made up of quartzose conglomerate, dipping southwest 8°. Angular fragments and detritus of this rock were found scattered near the base and in the vicinity of the range, but none carried to any distance. The hill itself was covered with small rounded masses of jasper and trachyte, neither of which were observed in place here.

Big Horn, or Goat mountains are a series of parallel ranges running nearly northwest and southeast, and overlapping each other; the trail turns round the northern edge of the range, which presents there a crescentic outline, with high mesa land sloping down to the river; over this mesa the trail leads and exposes a surface of granitic syenite, with here and there a felspar porphyritic rock, (leucite.)

Upon this granitoid basis reposes thick beds of jasper and silicious rock, the latter a conglomerate of white quartz pebble, which, further up, becomes distinctly stratified, and constitutes the mass of the mountain above 1,000 feet high.

The dip being 60° or 80° southwest, and the thickness of the conglomerate beds two hundred feet, the line of junction of these conglomerates, with the underlying (metamorphic) silicious rock, is well marked on the eastern side of the mountain.

Sixteen miles east of these hills the western limit of the basaltic region is met. This region extends north and south, in a well marked and almost unbroken line, with its escarpment westward. The basalt mesa is raised sixty to eighty feet above the river bottom. The upper-

*A portion of the soil of the desert a mile away from the bottom margins, where no overflow reaches, was selected and preserved for analysis, the result of which is communicated in the chapter on Chemical Analysis.

most layer is a mass of blackish, basaltic rock, ten feet thick, and almost horizontal; lower down it merges into a dark green augitic amygdaloidal rock, the cavities being filled with white earthy matter which drops out on weathering of the rock, the latter appearing to be a vesicular lava.

Standing on the granitic mesa at the foot of these mountains, and looking backwards over the trail travelled, the character of the country becomes apparent; it is an immense extended plain as far as the eye can reach, (about sixty miles,) sloping slightly to the southwest, and equally level north for thirty-five miles, the horizontality only disturbed by the isolated hills or ranges described, whose general direction is north 60° west. The soil of the plain is uniform, a felspathic or granitic sand, with occasional drifts of fine quartz sand, easily impressed by the hoof of the beast, and brilliant, so as to pain the eye in midday by the reflection of the sunlight. There is not a particle of humus or mould in the soil, nor is there any opportunity for its production; as there is no running river or stagnant water on this mesa land, none but the most desert or thorny plants can sustain themselves in such situations; no tree or herbaceous shrub is found after leaving the valley bottom; and from this point to the Gulf of California, on the elevated land, it is a continuous desert, whose character is aggravated the nearer the level approaches that of the gulf.

Between Big Horn mountains and the basalt mesa the bed of the Gila spreads out into a flat, which in places is swampy and overgrown with willow, but generally has a fertile alluvial clay soil, slightly calcareous, producing abundance of grass; it averages three to four miles wide, bounded by a small terrace thirty feet high, composed of fine sand and clay, and covered over with jasper pebbles.

The alluvial soil contains numerous angular quartz fragments.

About five miles north of camp, (June 22,) at the base of Big Horn mountains, are two small hills, one flat-topped and more easterly conical; on the western edge of the latter, or in the trough between the two hills, which are not more than 600 feet high, is a vein of native copper, which is found distributed a mile distance from the hill along the bed of a rivulet. The party who brought in the specimens (on foot) described the ore as found very abundantly. Accompanied by a single private soldier as escort, I crossed the river to examine the locality of this native copper, samples of which had been brought into camp the day previous by that individual. After a delay of some hours in finding a fordable spot in the river, (as it abounds in quicksands here, and forms a series of islands,) and in endeavoring to force a passage through the brushwood lining the bank, we at length arrived at the place near where the copper had been picked up. It was in an arroyo (dry bed of a small stream) which descended from the most westerly of the two hills, and small specimens of the ore were found in the creek bed, accompanied with metamorphic sandstone and basalt. The ore was no doubt in the hill higher up; but as the camp had moved on, and we were some hours behind, it was not deemed safe to remain any longer in the locality, and we retraced our steps to meet the trail.

These small hills belong to the Big Horn range, and there is little doubt that those also contain this metal at points where trappean intrusions occur. They are described by travellers as yielding it fifty miles further south along the range. It is a very rich ore of copper, yielding above 80 per cent. of pure metal; the seam is narrow, not more than two inches wide. There is much facility for obtaining and transporting the ore at this point. The hills lie within a couple of miles of the river, whence by rafts or flat-boats the ore could be carried to Fort Yuma, and thence by steamer to the Gulf of California. The smelting of this ore by a blast furnace would not be a very expensive operation, but it is doubtful if there be sufficient wood at the locality for that purpose. A copy of the analyses of the ore is given in the chemical chapter.

Twenty-one miles east of Goat mountains the Gila emerges from a narrow valley bottom cut deeply through the elevated mesa land, which rises abruptly 70 to 80 feet above the level of the bottom land. This is the western limit of the immense overflow of basaltic lava alluded to, which spreads over the whole country at this point from north to south. The trail which travels on the river bottom for a few miles ascends the mesa by a new route, the former having been washed away by the encroachments of the river altering its bed. The western edge of this lava overflow is abrupt, difficult to climb, and well defined, the large fragments not being transported to any distance; it is not regular, but deeply cut in, forming semi-lunar margins with cuts entering some hundred yards. In these gaps the trail ascends, it being the only ready mode of reaching the summit.

This lava mesa rises by a very gentle slope to the east and north, and appears to preserve a horizontal line from north to south. Through a cañon or break the Gila flows westerly, and has in many cases worn a recent way for itself through this basaltic region; but as the valley of the river is very wide in some places it is difficult to imagine that the river could have formed this course for itself by wearing its passage silently for ages through this overflow; it would rather appear as if there was a valley or gap in the flow, produced by some other cause, which the river now occupies.

The hills north of camp (June 22) have flat basalt-capped summits, and appear to have a more easterly trend than the ranges further west. The outlines of the jasper and sedimentary quartz rocks are discernible, dipping S.W. The upper surface of the mesa is smooth, without any drift or travelled materials, and covered over by a light dust of its degradation. The river along this cañon continually changes its bed, and terraces exist on each side of the stream, showing at least two different points of elevation. The overflow of the river in time of freshets, as shown by drift, is 14 feet, and lagoons are produced by the retiring waters.

The basalt is a dark blue fine-grained augitic rock, which does not readily decay; hence there is so little detritus found travelling over its surface. Yet, though not disintegrating, large masses are broken off and rolled down, accumulating at the bass, although there are not any drift or travelled fragments met with at a distance from the overflow. The fall of these large masses appears to be due to the action of the river, which, changing its bed, carries its waters close to the base, and undermines it by removing the soft yellow sand rock which underlies the basalt. Perhaps it is by this action alone that the Gila has found its way through the overflow, and formed a channel for itself in some places over two miles wide; for there can be little doubt that the lava north of the river, and that south, were originally connected, and, from the horizontality of the surface, it is evident it has undergone no action of local upheaval since its outpouring. Mechanical action has, therefore, been the means by which so deep and wide a chasm has been made in it, and there is no source so obvious as the action of moving water, although the Gila does not appear a stream sufficiently powerful to produce such effects. Looking south and east over the basalt mesa two conical hills, about 15 miles distant, have the appearance of being extinct volcanoes, the summits being crater-shaped. From these it is possible this lava may have flowed when the whole was as yet below the surface of the waters.*

The underlying sandstone did not yield any fossils on examining it, and was in places rendered quartzose and metamorphic; it is probably the extension of the conglomerates found

* This basalt also contains small plates of salvadorite scattered throughout, and has small vesicular cavities filled with drusic chalcedony.

on Big Horn mountains and further west, which are themselves most probably tertiary. On the north side of the Gila the basalt flow does not approach the river, but in many places is as far removed as seven or eight miles, the intervening space being occupied by a low, sandy mesa, not more than twenty feet higher than the river bottom. On the lowest portions of this mesa mesquite grows well, and in the river bottom a luxuriant growth of grass and willow ; on account of the width of the river valley at this point, and its being well supplied with water, there is no doubt that, by irrigation, cotton, maize, yams, and all the growth of the southern States, (rice excepted,) might be raised here.

Hills of quartz conglomerate, capped with basalt and trachyte rocks, form the horizon on the north or right bank of the river, having a trend north toward the Colorado ; these are also repeated south toward the eastern limit of the basaltic mesa, forming hills 700 to 900 feet high ; near the east limit of this overflow is a small hill 700 feet high through a cañon in which the trail runs, and to avoid which the river makes a bend to the north.

Trachyte and porphyritic (red felspar paste) rock formed the axis of the upheave, and on the eastern side an outflow of basalt forming an elevated table or mesa land, extending from five to seven miles in an easterly direction ; but as the river lay to the north, the trail left the mesa, and descended to the river bottom. In ascending this hill on the west side, the slope was easy and lay over thick beds of drift gravel and felspathic sand lying unconformable ; the axes of the hills were composed of reddish felspar dykes and intrusion of white porphyritic trachyte rock ; these are flanked by quartz conglomerate rock, stratified and metamorphic, the former dipping 20° southwest.

On passing through the cañon and reaching the east slope, the drift gravel no longer appears, the trail passing over the basaltic floor again, which constitutes the mesa ; if the basalt covering existed on the west side of the range, it must have been covered up by the deep layer of loose conglomerate gravel. Underneath the lava is a cream and salmon colored sandstone grit.

In the river bottoms, angular fragments of lava, (basalt,) with felspar porphyry veins, chalcedony, amygdaloidal lava, and reddish amygdaloidal felspar, semi-transparent quartz and epidote. On the 23d of June the basalt mesa was ascended, and on the afternoon of the 25th had cleared its eastern limit ; during this time the trail made many descents to the river bed for water and to avoid the detour which the deep gashes in the flow would have rendered necessary. It is upon this mesa that the hieroglyphical inscriptions occur, delineated by Major Emory, (notes of Mil. Recon'ce, p. 89 ;) they also were found on the edges of the basalt plain, where the trail descends to the river bed. The total width of the basalt overflow is above thirty-six miles from west to east, and its extension north and south is much greater. Since its outpouring it appears to have undergone but little alteration of position ; and the only chemical change is that of the weather loosening the amorphous zeolites from their small cavities and washing them away, leaving the surface of the rock cellular, giving it the appearance of a vesicular rock ; but it is distinctly amygdaloid and contains no air cavities.

At the base of the trachyte hill, forming the east edge of the basalt mesa, the river again spreads out into a wide bottom with lagoons, and covered with willow and mesquite, and supplying tolerable grass ; on the upland, on each side, there is no vegetation, save that of desert character, larrea and sage ; the pitahaya (cereus giganteus) is abundant and increases in size and beauty the further west the road is travelled. East of these lagoons the trail leaves the river which passes north to turn a large mass of mountain, the road running east, a little south over the Jornada to the Pimas plains ; this distance, forty miles, without water, is across a range of hills, which, coming in from the northwest, form elevated ridges, round which the Gila turns after having received the Salinas waters. These ranges are parallel, and having sloping plains to the west. They are granitoid in structure, of a blackish color externally; but the fresh surface displaying white and pink felspar, intermingled with clear crystals of transparent quartz, adularia occurs in veins and crystals. The veins of reddish felspar run northeast and northwest, intersecting each other. Quartz veins run north 30° east at the most elevated summit of the trail; in the pass epidote occurs in seams, and a black syenitic granite, which easily rusts and decomposes. The rocks at this point are mostly felspathic, with but little quartz or mica; occasionally masses of fine-grained granite occur without any granular structure; thick beds of gray felspar rock with rhombic cleavage. Cubes and prisms of titanium ore occur in the quartz veins which cut through the felspathic granite, constituting the mass of the mountain. As a whole, it may be looked on as a series of granite hills running parallel at eight to twelve miles apart. The ascent from the west for fifteen miles being very easy, when the summit is gained, a cañon passing through the range and opening into a flat plain of ten miles wide; this summit plain is elevated, the trail leading direct east through another cañon (in a second range of hills) and then easily descending some sixteen miles to an alluvial plain at the base of the mountain. The whole of this travel, forty miles, is over a loose, stony conglomerate and felspar sand, without water, and is known as the Jornada of the Pimas plains. The mesquite, larrea, green acacia, and the fouquieria, with the cereus giganteus, (pitahaya,) are the chief growth. The cereus constitutes the only tree found 100 feet above the plain, upon which it never comes down; on the east slope, several echino-cactus and mammillaria were seen. The mass of this range is a felspar granite rock, in places passing into protogine; the first range crossed contained albite in the granite, with large crystals of quartz, seams of epidote, and, in the cañon, a blackish granite verging into a basalt in appearance, close-grained and black on the outside. Gneissose rock, dipping 25° west, lay on the left side of the cañon ascending it; no metamorphic rocks were observed on the east side of the range, which has received the name of Sierra Estrella or Star mountains.

In passing through the second cañon, the more eastern range was observed to be made up of a reddish granite, blackened on the weathered surfaces, containing large crystals of felspar, (orthose,) adularia in veins and crystals, and cut up by threads and seams of quartz, as observed in the western range. A third range, lying eastward of the trail and between it and the river, has a similar constitution, and it was in this latter that the specimens of titanium ore were collected. The summits of these ranges cannot be less than 2,000 feet above the plain; they can be approached quite closely, owing to the level slope of the plain at the base, and have not the rolling foot hills which mountains usually possess. Taken as a whole, this Jornada is a double inclined plain, sloping east and west, away from a central line—the line being this series of hills running N. W., rising abruptly out of the sloping plain; this character is very common to the topography of this region, the hills not possessing any valleys proper to them, but appear to rise out suddenly from the strata (gravel and conglomerate unsolidified) which repose uncomformably round the base, and contain fine quartz and felspathic detritus, with occasional debris of basalt and porphyry; fine granitic sand is found in the dry beds of the arroyos; several of these granitic ranges lie parallel—each single crested and presenting no trace of sedimentary rock on their sides. The ascending slope (western) is 15 miles long, and the eastern or descending slope 24 miles.

A section of Sierra Estrella is given on plate IX, figure 3.

Fig. 3 also represents the disposition of the Jornada viewed in section.

Descending the eastern slope of these hills the plains of the Maricopas wells are reached. These are flats on each side of the Gila, above its junction with the Salinas river. The river flows through these plains, which are broad and well supplied with coarse grass. At the point termed the Maricopas wells, which are several holes dug 7 feet down, and in which the water rises within 2½ feet to the surface, the soil is clayey and retentive, each well being a small body of water resting on yellow clay; when the well is emptied it fills in very slowly, the water at this season being slightly saline. The influence of this body of subterranean water is marked by the difference of vegetation, which, as soon as the hill slope commences, ceases to bear grass, rushes, canchalagua, and mesquite, and in their stead appear the fouquieria, prickly pear, and pitahaya. The valley of the Gila river is here very wide and the bottom a fine sandy (granitic) clay, very light in color, and only fertile where watered by sequias of the Pimas, when it produces abundantly.

On each side of the river the Pimas cultivate the low land, where the sand and fine clay has a darker tint, from the presence of a small quantity of humus; it is, however, a mere trace, and at the Maricopas wells is not more than half an inch thick, as shown by digging the fresh soil near the springs. Portions of the soil of the cultivated land of the Pimas, and of the soil upon the mesa, above the line of grass at the Maricopas wells, were collected and submitted to chemical analysis; the results are given in the chapter devoted to that purpose. There does not appear to be any difference between the mineral character of the two soils; the texture differs, that of the cultivated land being alluvial, and more quartzose.

The cultivated ground of the Pimas is fenced around, each field being small, scarcely 150 feet each way; a sequia runs around half a dozen fields, giving off branches to each. Corn, cotton, pumpkins, melons, and squash, were the chief articles of cultivation. A small portion only of the valley is under cultivation, being that along the river bank; but it is susceptible of being made productive much further away from the stream. It is on irrigation only that a secure crop can be depended on, and as the Gila has much less volume here than below, where it receives the Salinas, occasionally the river bed is completely drained by the sequias. More care and economy in the use of water would be necessary under a greater breadth of cultivation. The immediate river bottom is here between six and eight miles across; the mesa land is not more than seven feet above this level, and slopes back, in every direction, very gradually to the mountains, which are at six, eight, and twelve miles distance. The altitude of the Pimas lands near their villages is a little above 1,100 feet above sea level, which, combined with the proximity of long mountain masses, caused the deposition of dew at night, the first which had been experienced since leaving Vallecitas; it was quite copious when passing the Jornada to reach these plains.

Leaving the villages to the west, after a few miles travel, low spurs of a range coming in from the southeast are met with. These consist of protogine and talcose slate; on the north side of one small hill, near the trail, fine-grained gneiss was observed, dipping 35° west; still further east the trail strikes the river twelve miles east of the villages. On the mesa the soil is a felspar and granite debris; near the river it is a fine sandy clay, similar to that of the Pimas lands.

On the river, at this camp, (July 3,) the trails diverge; the well-beaten ones are turning away southeastward, over the elevated table land, which stretches out without any apparent limit into Sonora, toward Tucson; the uniform level being here and there only disturbed by an occasional low hill of felspathic granite or protogine. Along these trails the wagons and main party proceeded; a small exploring party continued the trail along the river bank, so as to examine the cañons of the Gila and the San Pedro river. The geology of this latter route alone is described.

Along the river above, where the trails diverge, low granitoid ranges approach the river and narrow its bottom. These ranges occur on both banks of the stream, which, in some places, is not more than 30 feet wide and 2½ deep, having its banks thickly planted with cotton-wood, willows, cane, and mesquite. The river water is clear and good, and the bottom a micaceous granitic detritus.

Plate IX, fig. 1, displays a geological section from Big Horn mountains to the basalt mesa. Plate X, fig. 1, illustrates the geology from the Pimas villages to the Gila river; fig. 2, the structure of the hill at camp July 6, referred to on the next page; and fig. 3, a section along the river to illustrate its notice in the next chapter, where it is described on page 140.

CHAPTER XX.

CAÑONS OF THE GILA RIVER AND PIÑALENO MOUNTAINS.

Basalt overflow.—East of the Pimas villages.—Physical appearance and topography of the cañons.—Trend of the hill ranges.—Saddle mountains.—Breadth of the primary rock.—Elevation of the sedimentary beds, eastward. Subsequent alterations of level.—Plutonic forces.—Aggregate of igneous rocks.—Spire hills, their structure.—Basalt dykes.—Metamorphic sandstone.—Its lithological character and geological age.—San pedro river.—Its course.—Fertile valley, gypseous beds of.—Denudation, thickness, position, variety and probable age of.—Conglomerate of the upper part of the valley.—Thickness and position.—Auriferous gravel.

Thirty-two miles east of the Pimas villages, along the river course, a region of basaltic overflow is again met with. The soil of the bed of the river is light, sandy and granitic, and the pebbles volcanic greenstone—basalt, jasper, greenish and reddish porphyry, with brown fine conglomerate. The river is terraced on each bank, composed of fine gravel drift overlying basalt, which appears to flow in a sloping mesa or plain from the north, where a pyramid shaped hill appears to present the outline of an ancient crater. Three miles further up the river the country becomes greatly disturbed, and the elevated crests, which run north and south, crossing the river, narrow its bed, and form what is known as the cañons of the Gila.

This is the commencement of a region very much disturbed in its geological relations and presenting a great deal of confusion in the appearance and stratification.

At the entrance of the cañon, and ascending an elevated point over the river, (camp July 6,) the topography of the vicinity appears simple. So many as six ranges of hills can be seen, coming from the north and running southward, (S. 40° E.) These hills, generally speaking, increase in altitude to the eastward, the last of which in view has the well known form of the Saddle mountains in its range. Through this last range, and north of Saddle mountains, the Gila cañons, and in its downward course it cuts its way across those smaller ranges to the west, until finally it emerges on the open plain leading to the Pimas lands.

This belt of mountain country, travelled in this route, is 34 miles from the entrance of the cañon to the mouth of the San (José) Pedro river. This breadth of country is wholly occupied by igneous and erupted rock. The western or lowest hills are of plutonic and primary rock, while the more eastern are sedimentary and capped with basalt and amygdaloidal trachyte. Upon many of these flat capped summits trees and vegetation grow, and they appear to have been at one time the level surface of the country. Several hundred feet below these is at present the river bed ; and its size and volume appear totally incapable of having produced such results of denudation and removal as must have occurred. Two forces have been at work : 1st. The primary upheaval of the granitic basis, carrying the sedimentary beds with it ; and, 2d. The plutonic force, as evidenced by the amygdaloid and basaltic lavas. These are best displayed at the western end of the cañon, where the river leaves the mountain region. At the very point where it finally escapes the river bed exposes a section of an anticlinal axis with plutonic intrusions, and the small valley around has much the appearance of a centre of plutonic action, judging from the high dip of the strata and the semicircular form of the igneous rocks around.

Plate X, fig. 4, displays the geological character at the place where the river leaves the mountains; the stream taking the advantage of the chasm between the plutonic axis and the elevated strata on its southern side. The upheaving mass on the north side of the river is variously composed—thus, commencing at the water's edge and ascending the right bank of the river:

1st. Hornblende porphyry, (felspar and hornblende, in crystals.)

2d. Basalt.

3d. Hornblende porphyry; crystals of hornblende, large.

4th. Amygdaloidal trachyte; a brownish felspar rock.

5th. Felspar in dykes, walled by

6th. Trachyte.

The basaltic dyke has a thickness varying from 15 to 20 feet, and rapidly merging into the hornblende porphyry on either side. The felspar dyke has a greater breadth and does not merge into the trachytic amygdaloid, with which it is in contact.

This intrusive mass of varied plutonic character is itself a foreign body, thrust through the granitic basis which here and there (though not appearing in the immediate locality) shows itself. In its elevation it has carried up with it two beds of stratified sandstone and a capping of basalt and purplish trachytic amygdaloidal felspar. The latter is a layer about six feet in thickness, and underlies the basalt, which is about 15 feet thick. The great mass of stratified rock is a yellow sandstone conglomerate, which dips away from the central mass at an angle of 15°, and generally toward the east; but at this point there is no uniform dip over any extent of ground. South of this point a few hundred yards is a cañon in the bed of a creek, emptying itself lower down into the Gila, where the sandstone is better displayed and slopes gently, with a dip 12° east; it is here yellow conglomerate, about 60 feet thick; the pebbles being granitic and volcanic. It was up this creek the trail led to reach the Gila, as it is scarcely safe to travel through the cañon along the immediate bank. Cotton-wood and good grass were on the narrow river bottom at the entrance of the cañon.

The following is the list of plutonic and igneous rocks met with at the cañon and a few miles up the river on each bank. Plate XI, fig. 1, shows the structure of the cañons.

A. Felspar rock with quartz crystal disseminated, resembling "eurite."

B. Felspathic granitoid rock, with epidote.

C. Felspathic rock, lamellar, (in dykes mostly.)

D. Syenite.

E. Amygdaloidal trachyte, felspathic rock with glassy crystals.

F. Basalt, compact and amygdaloidal.

All these varieties may be found congregated within the space of a few miles. Plate X, fig. 3, represents an exposure afforded by the river in travelling up, on July 6th; the section embraces ten miles.

A few ranges in the lower part of the cañon, though of an elevation from 500 to 800 or even 1,000 feet, are yet comparatively narrow in their base or in cross section, and appear to be made up wholly or in great part of variety C. Such are the "Spire" hills, which present an appearance alike fantastic and grand; from the warm tone of the flesh-colored felspar, the absence of vegetation, its extreme roughness in ascent from the huge masses of rock on its side and base, and the pointed pinnacles and turrets which its outline, sharply defined on a clear sky, presents, the observer is forcibly struck with the singularity of the landscape.

Plate XI, fig. 2, exhibits an outline of one of these ranges, from north to south, and fig. 3 gives a section in which the felspar dyke rises through the mass and forms the crowning pinnacles and spires.

The western or granitic portion of this elevated country unites on the left or south bank of the Gila to form a lofty granite range, the Sierra Catarina, which preserves its southeast trend, crossing the San Pedro about 65 miles above its mouth and blending in at that point with the foot hills of the Sierra Calitro, the chain which lies on the east bank of the San Pedro. Another range lies east of this latter, and is connected with it, where the Gila river breaks through the range, but separates, as it passes south, to form the Piñaleno hills, which contain mountains Turnbull and Graham. This is the loftiest of the parallel chains, and is continued further south, where it is met with as the Chiricahui mountains, and as far as Guadalupe. It is, however, but one of three ranges—having the same strike, the same structure, and upraised by the same cause, and the whole may therefore be classed together as one mountain system.

The Piñaleno system.—The Sierra Catarina comprises the primary and volcanic rock of this system, which, united into one mountain mass south of the Gila, is on the north side of the river spread out into several ranges of granitic and felspar porphyry rocks, preserving an uniform northwest trend. Trachyte, red porphyry, and basalt, are the intruding rocks in the granitic hills; the trachyte in many places being spread out like a bedded rock over the sandstone, which it has rendered metamorphic.

While, as has been stated, the trend of these hills is northwest and southeast, it would appear as if the force was more energetically exerted several miles north of the river, or at least exerted more in parallel lines than over the whole surface; that it diminished south and eastward, and that the course of this river was near the southern termination of the wave force which ruptured the crust and extended the felspar and lava rocks. The chains which come from the north have their northern extremity elevated several hundred feet above the southern end; and while the mountains in their passage south drop down, the table land rises until 90 miles south, about latitude 32°, the elevated mesas of Sonora and Chihuahua are reached, and the mountain ranges of the north appear to exist only as isolated hills rising out of the general plain.

The ranges to the east of the San Pedro are less contorted, and the stratification less inclined; the hills being loftier, allow also better examination of the strata underlying the basalt. Figure 4, plate XI, shows the disposition of the strata at camp July 7.

The sandstone which is exposed on the western faces of these hills being capped by basalt and red amygdaloidal porphyry, has here about 500 feet in thickness uncovered. The total height of the range on the right bank may be 2,000 feet; dip of the sandstone 25° south, 75° east. At its base is the river bed of alluvial sands and clays, and through which the Gila has cut thirty feet. A low mesa, or terrace, is on each of the rivers, formed of gravel, the decay of the sandstone rock, intermingled with the wash from the primary rocks on the left bank of the stream. Of these gravel and river stones, three out of four are porphyritic; the rest granitic and feldspathic. Only two varieties found in the stream are not local: one a deep red (stilbite) porphyritic rock, with minute crystals of hexagonal green mica interspersed, and the others are encrinital limestone, grayish in color, and almost metamorphic. These were carried down by some of the northern tributaries, and are, perhaps, derived from outliers of the Mogollon system.

On the south (left) bank of the river the sandstone again appears, dipping in the same direction; but at a higher angle, 28° to 30°—it reposes on a mass of erupted lamellar feldspar, which forms an angular, sharp crested hill, of small elevation. Further south and west of this raised bosses of granite protrude. The sandstone on this side of the river is a coarse conglomerate of granite and feldspar porphyry, with reddish porphyritic pebbles interspersed. On the north side the sandstone is made up of quartz and feldspar, in fine particles, including syenite and greenstone and basaltic pebbles. If this bed extends under the river, and is one with its congener, the thickness of the strata would then be over 2,000 feet.

No trace of fossils could be found in the sandstone strata. This rock corresponds lithologically to the old red sandstone or Devonian system. It is here found underlying the carboniferous limestone situated further east, on the Sierra Calitro, and is the furthest point to the west to which it has been traced along this line. The conglomerates found on the desert have not the reddish tint, nor the coherence of this rock, and are similar to that flanking the east side of the Cordilleras.

In the valley between the Sierra Catarina and the Sierra Calitro the San Pedro river flows and empties into the Gila. From that point the Gila turns northeast, while the course of the San (José) Pedro is south, 20° east, and runs at the base of a range parallel and almost continuous with that in which Saddle mountain lies. These are the Sierra Calitro. The river rolls on the west side of the chain and receives several small creeks flowing out from it. The valley of the river becomes wider for several miles up, forming a splendid bottom of fine grass and wild vine, the bottom being in many places a perfect thicket with jungle and bush.

From the mouth of the San Pedro, for seventy miles up its stream, the bottom is cut out from nearly horizontal strata of gypseous rocks. The mesa and low land which rises gradually up to the base of the Calitro hills are altogether of this formation. Of a loose texture, they are easily eroded by the freshets from these mountains, and not only are deep channels worn for the passage of Arivaypa creek and other small streams, but even the whole mesa is cut through; so that what at first sight appears a smooth ascent along a sloping mesa, is found to be a series of hills and valleys, with dry arroyo beds, whose sections show the denudation which has occurred. The Calitro hills lie about eight to ten miles east of the river. The west bank of the San Pedro is bounded by foot hills of the Santa Catarina range; these are of lamellar felspathic rock of the same character as the Spire hills. They approach the river closely, and generally the river keeps on the west side of the valley.

There is a slight dip to the east in these gypseous beds, which are of great depth; in some of the valleys as much as 240 feet of yellow sand rock is exposed, (half a mile east of river, July 9.) It contains broad veins and seams of gypsum, massive and amorphous anhydrite in seams two to four inches thick, and repeated five times in a thickness of 30 feet, with muriacite, and also seams four to six inches wide of selenite. At the base of the Calitro range it is overlaid by a rough conglomerate of jasper, porphyry, and granitic pebble, from 80 to 100 feet thick. This bed also dips eastward toward an elevated crest of felspathic granitoid rock, which forms the outlier of the Calitro range; reposing conformably on the east of this crest, and apparently upraised by it, are thick beds of hard yellow sandstone, (grit,) of which the lower strata, in proximity to the granitoid rock, are metamorphic, and contain quartz crystal in abundance. These strata might be 500 feet high. Still east of this, in a deep valley in these hills, a bed of red granitoid rock (red felspar porphyry) occupies the bottom of the valley, and underlies the thick beds of red sandstone which form the elevated hills of the range, that are cut through by seams of porphyry, and capped by basalt and amygdaloidal trachytic rock. The gypseous beds are cut off from any contact with these elevated hills by the felspathic crest, which constitutes their base, and is limited in surface extent by that ridge upon the east. On the west it reposes unconformably upon the granitic elevation of the Santa Catarina hills, but is separated from immediate contact by the bed of sandstone conglomerate, represented in figure 5, plate XI, where the sandstone is marked *c*.

The gypsiferous series met with in passing up the San Pedro are of great thickness; of these, the lower beds are encountered three miles above the mouth of the river, the upper beds sixty miles up stream. The same series are met with by leaving the river bottom and ascending the mesa towards the Arivaypa hills. They are as follows, commencing from above:

	Thickness.
A. White marly rock, soft and friable, wearing into holes	80 feet.
B. Greenish, aluminous rock, hard and slaty; anhydrite	10 "
C. Brownish gypsiferous clays	100 "
D. Yellow sandstone, with seams of selenite 4 to 12 inches thick	100 "
E. Conglomerate of igneous pebbles, syenitic, porphyritic, and jasper	60 "
F. Greenish arenaceous gypsiferous rock	60 "
Total thickness	410 feet.

The upper beds are marly clays; the lower, grits and conglomerates. It has already been stated that these beds are unconformable to the Santa Catarina hills, whose lamellar felspar dip easterly (4°) on its eastern slope. At Tucson, gypseous rock is also found dipping slightly west; so that these beds appear to have been deposited on the slopes of the Santa Catarina, whose elevation is thus less recent than these gypseous beds. It is remarkable that here these gypseous beds repose on conglomerate, and this latter on a primary bed. This is the same disposition which occurs upon the eastern slope of the sierra emerging from Vallecito. The gypsum beds there present also the same physical and chemical characters with those observed here. A section is given in figure 6, plate XI.

There can be no doubt that these beds correspond to the cretaceous strata of Texas and those east of the Alleghany range. On the San Pedro they repose on granite, and eighty miles up the river are covered up by the tertiary conglomerates and gravels which constitute the great desert of Sonora and of the basin. Lower down these, having been denuded, allow the exposed beds to appear. Like all other cretaceous beds, they are gypseous and marly above and sandy below; but they are singularly sparing in fossil remains, a few pieces of silicified wood, washed down by a creek, being the only traces of organization observed.

An analysis of the stratum A is subjoined in the chapter on Chemical Analysis, containing one-third its weight of clay and nearly one-half carbonate of lime; this gives to the whole mass a chalky character and cohesiveness. It is a very fine marl.

The stratum C is a mixture of clay and irregular formed crystals of gypsum, with minute crystals of common salt (chloride sodium.) The saline particles prevail, and give a rough and crepitating feel to the clay.

About sixty-five miles southeast of the mouth of the San Pedro a crested hill of granitoid rock crosses the river, through which the latter cañons. This rock is the continuation of Santa Catarina, which, in preserving its trend, crosses the river, whose tendency is to turn westward; from this point the gypseous beds disappear, being covered up, if they exist, by a thick bed of loose conglomerate gravel, granitic sand and gravel, with quartz pebbles.

The further up the river is travelled, to Tres Alamos, the deeper this bed appears to become, until the desert level at camp, (July 17,) at the crossing of the river, is reached.

This gravel appears to be the covering of the whole plain country around, and, from its great depth, is one of the causes of its great sterility. At the point where the river cañons it is about 100 feet deep. It always reposes uncomformably upon the conglomerate beds, which are there exposed, and which constitute the lower beds of the gypseous strata.

At the base of the small hills northeast of camp at Tres Alamos, this conglomerate is exposed, and, by pounding and washing the pebbles, quartz, red porphyry, and serpentine, a few small scales of gold were obtained. Southwest of the river, at Calabasas ranch, and at Tucson, gold is also obtained; and there is no doubt that not only where this conglomerate is exposed, but also in the granitic and felspar rock of Santa Catarina, from which the conglomerate is derived, gold could be obtained by washing. The scarcity of the water is the great drawback to its abundant separation. The cementing clay of the auriferous gravel had very minute crystals of carbonate of lime (arragonite) interspersed throughout.

Of the two varieties of plutonic rock which appear along the Gila and in the San Pedro valley—the basaltic and reddish amygdaloidal porphyry rock—the latter is a trachhyte, and exists in by far the largest masses, while the basalt occupies a stratum or layer a few feet thick over the general surface; the amgydaloid trachyte forms the great mass of basal rock in many of the upheavals of this region; yet it is remarkable that, upon the mesas and banks of the San Pedro, the scattered fragments of basaltic rock which lie strewed over the whole surface are very numerous, and constitute, indeed, the main portion of the detrital fragments; the fragments of amygdaloid rock bear no relation to those.

On the other hand, when we examine the conglomerates, especially those placed lowest in position, the amygdaloid is found to be the prevailing rock, giving the color and the character to the conglomerate, then granitoid rock, and least of all the basalts; in some beds the basalt is wholly wanting.

The basalt is found mostly in veins or dykes and the amygdaloid rock in masses, and, in almost every instance, the latter is covered up by basalt.

From the relative position of the two rocks, and from the constitution of the conglomerates, it is evident that the basaltic flow is posterior, in point of time, to the elevation of the amygdaloid rock.

When reviewing the structure of the Organ mountains, it will be found that a similar view of the relative ages of these plutonic rocks is advanced, based upon other reasons.

The crossing at Tres Alamos, on the San Pedro, is over 900 feet higher than the mouth of the same river 90 miles north. The valley has risen thus much toward the level of the hill tops, and nothing but the desert gravel meets the eye roaming over one of the most extensive prospects which nature can present—a flat of almost boundless extent toward the south, with the horizon line in a curve from its vastness, broken in upon only at a few points by an isolated range, the representation of the loftier and closely aggregated chains of New Mexico.

CHAPTER XXI.

DISTRICT OF PLAYAS OR SMALL VALLEY TROUGHS.

Ascent of the spurs of sierra calitro.—Approach to the playa.—Deposit of conglomerates —Granitic axis.—Stratified rocks on the west side of the playa.—Extent, surface, and boundaries of the playa.—Sand ridges of the margin, their origin.—Palæozoic rocks of the basin.—Volcanic rocks, serpentine and augite.—Thickness and dip of the encrinal limestone.—The playa in the rainy season, its physiognomy.—Chiricahui mountains, structure and trend of.—Its relation to the piñaleno mountains.—Structure of puerto del dado.—Porphyry dykes.—Dos cabezos —Volcanic rocks in canon.—Valle del sauz, limestone rock of.—Extent of valley.—Peloncillo hills.—Trachyte and basalt overflows.—Extension northward.—Successive eruptions.—Pyramid hills, their structure.—Valle de los playas, soil and sandstone of.

To reach the Playa de los Pimas from the San Pedro, at Tres Alamos, the trail passes over a low range, the subsidence of the Santa Catarina, joining by a spur the Calitro range of hills, and both merging into the general level of the extensive plateau; in so doing it divides into several spurs, and over the one which trends furthest south this road passes. The ascent, 14 miles to the summit, is easy, and is over beds of granitic clay and gravel, deposited very nearly horizontal, from 80 to 100 feet in thickness—dipping west a few degrees north, at a very small inclination. The upper beds appear to be of the coarser material. This formation is not found on the descent of this spur, which is composed of the exposed surface of the stratified rock. This is the eastern limit of this unconformable tertiary stratum of desert gravel.

The summit over which the trail runs has an elevation of 4,707 feet, and is a plane surface for several miles; the axis is granitic, very abundant in yellowish felspar; a quartzose compact conglomerate lines both sides of the axis, dipping N. 30 W. and S.E.; not more than 40 feet of thickness of these beds are exposed. Further down the eastern slope of this spur limestone is exposed, with a bare, thin soil covering it, the dip eastward; a few degrees south, and upon the back of the strata for some miles the road lies. This bed is fossiliferous—encrinital—and in places cyrstalline and metamorphic; a characteristic of it is the mode of weathering, leaving rough elevated surfaces—the whole strata being fissured throughout, and the cavities filled by white amorphous carbonate of lime. This rock is also very argillaceous, and weathers irregularly, leaving a brownish yellow, clayey surface, caused by the removal of the superficial crust of carbonate of lime.

GEOLOGY OF THE CALITRO HILLS.

These hills have been already noticed as the 2d range in the Piñaleno mountains. They are well seen coming up the Gila at the mouth of the San Pedro.* The Gila cañons through them and exposes vast masses of red sandstone, which constitutes the great bulk of the hill. The whole range is capped with limestone; the lower carboniferous beds, which, further to the south and east, is found in the basins and lower country, are here uplifted 2,500 feet above the level of the river bed, and broken through and tilted at opposing angles by basaltic and amyg-

* Where three distinct ranges running N. by W. parallel to each other may be seen in proximity, the Sierra Calitro being the most easterly of these. The Piñaleno range is hidden from view.

daloidal trachytic intrusions; a layer of amygdaloid being found in some places concealing the limestone. Saddleback mountain in this range is an instance of this tilting of the strata at short intervals apart, giving the hollow-backed appearance to the mountain from which it derived its name. This range is remarkable for the flat summits of the hills—forming large plateaus of several acres in extent. Its direction is north 45° west. The exposure of sandstone beneath the limestone capping cannot be much less than 1,000 feet. This rock has already been referred to the Devonian system, and is the oldest sedimentary rock met with on the survey.

The range has an average breadth of 10 miles, and cannot be less than 100 miles in length. Its course along the right bank of the San Pedro is above 70 miles in a straight line, and it can be traced by the eye more than 20 miles north of the Gila.

GEOLOGY OF THE PLAYA DE LOS PIMAS.

This playa is a level plain of white sandy clay, glittering with white quartz and felspar particles, which have not undergone attrition sufficient to round them. To the eye it appears an uniform flat, but it rises gently toward the north, where it is continued into the valley between the Calitro hills and the Mount Graham or Piñaleno range; it is from this northern prolongation of the playa that the fine quartz particles are, in all likelihood, derived, inasmuch as vast masses of loose quartz rock is found at the slope of the Calitro hills, and in the beds of the arroyos leading from that range on its east side.

Where the playa impinges on the base of the mountain ranges, several small, low sand masses are formed, the effect of winds on the plain collecting the sands together.

The low range of the Sierra Calitro, just described, over which the trail runs, forms the western boundary of the playa. On the eastern border lie the Chiricahui mountains. The granitic axis of both, being similar and in connexion, form the basin in which lie the stratified rocks of the palæozoic period. They lie conformable to the primary bed, and are, in a few places, cut through and displaced by veins of serpentine and dykes of augitic rock, which are more evident on the eastern than on the western margin of the playa.

The slope from the Chiricahui to the playa is gentle and rolling, cut up in a few places by deep, dry arroyo beds; it is here that the sedimentary strata are displayed in part. The limestone is exposed in the bed of a creek about two miles before the pass in the mountain is reached; it is here metamorphic, and filled with seams of white carbonate; in other respects it is similar to that forming the tabular slope of the west side of the playa; the beds slope down into the playa and form the superficial rock at least upon its margin. Higher up the creek bed there is exposed a bed of metamorphic sandstone rock. Sixty feet in thickness of this was exposed; it dips under the limestone, though its contact with it was not observed; ascending the base of the mountain felspar, porphyry, with quartz veins, constitute the foot hills.

The strata met with in the playa, and occupying the whole valley, are:

1st. Coarse red conglomerate, cemented by a gypseous and calcareous paste, including rounded pebbles, mostly of jasper, occasionally of augite, syenite, and other plutonic rock. On the Chiricahui slope this conglomerate is 90 feet thick. On the western limit of the playa it exceeds 100 feet; but as it is not fully exposed its total depth there cannot be declared.

2d. Whitish sandstone grit, metamorphic, and in places possessing double line of cleavage. This bed reposes on the conglomerate, and was not exposed on the western edge of the playa; on the eastern it was 60 feet in thickness. As this bed is much thicker further eastward, it is probable it may be here also, but its limits are covered up by superficial detritus.

3d. Encrinital limestone, metamorphic and crystalline in its lower beds; roughish; brown on the exterior; deeply fissured, the cracks filled with amorphous carbonate of lime; blue in the interior, and in some beds highly fossiliferous. Perhaps this is the superficial rock of the playa; none other crops out upon the surface or border. It is hard to fracture and weathers slowly, and is largely exposed on the western slope of the playa, where it forms for miles the bare rock of the surface, so lightly covered with soil that only cactus and fouquieria can support an existence.

On the west boundary this rock dips southeast 7°; on the east side it dips southwest 12°. The thickness on the western side is 150 feet; on the east it is covered up so that not more than 40 feet is exposed. But it is probable the total thickness is not less than 200 feet.

During the excessive rains in the rainy season, the whole or the greater part of the playa bottom is covered by water to a depth from a few inches to some feet. During some large portion of the year there is a small lake in the centre, and such has been noticed by some travellers, but the continued evaporation ultimately dries up all surface liquid, and leaves no traces but the soft clay bottom, marked in places with the rippled lines of the recent lake; the soft texture of the soil allows the foot to sink several inches down; and, on the margin of the playa, a collection of fine sand or beach of angular quartz; without vegetation on its surface it resembles an extensive field freshly ploughed and rolled, over whose heated surface the mirage depicts its beautiful and tantalizing lakes of great extent.*

The physiognomy of this district is peculiar, and different from what is presented in similar situations in the Atlantic States. There the interval between two mountains is a distinct valley or trough, and the approach to the mountain is broken by a gradual swell and rolling country; but here there is no valley—it is an uniform flat, running abruptly to the base of the hill, which thus stands boldly out, and once reached is immediately ascended. It would appear as if where these submarine elevations occurred that the shore actions must have been of some power and duration to deposit such an amount of sedimentary strata and detritus, that the whole valley proper has been filled up to an even level line; and but little alteration has been produced in this, save where the mountain streams have cut deep arroyos in its sides.

It is this horizontality of the detrital beds which has produced the playa by reason of the inefficient drainage of the waters; there being no decided fall in any direction, the water lodges in the subsoil, forming springs.

The vegetation on the Calitro hills is that of a desert; a variety of black walnut is found in the cañons near the summit, but the descent is quite sterile, being mostly an exposed bare rock, (limestone.) Fouquieria and agave, with palmetto, but no traces of mesquite, are found on the descent to the playa.

The slope to the playa on each side is very gradual, so that although a space of twenty miles intervenes between the Sierra Calitro and Chiricahui, yet the playa proper has not a greater breadth than eight or ten miles. It is difficult to estimate its length, as its boundaries north and south are not defined—stretching northwards between Mount Graham and the Calitro hills and rounding Chiricahui, both north and south, and spreading into the elevated plain country to the south and east.

* Lieut. G. Andrews, 3d Art., commander of the escort accompanying the survey, informed me that on his return with his company to Fort Yuma, crossing this plain early in December, he found a small lake, a mile wide and perhaps three miles long, four to six inches deep—the accumulation of the summer rains on the slopes and over the surface of the valley. This shows what a large volume of water is available if means were taken to preserve it.

It is smooth as a bowling green, without any river bed in its middle; the small creek beds, leaving the mountains on each side, only run a short distance, and lose themselves by sinking in the sand in dry weather, and in the rainy season by delivering their waters into the shallow lake which then occupies the playa bottom.

On the north edge of the playa, along the trail and toward the middle of the plain, are a series of pools or springs, which yield a large supply of water, which at this season was very cool but exceedingly unpleasant, being slightly saline, sulphurous, and highly impregnated with decaying vegetation. These springs form a boggy marsh or swamp as they flow several yards along, giving growth to juncus, carrizo, and tule. These springs are included between layers of clay in the alluvium, and are not derived from leakage through stratified rock. They are produced by the infiltration and wash of the slope of the plain outside the playa oozing up through some fissures in the clay. A large supply of water might be obtained by sinking wells along this line a mile north and south.

An effervescence of carbonate of soda and salt is found around this moist district.

GEOLOGY OF THE CHIRICAHUI MOUNTAINS.

The Chiricahui range is a small, well-defined mass of mountain, standing prominently out from the level basin which surrounds it. The playa just described extends around its northern and southern extremities, so that, though lofty and of considerable breadth, it is completely isolated, and forms one of the many peculiarities of this latitude.

Yet it preserves the trend common to all the mountain ranges here, viz: N. 40° W., and lies in the line of the prolongation of the axis of the Piñaleno range, of which it may be considered the southern extension, that range in which lie Mountains Graham and Turnbull.

It has also the same geological structure as the Piñaleno range. Major Emory crossed the latter in two places, and found on the slope the following disposition:

Granite, very coarse.

Red sandstone, in layers one foot thick.

Conglomerate of sandstone and pebbles.

The depth of the two last was many hundred feet, with the stratification much deranged. Near the mouth of the San Francisco the formations were:

Granite, with much red felspar.

Argillaceous limestone, with a west dip.

Sandstone, calcareous and coarse grained.

Diluvium.

Descending the Gila toward Saddleback Peak the following order of rocks occurred:

Granite.
Compact limestone.
Black slate.
Red sandstone, dip southwest 25°.

Although the limestone and granite were observed very close together, yet in no case were they found in contact.

Saddleback Peak, when viewed from a distance, appears to be made up in its upper portions of limestone capped by amygdaloid, and, perhaps, composed below of sandstone, limestone, and conglomerates.

The order of the strata on the western slope of the Chiricahui, along the trail, was—

Granite, felspathic.
Serpentine, auriferous.
Hornblendic black slate.
Quartz, ferruginous and drusic.
Jaspery conglomerate, (exposed,) 90 feet.
Sandstone, with cleavage lines, 60 feet.
Limestone, compact and metamorphosed, 100 feet.

As has been stated already, it is difficult to give the estimate of the jasper conglomerate with any approximation to truth, as it is not fully exposed. The serpentine is in thin beds, and the black slate is not more than fifty feet thick. The ferruginous quartz is rather an altered or metamorphic sandstone; an interval of 500 feet at least here separates the limestone from the primary rock, and it is probable that, though not observed at the mouth of the San Francisco river, this intervention exists there also.

It may be remarked of the limestone strata which were encountered on the slope of the Calitro range dipping eastward, that they showed themselves there for the first time, that rock not having been observed on the eastern slope of the Sierra Nevada, nor at any of the small ranges on the desert or up the Gila. At Goat hills, and a few other points, the conglomerate is the only rock exposed which should not be confounded with the sandstones and conglomerates below the limestone; lithologically dissimilar, they are also of very different ages.

"PUERTO DEL DADO."

The pass through the Chiricahui, so called, is a narrow, winding trail; it opens up into small valleys of unusual fertility, enclosed by mountain walls. There are no secondary rocks in the Puerto. The whole mountain is a mass of primary rock, of which a reddish felspar granite, mostly of a coarse character, forms the chief part; veins and dykes of porphyry felspar cut through this and reach the summit, and, from its being of a finer texture and less acted on by the weather, form those turretted summits which, visible from a great distance, and situated upon the apex of the hill, constitute what are called the Dos Cabezos. These cabezos are repeated in several places along the crest wherever the porphyry dyke happens to be produced, but those which are known as such are on the most prominent point of the mountain. At the western entrance of the cañon several quartz veins running north and south cross the trail, one of these being 40 feet in width; accompanying these is a blue quartzose chalcedonic rock. In the granitic rock the felspar crystals are large, distinct, and reddish, and everywhere through these smaller, as well as the larger hills, felspar dykes, rising at an angle of 60° from the east, cut their way and form the angular crests.

The whole mass of the mountain is more felspathic than granitic—thus, felspathic rock; rock felspar crystals, in a felspar paste; felspar rock amorphous; felspar rock, with rhomboidal cleavage; porphyritic felspar, *i. e.*, quartz and felspar—a rare rock; quartz veins, both ferruginous and vitreous, which usually run at a right angle to the felspar dyke, whose general direction is N. 60° E. Such is the constitution of the whole mass of the Chiricahui, from the entrance to the exit of the cañon, a breadth of nearly ten miles.

Dykes of augite, in some places 15 feet in width, cut through the felspar rock in the creek bed on the east slope of the Puerto, and thin beds of serpentine are found occurring on this as well as on the western entrance of the Puerto.

Although properly considered as one mountain mass, elevated synchronously, yet, in crossing it by the cañon, the valleys in the interior are disclosed ; they are elevated considerably above the level of the playa outside, (which, itself, has an elevation of 4,236 feet,) being above 5,000 feet, and are of small size; being enclosed between the crests of lesser ranges which cross obliquely, from east to west, small streams flow in due season down from the main mass of mountain, and have worn deep beds in the granitic rock and carried the detritus into the valleys to form their soil. The accumulated water of snow meltings and of rain upon an impervious bottom, leads to the production of wells and springs, with which some of the valleys were supplied. There was abundance of good grass and small timber; oak, cedar, and walnut, arbutus, and wild cherry were the common growth ; such are the results of an increased altitude, and a good supply of water on this latitude.

The great mass of Chiricahui is uplifted on its western side ; it is there that Dos Cabezos towers, and there the trail rises abruptly to the summit, which is not more than three miles from its western entrance ; the remaining distance, seven miles, is a slow descent through a narrow cañon, tortuous and difficult for wagons ; the cañon leads along a creek bed winding through a series of foot hills, also granitic, but dislocated and injected by veins of crystalline felspathic rock, augitic dykes, and masses of serpentine. There, also, the type of the rock is felspathic, sometimes porphyritic, and sometimes lamellar. The proximity of augitic and serpentine rocks would lead to the supposition that these cañons might be auriferous, as also the black shale near the serpentine on the west side. Gold is stated to have been found in the mountains by the Gila Apaches, and brought to the Rio Grande by them. Our time did not allow an exploration.

VALLE DEL SAUZ.

Emerging from the cañon on the east side of the Chiricahui, the limestone rock is again met with ; it is in close proximity to the felspar rock, dipping northeast at an angle of 40°. The lower strata are metamorphic and converted into a white granular marble; the upper beds preserve their bluish color on fresh surfaces, weathering to a brown tint on the surface; one bed full of encrinital stems, others suffered much from the fossils dropping out, leaving the matrix in a crumbling condition. It is here 180 feet thick, and the dip at the edge of the valley is 11° southeast.

This is the only stratified rock observable to the edge of the valley. This plain stretches from the base of the Mount Graham range, southward, rising slightly in the latter direction, Chiricahui bounding it on the west, and the Peloncillo hills on the east; the breadth is fourteen miles, and in the valley bottom, which approaches the latter hills, the Arroyo del Sauz flows at times. At this visit nothing but pools of muddy and brownish water were visible, occupying deep holes in a clay bottom.

The valley has a slight slope to the north ; its bed is a red felspathic clay, with beds of drift gravel of considerable depth. The clay beds serve to retain the rain waters and those of the river channel, forming the water holes found in its bed.

This plain presents the same features as the playa just described, as far as regards vegetation, without being absolutely bare, as that was ; yet its growth is of that thorny, worthless, desert character. Fouquieria, larrea, yucca, palmetto, and agave, are the only growths on the slope of the plain, down to half a mile from the river, where the mesquite tree begins to appear, and the willow is found collected round some of the water holes in the bed of the stream. The alluvium in the immediate vicinity of the stream bed is a very fine clay, which puddles well and serves to retain the water. The soil of the slope is a decomposed felspathic granite and a reddish silicious sand. From the character of the vegetation on the slope, it is evident but little water is retained there, and no creek carries its bed sufficiently far to deliver its waters into the Sauz stream. The rain water absorbed into the soil probably finds its way to the lower level of the valley near the river bed, and may go to form the water pools existing there in dry seasons.

Although no rock was observed here in place overlying the limestone, yet the depth of detritus and gravel on the upper edge of the plain leads to the suspicion that a sandstone rock is the immediate basis rock; the reddish silicious sand also presupposes that it is a reddish sandstone, such as is found further east.

Looking back at Chiricahui from the Sauz brook it appears a much larger range than when seen from the playa. The eastern and southern prolongation of the mountain is only visible from the Sauz valley, where it appears to run 30 miles south of the cañon. The highest peaks of the mountain also lie to the south of the Puerto, and attain an elevation of 6,000 feet above the sea, or 2,000 feet over the plain on either side. At such an elevation this great mass of rock must attract the rain clouds of summer and receive a large supply of water; from September to April its summits must be frequently capped with snow, thus increasing the water supply. Still, it may be asked, what becomes of this water? is it all confined within the valleys of the range? The arroyo beds, which are numerous and some of them deep, leading from the flanks of the hill, flow one, two, or it may be even three miles into the plain, but, sooner or later, they ultimately lose themselves in the detritus of the valley; and of the few arroyos which drain out from the interior of the mountain into the external plain, not one of them flows permanently. There is not, in fact, comprised within the whole mountain region or its confines, one single permanently flowing stream. The stream beds show that occasional flows of water occur from excessive rain or from unusual thaws of snow, and that from their sudden rise the waters exert a great force in scooping out a channel; but this only exists for, at most, a few weeks in the year, and thenceforth diminish, so that for three-fourths of the year they are represented by dry beds. From the apparent condition of the surface, we must conclude, notwithstanding the lofty elevation of the basal plain and the mountain ranges, that but a small amount of rain falls in the year, and that the solar evaporation must be very nearly equal to that rain fall, whatever its amount; for, if not, the plains would become water soaked from having no good surface drainage, and would produce a varied and abundant vegetation.

CHAPTER XXII.

VOLCANIC OR DISTURBED DISTRICT.

Burro mountains.—Igneous and metamorphic rocks of peñasquitas.—Region about ojo de la vaca.—Red sandstone.—Character of spring.—Trachyte buttes.—Enumeration of the stratified rocks near the mimbres.—Structure of the mimbres valley.—Agua caliente.—Vicinity of the spring —Properties and temperature of the water.—Carbonic acid gas.—Volcanic disturbance of the region.—Giants of the mimbres.—Plain east of the mimbres river.—Picacho.—Elevation and structure.—Trachyte and greenstone dykes.—Observations on the picacho.—Structure of the vicinity of cook's spring.—Character of the water.—Jornada.—Basalt district.—Extent.—Trachyte outpouring.—Monument hill.—Mesas of rio grande valley.—Sandstone detritus.—Picacho of mesilla.—Topography of vicinity.—mesilla valley, extent.—River bottom, fertility.

PELONCILLO HILLS.

These have been so called from containing a few hills whose conical shape bore a strong resemblance to the Sugar Loaf, and whose form is so distinctive as to make them easily recognizable from a distance. This range is of but small length, about 15 miles, dividing the great plain east of the Chiricahui mountains into two, which interlock round the north and south extremities. Geologically, these hills are unimportant. They are upheavals of plutonic rock, extensive overflowing of trachyte amygdaloid, and basalt, covering up the stratified rock, the only one of which observable there is a reddish conglomerate, now appearing for the first time ; dykes of felspar, augite, and porphyry, (reddish,) run from north to south. Some of the felspar dykes are seventy feet in width, and run north and south. The axis of all the conical hills in this range are made of this rock, the dyke being readily traced by the eye to the summit. Milk-white and opaque chalcedony is very common, the amygdaloid rock often containing large nodules.

The amygdaloid and basalt capping of these hills dip toward the centre, as if there were two rents of the crust, and two upheavals, with a synclinal axis between. The whole breadth of the range is small, and the latter must be looked on as the termination of a basaltic efflux, which further north, at the junction of the San Carlos with the Gila, has produced a much greater amount of local dislocation.

A line of less disturbance, of a precisely similar character, lies a few miles east of these hills, in the middle of the Valle de las Playas. There are a few pyramidal shaped hills made up of felspar dykes, with amygdaloid and basaltic rock, both compact and laval.

The valley "de las playas" is an extensive plain, without any well defined slope to the north or south. The soil is much more arenaceous than that of the Sauz valley, and is much less deep. It is composed of a reddish felspar sand, mixed with white quartz pebbles. No water was found in the valley bottom. Opuntia and echino-cacti, palmetto were very abundant, with yucca, larrea, obione, and dwarf mesquite.

The blue limestone of Chiricahui is not seen here ; whitish metamorphic sandstone, with beds of yellow, slaty grit, and flinty conglomerate, form the valley basin. These strata are not visible on the immediate valley bottom, but can be traced on the hillsides, and near their summits. On the Peloncillo margin of the valley the dip is 8° south 20° east. On the pyramidal hills the dip is 12° north 20° west. East of these, and near the Ojo de la Inez, and at Peñasquitas, the strata exposed from above downward were—

	Feet.
Summit capping of felspathic amygdaloid	30
Sandstone grit, metamorphic	25
Blue silicious chaledonic rock, with seams of talcose rock	30
Yellow sandstone shale	45
Brown conglomerate flinty pebbles and agatized layers	66
Total thickness	196

I searched these sandstones in vain for fossils. They are, in position, superior to the limestone, and inferior to the gypseous beds of the San Pedro. The soil of this, the eastern extremity of the valley, is highly gypseous, being, in texture, a reddish sand, with whitish pebbles; these latter derived from the sandstone grit above alluded to as lying under the amygdaloid capping.

The Peloncillo and Pyramid hills, as they have a striking resemblance in form, so in structure are they alike. They are not protrusions of primary rock which have carried up their superimposed strata, such as Chiricahui and the Sierra Calitro, but they are injections of plutonic rock, which, rising in a fluid condition, has forced itself through the fissures formed by the subterranean force, and spread over the summit level of the plain, covering over the stratified rock, infiltrating itself between the strata, and metamorphosing them to a great extent, giving rise to every shade of silicious rock, from ordinary sandstone to chalcedony, opal, and chabasite.—(Plate XII, figs. 2 and 3, illustrate this intrusion.)

Trachyte and porphyry are the two species of rock erupted most abundantly; the former forming the crest of many of the hills, entering the cañon, and spreading itself over the surface like a stratum, while the porphryries are found in dykes, and do not appear to have been so fluid as the trachytes. A trachytic conglomerate is found capping some of the lower hills, the pebbles of which are porphyry, while the paste is trachytic; thus the porphyry injection would have been the first which occurred, the trachyte subsequently forcing its way through the strata by different fissures, and by the rupture of the crust involving the porphyry fragments in its mass. There are as many as five varieties of porphyry found, all of them having a fine clay felspar paste from light brown, passing through shades of red to violet, including small well defined crystals of orthose. On the east side of the Peloncillo range, near camp, August 4, in the cañon, a dyke of dense augitic basalt protrudes through the trachyte which lines it on either side; the vein is 25 to 30 feet wide, increasing in width downwards. East of it, in the bed of the arroyo at camp, the reddish felspar porphyry, containing quartz crystals of irregular form, is found 60 feet wide. This is the same rock found on the north side of the Gila in the cañons, and also among the igneous rocks at the foot of the Sierra Calitro.—(See Plate XII, figure 3.)

It may be perceived from the foregoing that there have been three distinct volcanic outpourings in these ranges—the Peloncillo and the Pyramids, considering them geologically as one. 1st, that of the porphyries; 2d, that of the trachytes; and 3d, that of the basalt, the antiquity of which were in the order indicated, and the earliest of them subsequent to the deposition of the reddish sandstone and whitish grit, which overlie the lower carboniferous limestone.

The result of these outflows has been, not only to elevate the district in which the flow actually occurs, but also the whole region in a line north and south, lifting it up to a much higher level without dislocating the strata so much as to tilt them up sharply. They have been dislocated very much in places, but the result has apparently been to produce faults, as if the whole strata had been elevated, and afterward, settling down unequally, produced the fissures or faults. It is worthy of remark that each valley, from the Santa Catarina range, with one exception, is at a higher level the more east it lies, thus:

Elevation of the San Pedro at Tres Alamos	3,413	feet.
Elevation of Valle de los Pimas	4,127	"
Elevation of Valle del Sauz	3,815	"
Elevation of Valle de los Playos, west side	4,269	"
Elevation of Valle de los Playos, east side	4,330	"

Thus, the effect of the Peloncillo range is to elevate the valley east of it over 450 feet, and the smaller range of the Pyramids appears to lift its valley 60 fect above its neighbor.

The trachyte and basalt country here blend together, forming a very elevated rugged land of hill and small valley, with rough cañons; it abounds in small wells and springs, which are found in the cañons, from four to six miles apart, the water being clear and wholesome.

BURRO MOUNTAINS, PEÑASQUITAS.

Leaving this valley of the Playas to the east, the foot hills of the Burro mountains are entered. These, in constitution, resemble the Peloncillo and the Pyramid hills, and differ from Chiricahui in this regard, that they have not a central igneous nucleus around which the strata are inclined, but are rather a series of waves, upraising great breadths of land, with bluffs generally to the east, and sloping more gradually westward; and though these hills individually attain no great elevation, the whole country appears to have been lifted up considerably. These porphyritic chains appears to have a pretty uniform direction N. 60° W., which is a much greater inclination than either Chiricahui on one side, or the Organ mountains, on the Rio Bravo, on the other. By this trend of the hill ranges open low cañons running east and west traverse them everywhere, and passes from one valley to another are easily found. The yellow sandstone is in some places hardened like enamel; in others, converted into agatized layers. The Burro hills, whose southern extension is crossed at Peñasquitas, and forms the rolling country at Ojo de la Inez and Ojo de la Vacca, lie more to the north, where they are gathered round the banks of the Gila, through which the river cañons. They are there lofty rugged masses of sandstone, broken through by trachyte and porphyries, narrowing the bed of the river, and diverting it northerly from its previous southern course. As the chain passes south, it drops down at the point where the trail crosses. None of the hills exceed 700 or 800 feet in height.

Exposures of rock in the cañon leading to the Ojo de la Inez showed the same succession of trachyte and porphyry rocks as on the Peloncillo ridge. The valley of the cañon ran up northwest, and was about 250 yards wide near the spring or water-pool. On each side the hills rose from 250 to 300 feet, capped at the summit by trachyte, covering up yellow sandstones and conglomerates. Thus, one hill, on the south side of the valley, viewed from above, downwards, afforded the following structure:

The estimation in feet is approximate.

Trachyte porphyry	30	fect.
Metamorphic sandstone	25	"
Blue silicious and chalcedonic rock	20	"
Talcose and trachyte layer	2	"
Yellow sandstone shale, dip 12° N. 20° W.	45	"
Conglomerate of agatized pebbles	50	"
	172	"

On the north side a hill, 100 feet high, yielded a similar section, excepting the exposure of the lower conglomerate. In some places the sandstone is hardened into enamel. The trachyte and porphyry protrusions run N. 60° W. (mag.) The trachyte in places has a ribboned structure, and resembles fossilized or silicified wood, but the appearance is communicated to it by its cooling while in motion, and being thus drawn out in an uneven plane; occasionally, chalcedony is found occupying cavities in it.—(Plate XIII, fig. 1, exhibits the strata as at Peñasquitas.)

From Peñasquitas to the Rio Mimbres the country is an elevated, broad plain, interrupted here and there by a few erupted masses of porphyry and quartz rock, forming conical hills. The same disturbance which upraised the Burro hills, acting here to a lesser extent, but in the same plane, and extending its influence in every direction around, even as far as the Sierra Florida, which presents a volcanic rugged surface similar to those in this neighborhood.

The only rock visible between Peñasquitas and the Ojo de la Vacca is a coarse red metamorphic sandstone, which crosses the trail obliquely, or from N.W. to S.E. The spring or "Ojo" is a deep well in the centre of a plain, depressed somewhat below the general level. Several holes have been dug about five feet around the natural spring to obtain a readier supply, the edge of the Ojo being boggy and full of rushes. The water is good and slightly sulphurous, but full of vegetable matter and animalcules. The evaporation of the surface water appears to keep pace with its bubbling up in the spring, since there is no stream rolling off from it, a slight marshy condition of the ground being the only effect. One-fourth of a mile east of the Ojo is one of the conical hills alluded to ; it is quartzose and porphyritic trachyte. Perhaps its protrusion may have dislocated the red sandstone, producing a fault, and giving an opportunity for the subterranean water to ooze up from beneath the fractured edges of a stratum.

Between Ojo de la Vacca and the Mimbres river the red sandstone strata are again crossed, which are better exposed here than west of the Ojo. It is a brick-red, homogeneous rock, with whity felspathic clay and nodules, and cavities sparingly scattered through it. The direction of the strata E.S.E., and the dip 26° N.N.E. The actual exposure was only 20 feet in thickness, though it is reasonable to think it reaches to next exposure of rock, making 190 or 200 feet in all. This forms the road bottom which crosses it, and in the angles between the edges of the strata water holes exist, which were well supplied with water at this time.

Lying immediately over this sandstone was a thin bed of whitish conglomerate or grit. The paste was aluminous, and the pebble porphyritic felspar. This bed was 15 feet thick.

Beyond this and overlying it was a thin bed of grayish clay rock, about two feet thick. Further east a thick bed of white felspathic conglomerate, 210 feet across. The included pebble is a dark, silicious stone. The conglomerate beds have the same trend as the sandstone, but the dip is somewhat less, being 22°.

The local disposition is thus:

	Feet.
1. White felspar conglomerate	210
2. Grayish clay porphyry rock, stratified	2
3. White sandstone grit	15
4. Red fossiliferous sandstone	188
Total	415

This last rock is in proximity to the amygdaloid porphyry. The geological relations of these sandstone beds will be considered further on, when describing the geology of the Mesilla valley and the Organ mountains.

VALLEY OF THE MIMBRES RIVER.

The Mimbres river lies in a depression or fault in the strata, which have been upraised immediately east of the stream, and which forms the elevated, rolling plain lying between the river and the Pichaco de los Mimbres. Where the trail crosses the river, on its left bank, are several low mounded hills with their bluffs to the west, and two rugged masses of porphyritic trachyte rock. Higher up the stream to the east these rugged hills with porphyry dykes are more abundant, and form, with the sedimentary rocks upheaved, the oak covered hills, in which the Mimbres has its rise. On the right bank of the river is spread out a great exposure of whitish and red sandstone, broken through by porphyritic amygdaloid, which latter is scattered over the surface. North of this, and separated by an interval of 20 miles of rising and rolling ground, lie the Copper Mine mountains. To the north and west is a wide and open plain, whose long axis is northwest and southeast, reaching to the Burro mountains, south of which lies the undulating, rough prairie, leading to Ojo de la Vacca and Ojo de Inez. This portion of the region is covered superficially by the white and red sandstone, already described, near Ojo de la Vacca.—(Plate XIII, fig. 3, illustrates the structure, and fig. 2 gives a section of the river bank.)

Between these two points, the Mimbres and the Ojo de la Vacca, and close to the trail leading from the former to the Copper Mines is that remarkable warm spring known as "Agua Caliente;" it lies about five miles from the river, and its position is easily found from the fact of a single cotton-wood tree growing beside it; as there are no trees for some miles around, it is easily recognized. A few osiers are scattered around the margin of the springs, which lie in a narrow valley. Where the springs issue out is a mound or bank of tufaceous deposit, formed by the overflow of the waters of the spring at some former time, previous to the side channels being formed. This mound is 20 feet above the valley level, and 2½ feet above the level of the water in the spring, showing that the spring, by the deposit of carbonate of lime from its waters has formed a basin wall for itself, and allowed its level to be raised above the surrounding valley. This calcareous basin is 25 feet across, and does not show bottom, except round the edges, which are rocky; a twelve foot pole thrust in toward the middle did not find bottom. The temperature of the spring was 130° Fah. at the surface, and was very painful to the fingers when immersed more than a minute or two. Loosely attached to the sides and floating in the water were thick, fleshy confervæ, green above and red on the under surface. From one point below, bubbles of gas rose in great abundance; some of these collected in a tin vessel were without sulphurous odor; the gas extinguished a taper and did not inflame, and was therefore carbonic acid.

Since this basin was formed, four small channels have been bored through the tufa wall, and open out a few yards down on each side of the main spring. Through these rolls out the water some paces down into little reservoirs, resembling artificial baths; to the inaccurate observer these might appear to be distinct springs, but close observation will show they are derived from the central spring. In these little channels the water does not attain the same, height of temperature. They read 108°, 110°, 115°, and 120°, respectively, in proportion as their channels of communication through the tufaceous deposit is more or less long. A large body of water flows off from this spring, and were it situated within the limits of civilization, it might be made available for medical or economic uses.

The water is agreeable to the taste.*

* It is to be regretted that a bottle of this water, filled on the spot, was broken, after having been carried several weeks, so that its exact constitution cannot be determined. However, at the close of six weeks, this water had preserved its transparency,

There is no other thermal spring known in this locality; to the east, several cold springs ooze out, and run a few yards down the valley, forming collections of carrizo or tule, the only vegetable growth in this region of barrenness. Notwithstanding the disturbed character of the region around, there is nothing to justify the conclusion that there is at the present time any volcanic forces in action; nor can this spring be supposed to be caused by any such existing force. The presence of an excess of carbonate of lime may have been obtained by the spring passing through the strata of carboniferous limestone, which may be presumed to underlie the sandstones of the surface; if this be so, the temperature should then be due to the depth from which the water has arisen to reach the surface; the temperature of the water, however, is an argument against the latter, as it is 70° above the ordinary temperature, which would be equivalent to a depth of 3,780 feet below the surface.

Northeast of "Agua Caliente," between it and the river, is an upheaval of felspathic porphyry, which has carried up the sandstone strata on each side, which dip northeast and southwest. The upheaval itself presents the appearance of a battery or fortification presenting its semi-circular point to the south. At some distance from this upheaval immense blocks and loose masses of sandstone rock lie heaped together in the most grotesque forms; some of them consist of several masses, one piled on another, and in some instances nicely balanced and ready to topple; seen from a distance, in this highly refracting atmosphere, now they resemble trees, and now men; least of all would they be taken for really what they are, disintegrated sandstones. They are now known as the Giants of the Mimbres. The wearing away of these grits, whitish and yellow sandstone, such as are described near Ojo de la Vacca and the Mimbres, show what a loose texture these rocks have; every heavy shower denudes them to some extent, and after some years they have no longer the same appearance or outline which they formerly showed.

From the Rio Mimbres to the extremity of the Picacho de los Mimbres is ten miles, and thence to Cook's spring, eight miles, the trail passes at the southern point of the hill; the intervening country is rolling land, not broken through by any extensive outcrop of volcanic rock; a natural section afforded by the Mimbres at the point where the trail from camp, August 10th, passes east to the Picacho, showed the porphyritic masses, forming the low rugged hills on the east of camp; and upheaved by these, and exposed to view by the wearing of the edge of the river valley, were the red and white sandstones and grits, already described at Ojo de la Vacca. These sandstones were exposed about a half mile south of the erupted hills, and dipped away from them south 12° east at an angle not exceeding 12°.

The rock nearest to the volcanic mass, and situated lowest down, was the red sandstone, with 30 feet exposed. Above it was the whitish grit, 50 feet exposed; and some few yards further south, another small *butte* was composed of the whitish yellow sandstones, dipping south at a small angle.

The Picacho de los Mimbres forms a very prominent landmark, both from its height and irregular conical form; it is 2,500 feet above the plain, about ten miles long, and stands unconnected with any other range, and is distinctly visible from the summits of the Organ mountains on clear days. It has an axis of reddish granite and syenitic rock. The felspar is red in

and no ochreous or mucilaginous deposit had taken place. It was faintly acid to litmus in the spring; from these properties it may be inferred that the water was not of a mineral character, the acidity being due to the carbonic acid, partly dissolved and escaped. In Mr. Bartlett's "Personal Narrative," when noticing this spring, the gas is stated to be *nitrogen*; this is a mistake. The water is highly charged with carbonate of lime, held suspended by excess of carbonic acid gas; at the high temperature of the fluid when reaching the surface, the latter is thrown off in bubbles, and the carbonate of lime no longer held in solution is thrown down, to form the sides of the basin. T. A.

both species of rock, and in the syenite the pyroxene mineral is in the form of slender crystals of actynolite. This constitutes the main mass of the mountain, whose line of trend is north 10° east and south 10° west. These syenites are cut through by felspathic dykes and broad veins or dykes of greenstone. This granite axis carries up with it the sandstone strata; the uppermost beds of which, the yellow sandstone, is found inclined on the west side at an angle of 20°, while up on the eastern slope of the Picacho the dip is 40° and 45″. The felspar porphyry dykes, which appear mostly on the west side of the mountain, run nearly north and south, and thus cross the geographical axis. Loose fragments of this mineral are found on the mesa forming the south end of the hill. About 200 yards east of the south end of the hill the trail crosses a dyke of greenstone, running northeast and southwest, about forty feet wide, accompanied by porphyritic felspar. This dyke can be traced northwest into the mountain, up its sides, and almost to the summit; it is not vertical, but appears to take the slope of the sandstone strata, which it covers up, and does not apparently cut across. Southward this augitic dyke can be traced to the Sierra Florida, into which it enters. The eastern flanks of the Picacho are of the red and yellow sandstones and white grit, which appears to be repeated several times by the elevation of the porphyry dykes, which, in conjunction with greenstone, cut up the small hills through which the trail approaches Cook's spring.*—(See plate XIII, fig. 4.)

There are two or three points of interest connected with the Picacho:

1st. Its trend is different from any of those further west, which generally varied between north 45° and north 60° west, while the Picacho runs east of north.

The trail does not travel south of the whole mass of mountain, but takes advantage of a depression in the hill immediately south of its highest point; there a cañon leads by a slight ascent, but tortuous course, across the mountain to Cook's spring.

From the time the Mimbres river was left, fertility may also be said to have disappeared; the fine grass found on the mesa and left bank of the river gradually thinned out, until a sandy, barren trail formed the rest of the route to the Picacho; for 10 miles nothing was seen but fouquieria, palmetto, and larrea. In the cañon, near the spring, good grass, cedar, and walnut trees again appeared, but at the spring itself there was no timber. Osier, three feet high, and bunch grass of a coarse kind, were the only vegetation.

2d. In the appearance of a distinct granite rock, a rock containing mica in small quantity, and syenitic rock; generally speaking, felspathic rock of the varieties of leptynite and perlite have constituted the hypogenic axis.

3d. In the greenstone dykes. Trappean and basaltic dykes and overflows have been dedescribed as forming a large portion of the district along the Gila. East of the Picacho, these volcanic rocks again make their appearance; there is nothing new, therefore, in the appearance of this broad dyke, nor hardly anything surprising in observing the geological connection between the Picacho and the Sierra Florida; but it may be remarked of the dyke, that, in tracing its course up the Picacho, it may be observed running between and separating the sandstones, and metamorphosing them into reddish quartz rock; it has merely insinuated itself between the strata, and has not upheaved them. The upheaval was produced by the granitoid axis, (syenitic rock,) and this upheaval was anterior to the intrusion of the greenstone dyke, for the latter preserves its direction unaltered, whether in the mountain or on the plain; it is therefore posterior in occurrence to the upheaval of the Picacho.

* Underneath the sandstone, and immediately in contact with the igneous rock, lies the blue limestone, reposing at an angle of 28°.

Cook's spring lies at the foot of the Picacho, on its east slope, between a series of porphyritic and trachyte dykes; a hundred yards northwest of the spring is a seam of porphyritic amygdaloid rock, running north and south. The cavities were filled with small nodules of chalcedony. The dykes here run north 12° west, which is the direction of the valley east of the mountain.

The spring lies in a small plain, and is a pool of sulphureous saline water 40 feet wide, which rolls down a short distance before being lost. A reddish quartz rock is abundant, cropping out in the cañon approaching the spring, and in the neighborhood of the latter. It is highly probable that this is nothing more than the red sandstone metamorphosed by the igneous action of the porphyries.

A valley, 15 miles wide, lies east of Cook's spring, in which no exposure of rock appeared; it slopes gently to the south; then commenced a broken ascending country, very rocky, made up of reddish porphyry, amygdaloid protrusions, and basaltic overflows. This country, a jornada from Cook's spring to the Rio Grande, is generally travelled over without stopping, so as to reach water, but is generally, nevertheless, travelled slowly on account of the rugged character of the road. A succession of hills in parallel rows, connecting by cañons, constitute its chief topography; it is a more elevated district, being 900 feet above the Rio Grande level; it occupies a breadth of 20 miles from the plain east of the Picacho to Monument Hill, which itself is a trachyte mass, and forms the eastern margin of this disturbed country. Looking from the west, this region presents a long line of trappean hills, conical porphyry, and trachyte pyramids toward the north, raised from 600 to 1,000 feet above the plain, and extending from north to south 50 miles; in the latter direction it sinks into the plain, which becomes more elevated.—(A section is given on plate XIV, fig. 1.)

East of Monument Hill the plain slopes down to the Rio Bravo, and presents long undulations dipping west. Approaching the valley bottom this plain is found to be an elevated mesa, from 150 to 300 feet above the river, which is descended through small cañons formed by the degradation of the strata, which here crop out at the bluffs. The strata dip west, and are of a similar character to those described—white, yellow, and red sandstones. The rapid disintegration of these produces the large amount of red sand which is found on the trail descending into the bottom, and the heaps of white quartz sand which there, as well as lower down, form in depots in particular parts of the valley. The town of Mesilla is built upon one of these.

The upper sandstone beds of this mesa land are highly gypseous—both crystals of selenite and fibrous gypsum being found abundantly.

The lower portion of the descent was over detritus, which is probably from 60 to 100 feet thick here on both sides of the river, derived from the denudation and decay of the strata exposed, being, therefore, composed of gypseous, arenaceous, felspathic, porphyritic, and trappean pebbles.

The trail from Monument Hill to Mesilla is over a country unbroken by any porphyry or lava intrusion, and but one elevation appears to diversify its surface; this is a conical hill about 800 feet high, opposite the town of Doña Ana, called the Picacho. This is an upheave of compact quartz and trachyte porphyry, which is connected with the hills to the north and on the opposite side of the river. The gypseous sandstones are well exposed at this Picacho and north of it. Carbonate of copper occurs in small quantity in these hills.

The basaltic overflow, which upraises the belt of country between Cook's spring and the river so many hundred feet above the level of the Mimbres and Rio Bravo, is about 12 or 15 miles wide. In its upheaval it has elevated the sedimentary beds in opposite directions, so as to form a synclinal axis, running north and south, the strata dipping east and west toward the middle of the disturbed region. Tracing this overflow northward, it does not appear to cross the river, but turns northwest toward the Copper Mines and the Burro mountains, lying directly north of the axis, where the trail crosses an elevated plain which stretches far to the northeast, north of the Picacho and northwestward from Doña Ana.

The rolling country between this trappean overflow and the river is due to the same trappean disturbances; and the present Mesilla valley and the bed of the Rio Bravo at that locality probably lie in the angle of a fault produced by such dislocation.

This rupture of the sedimentary crust and the dislocation of the strata dividing the latter into so many minor areas, bounded by trappean dykes and overflows, renders the district unprofitable as a means for obtaining water from deep sources, inasmuch as each minor district is thus fed only by the fall of water on its own area; in other words, artesian well borings are not likely to be successful in their result.

Mesilla valley.—The valley bottom, through which the Rio Grande rolls, is made up of alluvium and the finer detritus of the upper country, and varies in breadth from less than two miles in a few places, to nearly six. Through this the river meanders in a serpentine and not always constant channel, changing its banks so as to encroach yearly some feet occasionally on either side, and carrying suspended a large quantity of mud of a fine reddish tint, derived from the reddish sandstone and fine felspathic clays. After freshets, the waters of the Puerco and Galisteo carry down large amounts of mere silicious matters, which are sometimes strewed by overflow upon the lower and fertile bottoms of the valley to the injury of its productiveness; the variability of the force of the current and the body of water carried down leads to a continual shifting of the bed of the river, rendering the fording of the river unsafe, except at points which are rarely the same in different years.

The mesas on the east side of the Mesilla valley are chiefly covered over by this detritus, which overlays the whole surface within a mile of the river bottom; further back the superficial matters are derived from the decay of the underlying strata, and affords soils having but little clay, and either yellowish or reddish as the subjacent sandstone is white or reddish.

These soils lie at the base of the mountains, and for five or six miles toward the river; it then becomes more argillaceous and calcareous, until the thick bed of detritus alluded to, in forming the river bed, is reached.

These deposits are cut through by arroyo beds, and toward the north of the valley expose a layer of greenish sand with silicified wood, belonging to the cretaceous period.

The soil of the valley everywhere is porous, and saturated with the waters of the river, which give it thus a remarkable fertility. Cotton-wood is the only timber on the bottom, but it is much used even in the simple architecture of the towns; abundant crops of grass and roots, grapes, quinces, peaches, melons, and (other) garden vines. The fields are generally without fences, and watered by the sequias led from the river higher up. The soil is a light sandy clay, containing an evident quantity of carbonate of lime. The valley preserves the same fertility and general appearance from Doña Ana down to El Paso.

GEOLOGY OF THE ORGAN MOUNTAINS.

The Organ mountains lie about 14 miles east of the Mesilla valley, and have a granitoid axis, the direction of which is north 12° west.

The range may be about 100 miles long, running over two degrees of latitude; it drops down to the northward, where it forms the hills which lie on the east side of the Jornada del Muerto; there the axis is not apparent, but on the slope of the Pass San Augustine quartzose felspathic rock is found, and from there to the summit syenite, having slender crystals of hornblende and reddish felspar. This syenitic rock crosses the range and appears on the east side of the mountains, further south; on the east foot slope felspathic rock again occurs. But the great mass of the hills are made up of a felspar porphyry, somewhat resembling leptinite, the quartz being white and sometimes crystalline, in a pale flesh-colored felspar; the summits wear irregularly, and present the lofty broad pointed spires which have given them their name, from the fancied resemblance to a Spanish organ. From its structure it appears to be a very modern granitic rock.

A large mass of augitic trap lies on the west side of this porphyritic felspar, and appears to have come up through it. This dyke lies about three miles north of the Soldado cañon; thence, southwards, flesh-colored porphyry is the chief axial rock.

East of Fort Filmore the chain falls down into a range of much lesser height, the hills being made up rather of the elevated sandstones and sedimentary rocks than of the igneous axis. Such are the Chinaman's Cap and a few other peaks visible in travelling down the river. These low hills continue to El Paso, where they cross over to the right bank. The lofty portions of the range are found bordering the Mesilla valley.

Immediately in contact with these igneous rocks is a dark blue limestone, similar in character with that described as the carboniferous limestone of Chiricahui and further west. Near the Pass San Augustine it flanks the axis for 600 feet of elevation, with a dip of 30° to the west a few degrees south; here is a large vein of argentiferous galena, which is worked by Mr. Stevenson, and smelted in his furnace, near Las Cruces, on the river side.

Further south of the pass, along the range, this limestone forms the small hills on the west side, the dip gradually decreasing the further south these strata are examined. East of Las Cruces is a low rounded hill, standing isolated in the plain, about 500 feet high; it is of carboniferous limestone. Between this hill and the base of the Organ mountains no other elevation of rock occurs.

At the western debouche of the Soldado cañon a yellow grit appears, dipping west; further up the cañon the limestone is seen underlying it. In this sandstone is a vein of galena, which was worked some years back merely for its lead; it was not reported as argentiferous. Smelting works were erected close by the mine by Signor Barilla, who opened the vein; a small stream of water close by furnished the means of washing the ore.*

From the extreme red tint of the soil at the western base of the hills it would appear to be underlaid by reddish sandstone. The rock itself, however, was not observed in situ at this place.

On the east side of the Organ mountains the igneous axis is more exposed, the secondary strata not reaching by several hundred feet as high as on the west flank, and have a slope not exceeding fifteen degrees; on this account the strata are not so well exposed as on the west flank. The surface rock is a gypsiferous sandstone, contains veins and deposits of crystalline

* These works were of adobe, as are Mr. Stevenson's. I was not able to visit the old mine at Soldado cañon, owing to several lodges of Apaches being encamped there at the time of my visit. T. A.

gypsum, which in some places had been formerly worked by the Spanish settlers. This rock, probably of the upper trias, rests conformably upon the carboniferous limestone and forms low mesas, at the foot of which the trail to Salt lake travels.

Huge boulders and drift cover up the mesas, and deep ravines worn by the arroyo show the occasional intensity of moving water. The first mesa covered with these rocks derived from the range, imbedded in a reddish soil, extends about two miles from the base of the mountain. Then a second slope descends to the level of the wide plain, which reaches to the Sacramento mountains.—(Plate XIV, fig. 2, exhibits this section.)

A vein of white magnesian (talcose) rock is visible, cutting the porphyritic felspar rock through from the summit of the mountain to the eastern base, at an angle of 55°, and about 20 feet in thickness. In the vicinity of this is an old gypsum quarry, said to have been worked by the Spanish early settlers.

In the axial granitic rock mica is very sparingly distributed, and over large areas wholly wanting, only two ingredients, the quartz and felspar, being present; occasionally a few plates of talc occur, the mass in some places resembling protogine, and in others leptinite. It is scarcely a granitic rock, of which there is no true example in the Organ mountain range. The term felspar porphyry has, therefore, been used to express this species of rock; brownish grey masses, resembling gneissose fragments, are found included, and veins of argentiferous galena cut through this rock; one of these, on the east side of the mountain, about three miles south of Pass San Augustine, has been explored to the depth of nine feet, the vein winding from a half inch, at the surface, to four inches; its direction is nearly S.E. and N.W., almost vertical, with an inclination of 10° eastward.*

The galena vein is, in all probability, the same which is found on the west side of the pass, further north, in which Mr. Stevenson's mine is, and which has thinned out in this igneous rock.

The *Jornada del Muerto* is a valley of elevation; examining it at Doña Ana, its southern outlet, it is found to form a synclinal axis of sedimentary rocks, lying west of the syenitic and felspathic basin, constituting the axis of the Organ mountain range.

The hills north of Doña Ana, which form the eastern boundary of the Jornada, lie close to the Rio Bravo, and have the axis upon the east side of the range; approaching the summit, the carboniferous limestone is met with, not fully exposed; then, overlying the limestone, there is a thin bed of black shale, not more than 50 feet thick; then whitish grit, and above all, forming the summits of the range, reddish sandstone, at least 1,200 feet high. These dip at an angle approaching 20° westward, and, after sinking under the plain of the Jornada, rise on the opposite sides to form a short chain which skirts the Rio Grande northward, the summits of which are 2,400 feet, and appear to be made up almost wholly of carboniferous limestone. The sandstones which form the summits of the western range do not appear to rise up on the Doña Ana range, but, like as in the Organ mountains, form the substratum at the base of the hills. A section of the Jornada is given on Plate XIV, fig. 2.

The thickness of the whitish grit on the western range was 130 feet, and the red sandstone might have been 300 feet; it was much disintegrated.

The carboniferous bed could be better estimated on the eastern side of the Jornada, where it appeared to be from 1,000 to 1,200 feet on the Organ mountains. It showed a greater thickness north of San Augustine Pass than at any point where I have seen it.

A review of the structure of this range is given on page 166.

* Those gneissoid fragments are very different from true gneiss, and from the masses found included in the Cordilleras near Vallecitas; they are, perhaps, segregated masses of granitic mineral nucleating the hornblende or micaceous elements collecting in isolated patches.

CHAPTER XXIII.

OF THE MOUNTAIN SYSTEMS.

REMARKS UPON.—PINALNEO MOUNTAINS, PARALLEL RANGES.—GEOGRAPHICAL EXTENT.—CLASSIFICATION OF THE STRATA.—IGNEOUS ROCKS.—AGE OF THE RANGE.—MOGOLLON MOUNTAINS.—INTERVAL BETWEEN IT AND THE FORMER RANGE.—GEOLOGY OF.—IGNEOUS AXIS, IMPORTANCE OF.—OF THE LESSER RANGES AND ISOLATED HILLS BETWEEN THE SAN PEDRO RIVER AND THE COLORADO DESERT.—ORGAN MOUNTAINS, EXTENT, DIRECTION, AXIS.—STRATIFIED ROCKS OF.—CARBONIFEROUS LIMESTONE.—MINERALS OF.—EAST SIDE OF THE RANGE.—JORNADA DEL MUERTO.—RELATIVE AGES OF THE IGNEOUS ROCKS OF THE SYSTEM.—OF THE SANDSTONES WEST OF THE ORGAN MOUNTAINS.

SINCE observation in Europe has shown that the direction of the upheaval of mountain systems is a key to ascertain the epoch of their elevation, it becomes a duty in explorations upon this continent to try how far observations upon American mountain chains may afford the clue to their relative antiquity; but little, as yet, has been done here in this field. M. E. De Beaumont, who has applied the observations so successfully to France and Mediterranean Europe, having developed by his observations over 30 systems of elevation of different antiquity, has himself classed the Alleghany mountains in the systems of the *Ballous* of France, his second oldest system; and the ranges at Keewenau and Cape Blomidon are classed with that of Morban, in France, the fifth series of elevations. Other analogies are not yet admitted. Without endeavoring to ally the ranges of this country with those of Europe, and strive to form parallels where the resemblance is but remote, it may be useful, notwithstanding, to place by themselves the observations and generalizations made upon mountain ranges, and from the material form a system of continental elevations.

Throughout New Mexico the direction of the ranges are north and south. Those to the east, on the elevated plateau, running only a few degrees west of north, and those to the west diverging N. 45° W. to N. 60° W.

Those which are more conformable to the meridian are generally longer chains, while those running N.W. and W.N.W. become isolated ranges, or a chain of unconnected hills, which, however persistent in their linear direction, may yet be travelled round, owing to their isolated position. The Mogollon mountains are the only known exception to this rule. There are no ranges in the territory running east and west.

The hills crossed on the route were the ranges at the cañons of the Gila and at the mouth of the San Pedro river; these have been called here the Pinaleno mountains. East of these are the foot hills and outliers of the Mogollon mountains, and west of the Pimas villages are the Estrella hills and some isolated ranges of small importance. East of the Rio Grande lie the long chain of the Organ mountains. These will be considered in the order enumerated.

PINALENO SYSTEM.

The Santa Catarina mountain, the Sierra Calitro and the Pinaleno hills may all be classed together as one mountain system, as well from their proximity as their geological constitution. These ranges occupy a large portion of southern New Mexico and of the newly acquired territory south of the Gila, commencing in longitude 112° west and extending to 110°, and running obliquely north and south from latitude 31° 40′ to 33° 40′ N.

The Salinas river skirts around the northern border. The Gila river cañons across the whole series of ranges, on parallel 33°, and the San Pedro runs between the two western ranges from south to north. The three ranges run parallel during their entire course, preserving a pretty uniform direction of N. 45° W. and S. 45° E. The granitic axis lies to the west, constituting the Santa Catarina mountains. Basalt outpourings are on its eastern and western flanks, and on the eastern slopes are immense overflows of trachyte and porphyry, which have not only perforated and intermingled with the granite rock, but by forming rents and fissures and injecting fluid mineral into the sandstone rock has metamorphosed it completely. An analysis of the trachyte of this range is given in the chapter on chemical analysis. The rock was reddish felspathic rock, with crystals of quartz disseminated throughout.

The same trachyte is found extensively in the Sierra Calitro, but the great mass of this latter range consists of the secondary rock upheaved; Devonian sandstones and conglomerates, resembling in lithological character the Caatskill sandstones, with metamorphic quartz, constitute the lower portions of the mountain, which has a thick stratum of limestone capping the Devonian rock. Trachyte and amygdaloid rock are injected in some places, and forms capping and intruded beds in others.

The general dip of the strata of these hills is to the east, or rather east 12° south; but they are broken, and dip variously in places. The sandstones are very thick, and are in contact with primary rock, either granitic, lamellar, feldspar, or trachyte.

The Pinaleno range (properly called) forms the third and the most easterly of the system. This range is the loftiest and the most important of the three; in it lie Mounts Turnbull and Graham, Chiricahui mountains, and the Guadalupe range; the two latter are locally unconnected with the northern range, but they lie in the same trend, and have the same structure, and are, therefore, geologically one. The whole range has a central granitic axis of great breadth, (ten to twelve miles,) upon which lie conformably the Devonian and lower carboniferous rocks. The same sandstones and limestones which were seen on Calitro are here, the sandstones less displayed, the limestones more perfectly. Of the age of this last rock there could be no doubt, from the *productus* and encrinal stems so extensively distributed; it is very argillaceous in composition and highly metamorphic, passing into a fine saccharine marble in places. Trappean and serpentine rocks are found in this range, the latter being auriferous.

As the cretaceous strata of the San Pedro valley lie unconformably between two ranges of this system, it appears that the whole was elevated anterior to the cretaceous period. There are no rocks of the later carboniferous period found, nor do the sandstones of the Permian epoch, which are found east, appear in this range. Such may exist on the lower slopes of Chiricahui, hidden, perhaps, by the clays and gravel, in which case their elevation would not date further back than the Jurassic period. Since their elevation and the deposition of the unconformable cretaceous beds the whole western portion of the system was subjected to the action of a heavy current, depositing the conglomerates, which are found in the south of the San Pedro valley, from 80 to 130 feet thick, a deposit which is not found further east, but to the west may be traced to the very slopes of the Cordilleras, and occupying the sides of every hill of any elevation in the intervening space.

Limestone, serpentine, and porphyries are the chief rocks of the eastern range, and granite and sandstones of the west. The minerals are few—marble in Chiricahui, and gold in the serpentine of that range, and in the conglomerates of the Calitro and Santa Catarina. Veins of argentiferous lead ore might, if looked for, be found in Chiricahui, since it exists in the same rock east.

During the series of elevations which finally uplifted this entire range to its present altitude, the upheaving force must have been exerted even upon the southern portion of the range, raising the table land of northern Sonora and Chiricahui to so great a height. This strain may have produced a fissure from east to west, or cracked, and perhaps depressed, the strata along parallel 33°, and thus enabled the Gila to take that as its permanent course. Some such catastrophe must have occurred ; for it is scarcely probable that the river, unaided, could have cut through such lofty hills and hard rock as it appears to have done in its passage through these mountains, running, as it does, at right angles to the strike of the ranges.

The valley east of the San Francisco river separates the Pinaleno mountains from the western ranges of the Mogollon and Sierra Blanca hills. The table land on which these ranges are placed varies from 3,000 to 4,000 feet, and the summits of the highest hills reach 6,000 and 6,400 feet above the sea level. Mount Graham is the loftiest mountain in the entire system.

MOGOLLON SYSTEM.

The Mogollon mountains lie north of the Gila river, and east of the San Francisco, one of its tributaries. In this region, by many heads, the Gila rises, and from it it derives five-sixths of its whole volume of water. They are a lofty series of mountain ranges, between 108° and 110° west longitude, and 33° and 35° north latitude, lying north and east of the Pinaleno mountains, with which they have been confounded. But the different trend of the ranges show that these two series of mountains are distinct from each other, the dividing line of which upon the Gila is between the rivers San Carlos and San Francisco. The Pinaleno ranges run more north and south, never exceeding N. 45° W, while the Mogollon ranges run more east and west, and have an average trend of N. 65° W. and S. 65° E., or nearly twenty degrees more east and west than the former range.*

Little of the country embraced within these limits is known to white men ; it is the country of the Gila Apaches, where they have their strongholds and their lands of cultivation.

The Sierra Blanca range, which lies the most eastward, is very lofty, and, viewed from the north, appears to have an east and west strike.

The rocks which enter into the composition of this great mass of mountain, are whitish felspar granite, and amphibolic granite, metamorphic quartz, old red sandstone, and, according to Mr. Marcou, magnesian grits of the carboniferous system, magnesian limestone, and trias beds.

They are a very lofty range of mountains, reaching to an elevation of 10,000 feet in many of their summits. Snow is seen upon these for many months of the year, the meltings of which give rise to the Gila, and form the Salinas, which joins the Gila lower down.

The snow-capped region, thus yielding water during the summer months, is the cause of the fertility of the mountain vallies in the range, producing fine grass and corn to the Indians.

The ranges of hills which lie between the Santa Catarina range and Fort Yuma, and round which the Gila travels in its course westward, are of lesser importance than those enumerated. With the exception of the Sierra Estrella west of the Pimas plains, and east of the jornada,

* Mr. Marcou, in his geological chart and sketch, (report to the Geological Society of France,) describes the Mogollon mountains as extending from longitude 108° to 114° W., and throughout having a dip of N. 60° W. This is erroneous; it makes the Mogollon mountains occupy a district much larger than it actually does.

they are all lone hills, lying northwest and southeast, or nearly so, and have a trachyte or porphyry base, with metamorphic quartz and conglomerate lying conformably upon them. These strata dip southwest at a small angle, and in places vary from 100 to 300 feet thick. The conglomerate is in places a solid, coherent rock, while in others it is almost a loose gravel. This incoherent bed is usually horizontal, or nearly so, upon the igneous rock. Much of the Sonora desert, in its north extremity, has its surface of this stratum, and may, in part, owe its sterility to this loose and porous bed.

On Big Horn mountains it is solid, and resembles, lithologically, the conglomerate on the east slope of the Cordilleras, which is admitted to be tertiary; if so, these are most probably tertiary; but as no opportunity presented of comparing them with any well known contiguous beds, I have hesitated to assign them any other name or place than that of desert conglomerates. Should these be classed as tertiaries, there would then be presented a curious fact, the absence of palæozoic strata from the Sierra Santa Catarina to the Sierra Nevada or the Cordilleras.

This deep valley trough, where examined, shows gravels and tertiary stratified beds lying unconformably to the granite rock, with which they are in contact, but possessing no formation of earlier date than the Eocene period.

This holds good along the travelled route over the Colorado desert and along the lower portion of the Gila, where the granites are upheaved every twenty miles, intruded by trachytes and lavas, without any secondary rock until the Devonian sandstones of the Calitro hills are reached. In the Mojave valley, however, a mass of metamorphic limestone was met with upraised by a porphyry protrusion. The calcareous rock was probably of secondary formation.

Many of the lesser hill ranges just adverted to pass north of the Gila, and continue their northwest course until they reach the Colorado or the Santa Maria, cutting up that otherwise plane and desert country by a series of isolated ridges similar to those on the Sonora desert to the south.

GEOLOGY OF THE ORGAN MOUNTAINS.

Reviewing the structure of the Organ mountain range and the valley of Mesilla, it appears that the central axis is of felspathic and syenitic rock, cut through by trap and porphyritic felspar, and that the earliest sedimentary rocks found are the limestone and grits of the coal period. The limestone, full of encrinital casts, with a few moulds of productus and posidonomya, lies in immediate contact with the syenitic rock, and conformable to it.

On the Mesilla valley side of the Organ mountains, the order and thickness of the beds met with are:

Syenite and porphyry (leptinite.)
Limestone, 1,000–1,200 feet.
Yellowish grit, } In valley—covered by cretaceous sand and alluvium.
Red sandstone, }

On the other side of the basin, at Doña Ana, there is met:

Porphyry and leptinite.
Limestone, 1,600 feet.
Black shale, 50 feet.
Yellow white grit, 130 feet.
Reddish sandstone, 300 feet.

The black shale found on the Doña Ana range was not observed at the Organ mountains; as the limestone was the only rock elevated above the plain, it is probable the shale was covered up. Small masses of coal have been observed in the arroyo beds leading from the range, and have been tried in fires at Fort Fillmore, and are said to burn well, although ashy. This has led to the belief that a coal seam exists in the range. I have examined the shale beds without being able to find any seam or any specimen of plant impressions; from which failure, as well as the thinness of the shale, it is scarcely likely that a productive coal seam exists there.

The proximity of the Mesilla Picacho (although on the opposite side of the river) to this range, which is chiefly a trachyte and porphyritic upheaval, leads to the belief that it is connected with it, and is the southern continuation of the range; however this may be, there is at the river bed a great dislocation of the strata, raising the red and white sandstones of the right bank of the river two or three hundred feet above the level of those on the left bank. The river appears to have taken this angle of depression as the most suitable for its bed, and follows this line for thirty-five miles south, until the Organ mountain range touches at the El Paso, and constitutes the pass through which the river drops, forming rapids having a descent of twelve feet in one-half mile, advantage of which Mr. S. Hart has taken to establish a grist mill, whose prime mover is a turbine. The rock over which the rapids flow is the limestone, which towers on each side of the river in hills nearly 1,500 feet high.—(See Plate XIV, fig. 3.)

It is in this limestone that the vein of argentiferous galena already alluded to occurs; the gangue stone investing it is quartz, with sulphate of barytes and the associated minerals, phosphate and carbonate of lead, with some sulphuret of copper. The ore is described and its value estimated in the chapter on Chemical Analysis.

OF THE STRUCTURE AND AGE OF THE IGNEOUS ROCKS IN THE VICINITY OF THE MESILLA VALLEY.

Within a breadth of twenty-five miles there are three distinct species of igneous rocks, viz:

1st. The granitoid rocks of the Organ mountains.

2d. The porphyritic rocks of the Doña Ana, the Picacho, and the Monument Hill.

3d. The trappean and basaltic lavas of the belt west of the Monument Hill.

The granitoid rocks are the syenite and leptinite, which compose three-fourths of the chain. This must be looked upon as the most ancient of the whole, although not an ancient rock.

The porphyritic rocks are mostly trachytes, are destitute of hornblende or mica, and are mostly of reddish felspar, with minute glassy crystals of quartz. This variety of rock, very commonly found from the eastern edge of the Cordilleras, I have not seen east of the Sacramento mountains, Texas, though evidently in a much more viscous state when upraised than the granitic rock, yet they, with the exception of the Peloncillo hill trachytes, can scarcely be accounted a lava.

The trappean rocks are distinct lavas; much variety in the augitic basalts is met with, in respect to their physical condition, being found as compact trap, passing by various shades into cellular lava. Olivine is a constant constituent of all these trappean rocks in the central plateaus and their mountains. The wide vein of trap, in the Organ mountains, appears to have cut its way through the leptinite. The basalt of the plains west appears merely to have bent up, cracked, and forced through the strata, but not to have upheaved them. The upheaval appears to have been already affected by the porphyritic range of Doña Ana, which uplifted the Picacho. If this be correct, there are, probably, then, three distinct periods of disturbance in this district:

1st. The elevation of the Organ mountains.

2d. The elevation of the Doña Ana range.

3d. The trappean disturbance.

The first and most ancient of these, the upheaval of the granites of the Organ mountains, and other chains, must have occurred posterior to the Triassic or Permian (or Seral, of Rogers,) period. Perhaps most of it occurred between then and the cretaceous period, although, from the slight western slope of all cretaceous beds in this region, there was some further and final elevation since the latter deposit; which final uplift may be, as stated further on, attributable to the trap overflows.

The second, or the outpouring of the trachytes, occurred anterior to the third, as the latter, in many places, cuts through the red felspathic amygdaloid and trachyte.

The third, the trappean elevation, occurred posterior to the cretaceous period, and anterior to the general deposit of the tertiary conglomerates and sandstones, which contain many pebbles of these volcanic rocks.

AGE OF THE RED SANDSTONE WEST OF THE RIO GRANDE.

I had at first classed the reddish sandstone found in the Mesilla valley, and west to the Rio Mimbres, as an upper member of the carboniferous formation. I did this with some hesitation, as, in lithological character, it differs considerably from the texture common to the sandstones of the coal measures. It is of a bright brick-red color, fine grain, and, to the careless eye, homogeneous in texture. Under the lens, earthy white spots are observed, intermingled, composed of rounded grains of vitreous and opaque quartz, with minute spots of a black mineral. The rock is porous, and, though not friable, easily comminuted.

When pulverized and elutriated, the coarse parts examined by the lens exhibit the reddish fragments as angular, rough, felspathic particles; the black minute specks are small portions of amphibole which are disseminated through the red felspar. The quartz fragments are rolled grains of quartz.

The red particles, treated with hyrdocloric acid, partially dissolved, have the color removed, (produced by peroxide of iron,) leaving the insoluble residue chiefly consisting of amorphous, fine clay, (silicate of alumina.)

There is no trace of carbonate of lime or magnesia in the sandstone.

From its texture and chemical composition, it is a sandstone derived from the decomposition of the red, felspathic igneous rocks, which constitute the axis of the upheaved districts west of the Rio Grande; a granitic porphyry rock, which is fouud extensively diffused in the cañons of the Gila, at the mouths of the San Pedro, and along the sides of the Sierra Calitro and Mount Graham ranges, and to which allusion has already been made.

On account of its conformability with the whitish grit, and the bed of shale at the Horse mountains, northeast of Doña Ana, both of which it overlies conformably, it might be classed among the coal measures, looking upon the bed of shale as one of that series. The shale is dark colored and semi-bituminous, but nowhere could I observe any fragments of plant impression to indicate their age. The bed of shale, which is here thin, I have not been able to trace to the west. Although the limestone can be found in the valley to the west of Chiricahui mountains, and at the various exposures of it and of the white and red sandstones, at the Pichaco de los Mimbres, the Rio Mimbres, and at Ojo de la Vacca, I have nowhere seen the underlying shale; it may be that the elevation of the grits is not sufficient to bring the shale into view.

From its dissimilarity to the carboniferous grits, I incline to separate the red sandstone from that series, and would class it with the posterior deposits—the psamerythic, the lower new red sandstone of English geologists, the roth-todt—liegende of Thuringia, the Gres rouge of the peneën bed of France, and from its composition "roches a psephitis," by Cordier.

The minerals associated with this rock on tnis latitude—gypsum and rock salt—which effloresce on the degraded surface of the horizontal beds, refer it also to this place.

Further north in the Territory, Mr. Marcou has met with similar rocks, and classed them along with the red clay rocks east of the Rio Grande, including the whole under the term Trias. I am inclined, however, to the opinion that this bed is older than the trias, and lithologically on parallel 32°, it certainly bears no resemblance to the sandstones of Texas, with the exception of the bed of greenish ferruginous sand found between Doña Ana and the Horse mountains, already alluded to, lying unconformable to the elevated sandstones; there were no strata of cretaceous rocks exposed. This bed was observed by chance, while keeping up a dry creek bed to reach the hills at a favorable point. The creek had worn its way some 25 feet deep below the general level, exposing below the alluvial covering, which was a brownish sand 5 to 6 feet in thickness, a layer of greenish sand ferruginous and crumbling under the finger. The bed was horizontal; a depth of 16 to 20 feet was exposed, but its bottom was not reached; a layer of silicified stems lay horizontally in the sand about six feet below the upper surface, and a second layer eight feet below the first. Many of these had been washed out and carried down the creek bed. The wood was of various sizes, from an inch in diameter to six inches, and from six inches to two feet long. Most of the specimens had the external configuration of an equisetum. As this horizontal stratum lay on the upper terrace, or the mesa east of the Doña Ana, it can scarcely be supposed to dip under the river, which lies one hundred feet below. The present bottom of the Rio Grande being well defined on each side by an abrupt ascent from it to the mesa, the river may be supposed, therefore, to have worn its way through and removed this bed, leaving only these slight traces now observed on the upland.

The silicified stems gathered here were lost in the subsequent transportation.

CHAPTER XXIV.

OF THE PERMANENT SUPPLY OF WATER, AND OF THE FEASIBILITY OF OBTAINING ABUNDANT SUPPLIES BY ARTESIAN BORINGS.

Only a portion of the route deficient in the supply of water.—Extent of this district.—Geological summary.—Meteorology.—Region of summer rains.—Elevation of the district.—Annual fall of rain.—Causes of the diminution of rain westward.—Quantity absorbed by the soil.—Contrast of a north temperate and an inter-tropical zone.—Substitutes for artesian wells.—Water tanks.—Ordinary wells.—General conclusions.—Localities of natural supply on route.—Cook's spring.—Rio mimbres.—Ojo de la vacca.—Valle del sauz.—Playa de los pimas.

Along parallel 32°, the *shortest route* by which the Pacific can be reached, the difficulty of obtaining water is one which is shared in common with any other travelled road over the continent more northward, and a difficulty which, regarding the route itself, may be obviated.

It is only over a portion of the route in which the deficiency of water is felt; it is to this locality only that attention will be directed, and if it can be shown that in these less favored districts a sufficient supply of water can be had the argument applies *a fortiori* to the whole route.

This district is comprised between the Rio Bravo and the San Pedro, a distance of 253 miles; is not traversed by any large river, nor subject to a large fall of rain; to arrive at any conclusions concerning the facility of obtaining water sufficient for railroad wants, two classes of circumstances will require to be noticed.

1. The geological conditions.
2. The meteorological conditions.

1. Geological. A detailed description of the structure of the region has been given, and the sections appended illustrate the description. It is unnecessary, therefore, here to state more than that the first 85 miles west of the Rio Grande is broken up by basaltic upheavals and overflows; that from Cook's spring to Peñascitas succeeds a district which, though not so broken, is yet traversed by porphyry upheavals, producing faults, and having horizontal strata only over very small areas, so small as not to be conveniently tapped.

The elevated lands of Peñascitas and Ojo de la Vacca are the foot hills of a chain of igneous rock, (Burro mountains,) which lie northward. These lands are the dividing ridge of the waters of the continent along this parallel; those on the east running southward into the Gulf of Mexico, and those on the west rolling north (via the Gila) into the Gulf of California.

West of these elevated lands the country drops by a succession of troughs or valleys, separated from each other by short unconnected ranges of felspathic and granitoid rock, running N.N.W. and S.S.E. These valleys or flats have their rock basis of carboniferous limestone and overlying sandstones, and are four in number:

1. Small valley, with lagoons.
2. Valle de los Playas.
3. Valle del Sauz.
4. Playa de los Pimas.

The two first may be looked on as one valley. The two last have the lower mountain limestone and the Devonian sandstone conglomerates resting on primary rock. In these valleys the geological circumstances are eminently favorable for artesian boring, and there water might be had at 300, 500, or 600 feet deep, according to the distance selected from the margin of the basin, provided the climatal conditions were favorable; east of these basins the country is too much broken up by faults and dislocations to be available for ordinary artesian wells.

2. The meteorological conditions may be thus expressed:

The region lying between 30° and 33° north latitude is one of summer rains; within 100 miles of the Cordilleras it is a rainless district; but along parallel 32°, when it does rain, it is only in summer. This, of course, applies only to the country between the Sierra Nevada and the Rio Grande, for in west Texas, under this parallel, it is a district of autumn rains, and between the Sierra Nevada and the coast it is a region of winter rains.

The elevation of the district is as follows:

Fort Fillmore, on the Rio Grande, altitude	4,000 feet.
Basaltic belt and porphyritic district, average for 105 miles	5,000 feet.
Small basin district, 130 miles	4,000 to 3,000 feet.

From the last level, 3,000 feet on the San Pedro, the land falls until the junction of the Gila and Colorado is reached, when it is only 105 feet above sea level.

The elevation of the mountain tops are:

Summits of the Organ mountains	7,000 feet.
Chiricahui, or Mount Graham range	6,800 feet.
Sierra Nevada, on parallel 32°	6,500 feet.

In the two first instances the mountain tops do not exceed 2,000 feet above the plain, and, therefore, constitute but small points of attraction to rain clouds. The Sierra Nevada, on the other hand, is elevated nearly 6,000 feet over the district, immediately to its east, and hence becomes an impassable barrier.

The annual fall of rain over the district is thus distributed:

Annual fall at Fort Yuma under	3.00 inches.
Annual fall at Fort Fillmore, mean of three years	9.23 inches.
Annual fall at Fort Bliss, mean of three years	11.21 inches.

Forts Yuma and Fillmore are the extremes of the line. Fort Bliss is inserted to show the difference which a position 40 miles further south produces. The rain is accompanied by south winds, generally from the southeast or along the course of the Rio Bravo, but occasionally from the southwest. From the Rio Bravo the rain fall diminishes toward the west, until it is almost nothing upon the Colorado desert.

The rains at San Diego have no relation with those at Fort Yuma, although both places be in the same latitude, and only 220 miles apart, the mountain chain of the Cordilleras altering the climate of the two stations.

The cause of the diminution of the rain westerly may be due to two causes: 1st. That as the rain clouds come from the east, in passing over the district, they gradually become drier; and 2d. As the district west of the San Pedro gradually drops toward the Pacific, and thus becomes more heated by the sun's rays, the rain clouds are not condensed, but are raised further up in the atmosphere by the heat of the lower regions. In the Colorado basin clouds from the south were frequently seen drifting north, and when nearly overhead, gradually breaking up, and being dissipated under the immense heat of the plain. The difference in amount of rain fall between the two extremes, Forts Yuma and Fillmore, is $7\frac{1}{2}$ inches, which is spread over 650 miles, or $\frac{8}{10}$ of an inch of rain for every hundred miles, supposing the fall were evenly distributed; but it is scarcely to be expected that the distribution of rain is equal, or that it lessens equally over equal areas; for the elevated land is all toward the east, and receives first the saturated air, and would necessarily condense a larger proportion than an equal extent of elevated land toward the west; much more does it condense since the western district is so much lower; so that within the eastern half, or 325 miles, near the Rio Bravo, perhaps two-thirds of the total fall of rain is concentrated; in other words, it might be hypothecated that—

Within the first 350 miles, the fall would be from............... 12 to $5\frac{1}{2}$.
While within the second 300 miles, the fall would be from...... $5\frac{1}{2}$ to $2\frac{1}{2}$.

We can never reckon on the total fall of rain over a district as the quantity available for a subterranean supply. Arago tells us that not more than one-third of the rain which falls sinks into the ground below one foot; and in latitude 52°, in Great Britain, it has been found that it is only the rain which falls in December, January, and February, which can be counted on as feeders to springs—then, only in the coldest months of the year, can the rain sink seven feet into the clay, and be thus removed from the immediate effect of solar evaporation; in latitudes more south, a further depth must be reached to avoid evaporation, and, in parallel 32°, the depth cannot be less than 12 feet; it is not, therefore, one-third the total annual fall which forms the subterranean reservoir, but one-third of the quantity which falls in the three months when evaporation is least; the total fall, during this period, is 18 inches, and six inches is the available amount for wells and springs, or one-sixth of the total fall.

An amount approximating this obtains over our north temperate zone, where the fall of rain is moderate (36 to 40 inches) and evaporation not excessive. But under parallel 32° it is widely different; there, while the winter months are cool, so as to freeze water, little, if any, rain falls, and that only above the plain level; but when the mean temperature is from 75° to 90° the rain falls at the time when evaporation is the greatest; so that the chance of much water sinking down 12 feet is greatly lessened.

According to the experiments of Dalton, and the tables of Daniel, it appears that at the temperature of 70° Fah., and during a calm, three times as much moisture is evaporated as at 40° Fah. These figures being the average temperatures of Virginia and the Gadsden purchase, during the period of available rain fall, it would appear that while evaporation is three times greater, the fall of rain is considerably less than one-half, almost one-third, in the latter mentioned place. This would give at the eastern portion of the Gadsden district 2 inches of rain available for wells and springs, and at Fort Yuma one-third of an inch.

This ratio is a very small figure to depend upon at the western limit, and it is fortunate that there the travel lies along the river Gila, and thus is rendered independent of that scanty supply. Chiefly for the reason given, (the great evaporation with the small rain fall,) and partly because in the eastern limits there are no strata of small inclination, (except the basin districts, which are not broken up or much disturbed by plutonic forces,) I have come to the conclusion that *sinking artesian wells is unadvisable between the Rio Grande and Fort Yuma.*

The experiments made in artesian borings in Europe and this country have been made (with a single exception) in north temperate latitudes, and none south of parallel 36°. Inferences drawn from such results, and applied to the interior of a continent, under latitude 32°, must be erroneous, unless the considerations to which I have alluded be attended to.*

Nothing is more common than the loose verbiage in the mouths of many, that, the geological circumstances being favorable, artesian wells are possible to be produced.

This may be true in north Europe and along our Atlantic coast, where the rains are constant, and to a high figure; but it is not true in the Gadsden Purchase, because the climatal relations approach that of the tropical zone.

An objection may be raised to the arguments advanced and the conclusion drawn, based upon imperfect observations of the climate. It may be said that the registers of Fort Yuma, and those on the Rio Grande, afford no index of rain fall of the country between these points, and that, as the country inland is more elevated, it is but reasonable to suppose that a large supply of rain does exist. The reply to this objection is, that no matter how ignorant we may be of the actual rain fall, as estimated by a rain gauge, yet that there are always evidences sufficient in the district furnished at once, and visible at a single inspection, which can lead to an approximation of the actual fact. These evidences are, the appearance of the water-courses, and the character—the species—of the vegetation natural to the district.

If the water-courses be short, if the bed be rugged, filled with large stones, washed out from above and impacted in gravel, and if it suddenly terminate by opening upon plain land, and does not empty into another channel or river bed, then it is the course of a short and tumultuous body of water, collected together suddenly, and rushing along in a mass, and not in a continual stream—it is a torrent and not a river. It does not signify how deep the sides of the water-courses are—these do not indicate long continued and low action; a small creek, suddenly emptying into the Hudson river below Newburg, has (in 1852) in one night excavated a bank 60 feet deep; it is but the evidence of force or power of water, but not of its actual quantity, or of its continuance of action.

Especially is this true where it does not empty into a larger stream bed; it shows that the total quantity has been too small to prolong it into a stream. Numberless are the arroyos or creek beds of this character, which give out, or lead to nowhere.

Again, with regard to the evidence derived from vegetation. This is more certain than the other. Let us consider a district which has no subterranean supply of water, and wholly dependent upon the rains. Suppose such a district to be wholly destitute of vegetation, the observer would infer either of two things: 1st, that no rain at all fell, or that it did not fall at the time favorable to vegetation. The first supposition is improbable, as we know there are few places on the globe where some rain (slight though it be) does not fall; and it is not true of any locality on the route, for in some of the most barren localities the arroyo beds were found; and in others, as the playas, the surface was ripple-marked by superjacent water. With regard to the second supposition, that it did not fall at the favorable time to benefit vegetation, it may be worth while to inquire into its meaning: Is there any time peculiarly favorable to vegetation? are plants so obstinate, and such formalists, as to grow in exact months in spring time when it does not rain, and refuse to grow in summer when it does?

Our knowledge of vegetation shows that plants will grow when the supply of moisture in the ground is sufficient to carry the food it requires in a liquid state to its roots; it cannot grow until after some rains, nor mature itself until after more; and that, let it be supplied with

*The artesian borings, as they are called in California, are not cases in point; they are, in fact, not artesian wells, but simply deep clay borings.

moisture sufficient, it will continue to grow for the whole term of its life, independent of month and season, converting the annual of the north into biennials and perennials further south.

It is, therefore, to the sufficient supply of *water in the soil* that the growth, whether at the outset or in continuance, takes place. The fall of rain does not influence this growth, except in so far as it saturates the soil. Hence, when we say that a fall of rain does not occur at the time suitable for vegetation, we mean that the rain fall does not sink into the earth—that it is either wholly or mostly evaporated by the excessive temperature. If this be true, the rain fall is not sufficient to supply depots of water for artesian borings. Thus the absence of vegetation is an evidence of a deficient supply of water.

Now, when irrigation is applied to those plains susceptible of supply from rivers, the thorny vegetation disappears. The obione, the larrea, artemisia, fouquieria, and the pitahaya, all are removed, and the mesquite, the willow, the cotton-wood, and other grasses supply their place; and so universal is the occurrence that the observing traveller can at once tell what is the hygrometrical condition of the ground, or subsoil, by an examination, at a glance, of the superficial growth.

From frequent observation, when travelling over this route, I have constructed the following table, which gives an approximate estimate of the value of vegetation, as an indication of the moisture of the subsoil:

1. Subsoil saturated with standing water—Tule or Carrizo, (Arundo phragmites; A. tessaria.)
2. Moving water, with pools—*rushes*, (Juncus;) willow, (Salix.)
3. Surface soil moist—Plantago, cotton-wood, (Populus monlifera.)
4. Six feet above river level—Cedar, (Juniperus;) dwarf oak, (Quercus;) walnut, (Juglans;) bunch grass.
5. Fifteen to 30 feet above river level—Mesquite, (Algarrobia;) *screw bean*, (Prosopis;) tunal, (Opuntia.)
6. Above 50 feet—Maguay, (Agave Americana;) yucca, Spanish bayonet, (Palmetto;) gramma grass, (Bouteloria.)
7. Where the foregoing plants disappear on level plains—Creosote plant, (Larrea Mexicana;) stink weed, (Eriodyction;) grease wood, (Obione canescens;) wild sage, (Artemisia.)

On elevated granitic soils—Pitahaya, (Cereus.)

In the most arid soil—St. Joseph's rod, (Fouquieria.)

Thus it is derived from observation that, by an inspection of the vegetation, we can form an estimate, not of the exact fall of rain, but of the moisture of the soil—that is, of the rain fall, which is available for wells and springs—and thus the conclusion, drawn in the absence of information derived fom the rain guage, is not likely to be far from the truth, or to lead to any great error in practice; for had sufficient rain fallen over and above evaporation on level plains, it would be elevated by capillary action to supply a new vegetable growth.

As for the water supplied by melting snows descending from the summits of lofty hills, and sinking between the strata and at the base, along the parallel examined, where there are lofty ranges, as the Organ mountains, Mogollon mountains, and the Pinaleno hills, there are also rivers formed, as the Rio Grande, Gila, and San Pedro; but as for the smaller chains, as Chiricahui, and others of less note, the quantity of snow collected is much less, and merely waters the cañons of the ranges; and by the time the stream has passed to the edge of the plain, it is dwindled down to an insignificant thread, which is lost by evaporation.

In thus condemning attempts to obtain water by artesian borings for railroad purposes, I do not wish to be understood decrying the district as incapable of supplying enough of that needful liquid; quite the reverse. There is enough and to spare, provided it be taken when it is supplied and stored away when it is abundant.* Large tanks and reservoirs, sunk into the ground, well built, cemented and covered over with frame work, so as to prevent evaporation, is all the apparatus needed to obtain plenty water. The various rivers and creeks, whose channels are full for a few weeks in the year during the rains, afford a large quantity of water, which might be tapped by open drains or sequias leading to these tanks, and their water thus saved at the moment of its fall. The Mimbres river, the Sauz brook, and the Ojo de la Vacca, might be thus treated. The surface waters which collect on the playas, which are often several inches deep by an area of a few square miles during the early weeks of autumn, might be appropriated also, and a sufficient supply kept at each station to last until the ensuing season.

Thus, by such means, at intervals of fifty miles apart, large supplies of water might be had along the route; and by adopting the same care and preservation of the water reservoirs, (for in these latitudes the water does not become fetid,) which is evinced in Egypt and Arabia for their wells, the continent might be crossed with comfort at any period of the year.

The thick clay beds which are spread over some of the Playa bottoms occasionally serve to retain large bodies of water beneath their layers. Sinking ordinary pumps or chains and bucket wells is called for, and small supplies could be thus obtained at lesser intervals, which would supply the minor wants of wayfarers.

The results of observation and reasoning appear to be these:

1st. The fall of rain small in amount, and during summer does not afford a sufficient supply to justify sinking artesian wells to any great depth in the region under discussion.

2d. But the fall of rain is sufficient for all viatic purposes, if it be secured when or shortly after its fall, and preserved in covered tanks.

3d. The clay springs found in the valley bottoms show that ordinary wells and pumps might with advantage be sunk.

Localities of natural supplies of water.—These are along the route: Cook's springs, Rio Mimbres, Ojo de la Vacca, Ojo de Inez, Valle de las Playas, Valle del Sauz, and Playa de los Pimas.

In describing in detail the geology of the route, those localities have been already described. They are now noticed again in their capability of yielding water.

Cook's spring (page 159) belongs rather to the class of wells than of springs. Its basin of supply is very small, being derived from the alluvial covering of the eastern slope of the Picacho de Mimbres; its sources are not subterranean, nor, considering the dislocated condition of the strata, could it be supposed that rock supplies could be abundant. The well occupies a surface of 600 square feet (approximately;) its depth at the edge, and two feet inward, is from four to ten inches, with a soft, muddy, clay bottom, dangerous for cattle to enter, which rendered the estimation of the depth toward the middle impossible. The overflow of water was very small, and was soon lost by absorption in the earth lower down. The probable overflow is about 200 cubic feet in 24 hours.

Rio Mimbres (page 156) is a mountain stream, derived from the rains falling in the narrow valleys and elevated hills, which are in juxtaposition and connected with the trappean eruptions

* Lieut. G. Andrews, 1st artillery, who commanded the escort accompanying Lieut. J G. Parke's survey, informed me that on his return, in crossing the Playa de las Pimas, in December, he found its bottom covered with a sheet of water six inches in most places by one mile wide and three miles long. Here was an immense body of available water.

of the Copper Mine mountains. In its course southward, its valley bed widens, and travelling over the grits and sandstone, which are loose and porous, it sinks down and disappears. Its volume carried down and the point of sinking varies with the season, some summers higher up, and others lower down; thus, at some seasons, the crossing at Cook's trail is dry, and at others a running stream.

The former was the case this summer, but the water was found about six miles higher up, where it existed as a large collection of fresh standing water in pools or lagoons, surrounded by willow thickets. Four or six miles higher up still, it was a running stream, about 8 feet wide, and from 18 inches to 2½ feet deep, travelling 2½ miles per hour. The valley of the river contained everywhere abundance of grass, with cotton-wood and walnut.

As the river runs in a line of fault in the strata, if it be desired to obtain water in the river valley, at or below where Cook's trail passes it, the river bottom and bed ought to be the spot selected for experiments. This is in a line running south 20° east from the magnetic meridian. Selecting such a line, and getting as close to the west side of a porphyry butte or hill would be the most likely method of tapping the river flowing beneath. A sinking to 12 or 15 feet near Cook's trail, and less than 25 feet for ten miles down, would be the utmost depths required. From the volume of water which the Mimbres carries down, as well as from its uncertain presence at the trail crossings, it would appear necessary to take the river higher up (four miles above camp) and carry it down in a channel, and fill reservoirs or tanks constructed on the line of road. Basins of water, of great capacity, might thus be obtained; and by taking the river at this point, the supply would be constant the year round. The conveying channel might be an open sequia, but the reservoirs would require to be covered. This stream, because small, is liable to be under estimated in its capability of supplying water. When crossed a few miles above the trail crossed upon this route, it has been found a constant stream by those who have crossed it. As such, Bartlett and Emory describe it, and as such it appeared when visited in the neighborhood of Ojo Caliente. When Major Emory crossed it, he describes it as 15 feet wide and 3 feet deep. Taking the lesser measurement, near Ojo Caliente, at 8 feet wide and 2 feet deep, with a velocity of 2½ miles per hour, there is a capacity for supplying water to fill a tank equal to 211,200 cubic feet per hour, or equal to a supply of 3,068,800 cubic feet in twenty-four hours. Thus, a single days' supply would fill a large tank.

Indeed, the Mimbres might be dammed higher up when the valley is narrow, and thus have a small lake formed, which could be constantly drawn upon, and form a reservoir, whence, by sequias, the wants of a railroad, several miles down, could be supplied. Sequias, though wasteful, are yet efficient for many miles. The town of Doña Ana, on the Rio Grande, is supplied by sequias, which come off from the river ten miles above.

The Ojo Caliente, described page 156, might also, if drawn upon, afford a large supply of pure water, palatable, though hard.

Ojo de la Vacca, page 155. This spring exists in a depression in the general plain, which is most likely formed by a fault; in the angle of uptilted strata the water rises. The central spring is surrounded by rush and tule, is about fifteen feet across, and yields but a small excess of water, which, owing to the depressed form of the basin, cannot overflow, and merely soaks the clay in the vicinity. As it does not flow, it does not admit of measurement; but as the removal of 200 gallons in twelve hours' stay did not appear to affect the spring, perhaps 1,000 gallons might be calculated on for every twenty-four hours as the surplus water of the spring.

The Ojo de Inez was not visited; it lies further up the cañon than the water holes at Camp

Peñascitas. The quantity of water is too small, and the position too far removed from the plain, to render it worthy of investigation.

Valle de las Playas, page 152. This arid flat cannot be depended upon for water; during the rainy season it collects in pools in depressions on the surface, and after the rains water may be had in the arroyo beds, by sinking from eighteen to twenty-four inches in the sand; but during the warm and dry weather even this fails; and in midsummer, before the middle of August, it is rare that any water is to be met with on the plain. This valley is imperfectly divided into two by the Pyramid hills. On each of the secondary troughs thus formed the detrital accumulation is greatest upon the eastern side, and it is in such situations, and somewhat toward the mountain, that sinking for ordinary wells should be attempted.

Valle del Sauz, page 150. This flat trough of land had no brook flowing through at the time of visiting it; there were merely pools of standing water, and no springs were found near the line of trail on this plain. The clay of the valley is of great depth, and it is likely that sinkings made through the clays in the line of the river bed, north of the Cienega, would be attended with success; but it is not probable that any large or permanent supply of water can be had from this plain.

Playa de los Pimas, page 147. After the supply which the Mimbres river is capable of yielding, that which this plain can afford ranks second. The permanent springs of the Playa are on its north extremity, in which direction the Playa slopes. They are in the alluvial clays, and arise from accumulations therein, derived from the rain fall upon the slopes of the valley, above the Playa level. The springs along the trail were numerous, and congregated within an area of a half mile square. The supply was large, and when drawn upon it readily filled up again. From these, or from new sources in the neighborhood, sunk a few feet deeper than the present wells, a large body of water is attainable; and not from this source alone, but from the large sheet of water which in autumn covers over the Playa throughout almost its whole extent, derived from the summer rains. An immense volume of water is at command for three months of the year, which, if stored in large reservoirs or tanks, would form a supply sufficient to carry through the remainder of the year, until the return of the annual rains. In these latitudes there is little fear about the preservation of the water, as it does not appear to undergo changes of decomposition such as occur in colder latitudes.

CHAPTER XXV.

ECONOMICAL GEOLOGY.

Localities of supply of building stone, and nature of material.

Materials for building stone are plentiful, at small distances apart, on the route. On the valley of the Rio Grande, above El Paso, the carboniferous limestone of the Organ mountains crosses the river, and the proximity of the lofty hills afford abundant supplies of stone and lime, which might be transported up the river for some miles. In the Mesilla valley the small hill behind the town of Las Cruces is also of limestone, and is not more than three miles from the river. Twelve miles west of the river buttes of trachyte and basaltic rocks occur, which can be quarried extensively. The trachyte is a reddish hard rock, breaking with a sharp fracture, easily trimmed, and wears well. The basalt is a hard, dark green rock, more difficult to work than the trachytes. This overflow is from 20 to 25 miles across, and should the road pass to the south, along the plain, the southern edge of this overflow will afford the place for quarries.

Cook's Spring, 15 miles W. In this neighborhood porphyry and syenitic rocks abound. The latter are among the most durable of rocks; both of these extend south of the spring for some miles, and could, at that point, furnish materials. Greenstone is also abundant there. The Mimbres river, 21 miles W., on the immediate line of trail, does not afford building stone; but three miles up the river white and red sandstones and buttes of trachyte porphyry occur on the left bank. The white grits are not coherent, at least in the upper layers. The reddish, yield, in some of the beds, a very durable fine-grained stone, which will answer sufficiently well where great pressure is not exerted.

On the trail between the Mimbres and Ojo de la Vacca these same sandstones crop out, but do not rise above the road level; they are favorably disposed, from their stratification, for quarrying.

The valleys and small cañons of the Burro foot hills, as at Peñasquitas and other entrances, are well supplied with porphyries, trachytes, and metamorphic quartz; all hard rocks, and well exposed, so as to be easily removed. Twenty miles west are the Pyramid hills, masses of porphyry and trachyte, with metamorphic sandstone; and twelve miles further west lie the Peloncillo hills, which are immense extravasations of volcanic rocks, porphyries, trachytes, and basalts; the first and the last are the rocks best adapted, from their durability and close grain. Fifteen miles beyond the west edge of these hills the limestone of Chiricahui is reached, which, as it encircles the whole mountain at its base, can be reached readily at the northern end of Chiricahui, should it be desirable to turn the mountain. This rock is again met on the west side of the playa, on the foot hills of Sierra Calitro. The granitic centre of this hill yields a good stone. West of the San Pedro a similar granitic rock forms Santa Catarina, from which large supplies will be required to be drawn. Two outcrops of granitic rock and sandstone occur between the latter range and the Gila river, along the trail; the sandstone is a friable rock, and scarcely to be selected where the igneous rock can be had.

Within six miles of the Maricopas wells lies the long granitic chain, which crosses the Gila in a double range, bounding the Jornada; and from this point westward, along the bed of the river, to Fort Yuma, there is no locality in which stone cannot be obtained within fifteen miles, so interspersed is the river valley slope with those isolated hills. The basalt overflow, west of the Pimas, affords a capping of hard rock, from 12 to 16 feet thick, in unlimited extent. West of this is Goat or Big Horn mountains, yielding granite, quartz rock, and a hard conglomerate; and beyond that two isolated ranges of trachyte, porphyry and sandstone, until the hornblendic granites of Fort Yuma are reached. The most of the rock met with on the route is igneous, either primary or volcanic, both of them affording denser and more durable materials than the sedimentary rocks. They are also more exposed and easier obtained. The limestone, where it can be obtained, will be preferred for most purposes. The white calcareous rock at Tucson is too soft for a building stone, requiring coherence, but is well adapted for making lime from, and is the most western point known for obtaining that mineral.

CHAPTER XXVI.

TABULAR VIEW OF GEOLOGICAL STRUCTURE OF SOUTHERN NEW MEXICO, NEAR THE GILA.

It may be interesting to some to have the strata of southern New Mexico compared with those in other known parts of the globe. For the general standard the classification of M. Huot, modified by Charles D'Orbigny, has been assumed. The allocation of several of the beds is done with great diffidence, partly from the poverty of those strata in fossils, and partly because some have been already classed under formations different from those in which they are now assigned. This is particularly the case with the upper red sandstones, which have been classed in Triassic, but are here moved down into the Permian formation.

	General.	New Mexico.
	Quaternary.	
Modern alluvium	Fresh water beds	Gila, San Pedro, and Bravo River vallies.
	Marine beds	
	Raised beaches	Around Fort Yuma.
Ancient alluvium	Ancient turbaries	
	Loess of the Rhine	
	Bone licks	
	Caverns with bone remains	
	Beds with diamonds and gems	
	Gold, platinum, and metallic ores	Micaceous sands of Gila river; conglomerate clay of San Pedro river.
	Drift and diluvium	Loose sand and gravel of the desert south and east of the Colorado river.
	Erratic blocks	
	Tertiary.	
Pliocene	Pleistocene	Stratified sands and clays of the Colorado desert.
	Older pleiocene	Do. do
Miocene	Upper bed	
	Middle bed	
	Lower bed	
Eocene	Upper bed	
	Middle bed	Conglomerate rock of the Gila, Goat mountain, and the district west of the Pimas villages.
	Lower bed	
	econd glauconic bed	

TABULAR VIEW—Continued.

	General.	New Mexico.
	Secondary.	
Cretaceous	Chalk	
	First glauconian	Greenish sand bed of Mesilla and Doña Ana, San Pedro valley.
	Wealden	
	Neocomien	
Jurassic	Oolite	
	Lias	
Triassic	Variegated marls	
	Muschelchalk	
	Magnesian limestone	
Permian	Red sandstone	Red sandstone of Organ mountains and west to the Mimbres river.
Carboniferous	Coal fields	
	Millstone grits	
	Mountain limestone	Basin valley, from San Pedro to Mimbres, Mesilla valley.
Devonian	Red sandstone	Calitro hills, Piñaleno, Chiricahui.
Silurian	Slates and limestones	
	Primary.	
Igneous	Granitoid	General axes of the mountain ranges.

CHAPTER XXVII.

CHEMICAL ANALYSES.

NATIVE COPPER ORE.—SAN PEDRO MARL.—CARBONIFEROUS LIMESTONE.—ARGENTIFEROUS GALENA.—TRACHYTES.—SOIL FROM MESA OF SONORA DESERT.—SOIL FROM PIMAS PLAINS.—SOIL NEAR MOUTH OF THE GILA RIVER.—REMARKS UPON THE SOILS.

1. NATIVE COPPER OF RIO GILA.

CRYSTALLIZED in small cubes and octagonal prisms, from apparent passage of the octahedra into the prism; surface rough, and coated with a layer, $\frac{1}{8}$ inch thick, of malachite, in botyroidal excrescences; masses $1\frac{1}{5}$ inch thick, the breadth of the seam; small cavities in the interior, with incrustations of malachite.

Analysis of two specimens.

	Found.		Calculated.	
	1.	2.	1.	2.
Copper	11.00	8.97	81.84	80.66
Silica	1.30	1.29	9.67	11.61
Water } Carbonic acid }	1.10	.77	8.18	6.96
Loss	.04	.05	.31	.77
	13.44	11.08	100.00	100.00

Before the blowpipe faint traces of arsenic were detected. No. 1 was determined in the way used at the New York assay office—by solution in nitro-sulphuric acid, and evaporation to expel the acid—treating the residue with hydrochloric acid and precipitation on an iron plate.

No. 2 was determined by a plan recommended by M. Rivot, in the Annales des Mines.

The ore was dissolved in nitric acid, and the solution diluted; sulphurous acid passed in until the solution smelled strongly; then a solution of sulpho-cyanide potassium added, until no more precipitation occurred.

The precipitate, dried and burned with an equal weight of sulphur, gave the copper as sulphuret.

In the analysis the silica separated as quartz sand, and was not combined with the green carbonate of copper. The ore might then be represented as made up in 100 parts of—

	Specimen 1.	Specimen 2.
Hydrated carbonate of copper—"green malachite"	28.63	24.36
Native copper	61.39	63.36
	90.02	87.72

The difference representing the silica and impurities.

2. MARL, SAN PEDRO RIVER.

	Found.	Calculated.
Matter insoluble in hydrochloric acid	4.224	31.5
Alumina and peroxide of iron	.844	6.3
Carbonate of lime	5.856	43.7
Carbonate of magnesia	.703	5.2
Soluble salts, as—		
Sulphate of lime, chloride of sodium	.362	2.7
Moisture	1.411	10.5
	13.400	100.0

A fresh water deposit.

3. LIMESTONE, CHIRICAHUI MOUNTAIN.

Color, blue. Specific gravity, 2.74.

	Found.	Calculated.
Silica and insoluble clay	5.020	35.30
Alumina and peroxide of iron	2.928	20.33
Carbonate of lime	4.864	33.77
Carbonate of magnesia	.324	2.22
Alkaline salts	.270	1.35
Moisture and traces of organic matter	1.000	6.94
	14.388	99.90

4. LIMESTONE, ORGAN MOUNTAINS.

Physical characters same as 3.

Insoluble silicates	38.00
Alumina and peroxide of iron	12.17
Carbonate of lime	37.65
Carbonate of magnesia	3.16
Alkaline salts	1.75
Moisture and organic matter	7.25
	99.98, in 100 parts.

5. TRACHYTE, PELONCILLO HILLS.

Specific gravity, 2.56.

Silica	69.470
Alumina	22.600
Peroxide of iron	.720
Carbonate of lime	2.154
Carbonate of magnesia	.300
Alkalies	4.666
	99.910, in 100 parts.

TRACHYTE, CAÑONS OF GILA RIVER.

Specific gravity, 2.64.

Silica	57.15
Alumina	16.90
Oxide of iron	8.50
Oxide of manganese	.04
Magnesia	1.86
Lime	6.40
Potassa	3.80
Soda	1.10
Water	3.28
	99.03, in 100 parts.

6. ARGENTIFEROUS GALENA, ORGAN MOUNTAINS, WEST SIDE, STEVENSON'S MINE.

Specific gravity, 7.8.

Lead	86.40
Sulphur	13.34
Silver	,16
Manganese	.20
	100.00

7. ARGENTIFEROUS GALENA, EAST SIDE OF ORGAN MOUNTAINS, FORT MINE.

Specific gravity, 7.75.

Lead	86.00
Silver	.17
Sulphur	13.36
Manganese and antimony	.67
	100.00

8. SOIL, EIGHT MILES EAST OF FORT YUMA, CAMP ON GILA.

Silica	81.22
Alumina	8.00
Peroxide of iron	.67
Oxide of manganese	.07
Lime	1.15
Magnesia	.71
Potass	.84
Soda	.76
Carbonic acid	1.00
Sulphuric acid	.54

Phosphoric acid	.07
Chlorine	.37
Vegetable matter	1.60
Moisture and loss	3.00
	100.00

9. SOIL FROM PIMAS PLAINS.

Silica	83.24
Alumina	7.00
Peroxide of iron	.78
Oxide of manganese	.11
Lime	1.88
Magnesia	.67
Potass	.37
Soda	.41
Carbonic acid	1.27
Sulphuric acid	.21
Phosphoric acid	.04
Chlorine	.28
Vegetable matter	1.24
Moisture and loss	2.50
	100.00

10. SOIL FROM DESERT SOUTH OF PIMAS VILLAGES.

Silica	89.26
Alumina	6.40
Peroxide of iron	.87
Oxide of manganese	.15
Lime	.44
Magnesia	.33
Potass	.66
Soda	.42
Carbonic acid	
Sulphuric acid	.10
Phosphoric acid	.03
Chlorine	.30
Vegetable matter	
Moisture and loss	1.44
	100.00

These soils have one common source, a decaying, felspar granite rock. The fragments of quartz are rounded and semi-transparent, intermingled with minute crystals of white felspar and brown colored mica; small particles of amphibole may be seen through the soil when examined by the lens. The different degrees in fineness of the granite debris constitute the chief difference in the soils, regarding them mechanically. The soil of the Pimas valley is finest in texture; next, and differing but little from it, is that of the lower Gila, while that of the desert is much coarser. In chemical composition they also approach each other. They are essentially light, sandy soils, in which the quantity of useful mineral matters vary from 15.80 to 9.5 per cent.

They are poor, granite soils, of which the desert specimen is the type; to this has been added some vegetable matter, and some carbonate of lime in impalpable powder. The soil of the lower Gila has vegetable matter also, and a lesser amount of the calcareous element; this, in both instances, has been derived from the river alluvium. There is, however, lime as silicate in the desert soil, which, could it be cultivated, would soon yield carbonate.

The desert soil so nearly approaches the others in chemical constitution, that we may conclude that the sterility is not due to the soil, *per se*, for transplant this soil to the margin of the Gila, and in a few years it will resemble the others. It is to the presence of organic matter (vegetable) that the fertility is due, and the vegetable matter is due to the moisture of the soil, so that, ultimately, it is to the presence of water that fertility is owing, and it is to its absence that sterility is imparted. While, therefore, from this we learn that all the bare and apparently desert low country may be cultivated with success, where it can be irrigated, we also learn that on the upland, where irrigation cannot be practised, and where a few showers per year are all the water received, the brand of perpetual sterility is inalterably fixed.

CHAPTER XXVIII.

LIST OF MINERALS COLLECTED.

No.	Name.	Locality.
1	Schorl, albite, and lithia mica	San Felipe, California
2	Albite and hexagonal mica	......do
2	Schorl in albite	......do
3	Schorl in albitic granite	
4	Protogine	San Felipe
5	Syenite	Vallecitas
6	Porphyry, with epidote	Fort Yuma
7	Hornblende and porphyritic granite	......do
8	......do ......do	......do
9	Trachyte porphyry	Camp 1, Gila, New Mexico
10,11,12	Amygdaloid basalt	Camp, June 15
13	Amygdaloid trachyte	......do
14	Pepperino	......do
15	Native copper, with malachite	Big Horn mountains
16	Doleritic basalt, including porphyry	
17,18	Jasper and metamorphic quartz	
19	Chalcedony (agatic)	
20,21,22	Oxide of titanium, rutile and sagente	Maricopas
23	Protogine. 29. Talc rock	Pimas villages
24	Albite	Tucson
25,26	Azure copper ore, chysocoll and malachite	Near Tucson
27,28	Impure red oxide copper	......do
30	Riband porphyry (trachyte)	......do
31,32	Calcareous rock	......do
33	Chalcedony geode	......do
34,35	Basalt	San Xavier
36	Porphyry, with labradorite	Tucson
37	Talcose rock	......do
38	Pyroxene and felspar	......do
39	Encrinital limestone	Gila river
40	Red felspathic trachyte	......do
41,42	Trachytes	......do
43	Silicified wood	San Pedro river
44	Augitic crystal (concretionary?)	......do
45	Red quartzose porphyry	......do
46	Trachyte, with phlogopite	......do
47	Greenish metamorphic slate	......do
48	Drusic quartz	......do
49,50	Gypsum; gypseous marl	......do
51	Chalcedonic geodes	Iguana creek
52,53	Crystalline limestone	Chiricahui
54	Aztec pottery	
55	Trap, from dyke in	Puerto del Dado
56	Metamorphic shale	Chiricahui
57,58	Encrinital limestone	......do

LIST OF MINERALS COLLECTED—Continued.

No.	Name.	Locality.
59,60	Trachyte and porphyry	Peloncillo hills
61,62,63	Trachytes	do
64,65,66,67	Porphyritic rocks	do
68	Basalt. 69, 70. Trachyte	do
71	Trachyte, cooled when in motion	Burro mountains
72	Chalcedonic quartz	do
73	Sandstone metamorphosed	do
74	Magnesian rock with porphyry pebbles	do
75	Talc and porphyry rock	do
76	Metamorphic quartz	do
77	Syenitic porphyry	Mimbres
78	Felspar porphyry	Picacho
79	Felspar porphyry, with actinolite	do
80	Jasper porphyry. 81. Greenstone traps	do
82	Actinolite porphyry. 83. Greenstone	do
84	White quartz grit	do
85	Trachytic sandstone	
86	Red sandstone	Ojo de la Vacca
87	Sandstone grit, giants of the Mimbres	Rio Mimbres
88	Chalcedony	Cook's springs
89	Actyonilite porphyry	do
90	Silicious deposits, filling veins	Burro mountains
91,92	Porphyry and silicious sinter	Picacho, Mesilla
93	Trachyte	Monument Hill
94	Trachyte	Ojo de la Vacca
95	Actynolite porphyry	Picacho, Mesilla
96	Red sandstone	Between Mimbres and Mesilla
97	Trachytic porphyry	Peloncillo hills
98	Silicified wood	Mesilla valley
99	Volcanic rock, from basalt plain	West of Mesilla
100,101,102	Porphyries and sandstone	Picacho, Mesilla
103	Trachyte	
104	Orthose, including small crystals of quartz; summit of	Organ mountains
105,106	Trap, on west side of	do
107	Sulphate barytes gangue	Stevenson's mine
108	Carboniferous limestone	do
109	Whitish calcareous rock	do
110,111	Argentiferous galena	do
112,113,114	Psilomelan and barytes, associated with galena, in Stevenson's mine	Organ mountains
115,116	Gangue stone, from walls of mine, containing fluor spar and phosphate lead	do
117	Litharge and slags from adobe furnace at Stevenson's	do
118	Fluor spar, octahedral and massive........do	do
119	Sulphate barytes and oxide manganese......do	do
120	Cerusite ....do	do
121	Trachyte, Cañon Soldado	do
122	Fibrous calcite, in veins	do
123	Greenish arenaceous schist, with carbonate of lime	do
124	Rhomboidal calcite, with talc crystals	do
125	Gypsum	
126	Suite of fossils illustrating the marine fauna of the Coast mountains	California

CHAPTER XXIX.

REPORT ON THE PALÆONTOLOGY OF THE SURVEY.

BY T. A. CONRAD.

DEAR SIR: Accompanying this is the description of the fossils collected by you in southern California.

In the Proceedings of the Academy of Natural Sciences for 1855, page 441, I have remarked that the Miocene of Santa Barbara contains a group of shells more analogous to the fossils of tne Atlantic slope than to the existing shells of California; but it is evident, from the specimens in your collection, that there must be subdivisions in those tertiary deposits of California which range between the Eocene and Pleiocene periods, for the group of the Estrella valley and Santa Inez (Barbara) mountains does not appear to contain one species, even, analogous to any in the Santa Barbara beds, and, on the contrary, some of them remind us of the existing Pacific fauna. Thus, *Dosinia Alta* is closely allied to *D Simplex*, *Hinnites crassa* related to *Hinnites gigantea*. *Pachydesma* and *Crytomya* are existing California genera, represented in the Miocene, and which do not occur in the Atlantic. I think it probable that the Estrella group may prove to be of later origin than that of Santa Barbara. There is another at San Diego, of which I have seen but a few specimens, and cannot yet determine its relation to the other groups. In referring these fossils to the Miocene group, it is not with the understanding that they are exactly parallel with European or even Virginian Miocene strata, but that they are unquestionably situated between the Eocene and newer Pliocene, containing no species analogous to the former, which is admirably characterized in California by its general forms, and even by a few well known Claiborne species. Like the Miocene of Virginia, the Estrella group is characterized by large and even comparatively gigantic species of Pectinidæ, so unlike any living on the coasts of California or the Atlantic States. It would seem that this family then reached their maximum of development and the genus Pallium was first introduced, and of far larger size than any which now exist. It is worthy of remark that the generic character is developed on a far grander scale than appears in subsequent epochs, the prominent teeth and thick hinge reminding us of the genus Spondylus.

Every new collection of Miocene fossils shows more clearly the connection between some of the tertiary strata of California and those of Virginia. The species in the present collection are far more interesting than any others of the same formation on the Pacific slope which I have yet seen. It does not appear that this group of fossils has any living representative in the present fauna of the Pacific coast, but several of them approximate to extinct Virginia species; and I am not sure that the large *Pecten magnolia*, herein described, is not identical with the Virginia species *P. Jeffersonius*. I think it may safely be assumed that the San Raphael hills, Santa Inez mountains, and Estrella valley, contain strata which are parallel to the Miocene sands and clays of the James and York rivers, in Virginia. No doubt there are groups of different geological age, as the species vary greatly in different localities; but in your collection I find not one Eocene species, and none more recent than the Miocene, except the few shells collected from the coast deposits, consisting of recent species, among which I recognize *Pachydesma crassatelloides*, Con. *Venus Nuttali*, *Saxidomus Nuttali*, and other species which live in the same latitude. This is most likely a recent, or post-Pliocene formation. It occurs in the valley of San Luis Obispo and at Santa Barbara.

The large Pectens, so like to Virginia species to which I have alluded, suggest the probability that large species of *Busycon* may yet be found in California. If so, it will be very interesting to compare them with the eastern forms.

I have no doubt but that the Atlantic and Pacific oceans were connected at the Eocene period; and the fossils herein described afford strong evidence that the connection existed during the Miocene period.

Of the Miocene shells collected by Mr. Blake in California, and described by me, I believe that no species, except *Pecten deserti*, and perhaps *Anomia subcostata*, is to be found in the present collection.

Yours, &c., T. A. CONRAD.

Dr. ANTISELL.

HINNITES, *Defrance.*

HINNITES CRASSA, Pl. 1, figs. 1 and 2.—Ovate or subovate, thick, irregular, with large, rounded, unequal, radiating, irregular ribs, squamose, and with foliated spines on the lower part of the valves or near the base; intervals of the ribs with 3 or 4 squamose, prominent lines; hinge profoundly thickened; fosset profoundly excavated, angular; muscular impression very large.

Locality.—Santa Margarita, Salinas valley.

This species is remarkable for the thickness of the hinge and the upper part of the valves in old specimens. It resembles the recent Californian species *H. gigantea*, Gray; and it probably attains a larger size than the latter.

PECTEN, *Lin.*

PECTEN MEEKII, Pl. 1, fig. 1.—Suborbicular, compressed; ribs about 19; lower valve convex, with broad ribs, not very prominent; convex depressed on the back, angulated on the sides, about as wide as the intervening spaces, and scarcely prominent at the base; upper valve convex depressed, with narrower and less prominent ribs, ears equal, moderate in size.

Locality.—San Raphael hills, California.

Named in honor of F. B. Meek. A very large species, comparable to *P. Jeffersonius* in size, but very distinct from all of the large Pectens of the Atlantic States. The upper valve is nearly flat, and both are thin for so large a shell.

PECTEN DESERTI, Conrad, (Blake's collection, desc. p. 15.)—Suborbicular, both valves convex; ribs about 23, rounded, somewhat flattened towards the base, about as wide as the interstices, in the lower valve much wider than the interstices, and the valve more convex than the opposite one; ears equal in the upper valve; left ear of lower valve extended downward, and very obliquely striated; cartilage pit profound; a submarginal channel parallel with the upper margin.

Locality.—Carrizo creek, Colorado desert; Carrizo creek of Estrella river.

PECTEN DISCUS, Pl. 3, fig. 1.—Suborbicular, slightly oblique, profoundly compressed or discoidal, thin; ribs about 17, rather distant, not very prominent, narrow, subtriangular, slender and more distant towards the lateral margins; ears very unequal, rather small.

Locality.—Between La Purissima and Santa Inez.

This species is described from a cast beautifully preserved in indurated clay. The height is about 2 inches. The upper valve appears to have been nearly flat.

PECTEN MAGNOLIA, Pl. 1, fig. 2.—Suborbicular, ribs 11, very large, prominent, convex-depressed on the back, laterally angulated, longitudinally rugoso-striate.

Locality.—Santa Inez mountains, Santa Barbara county, California.

This species will compare in size with *P. Jeffersonius*, Say, and is so remarkably similar to it that it may prove to be the same species when more perfect specimens are collected.

PECTEN ALTIPLICATUS, Pl. 3, fig. 2.—Obtusely ovate, thin; ribs squamose, slender, 9 of them distant, profoundly elevated, an intermediate small rib and fine radiating striæ, ears ——.

Locality.—San Raphael hills, Santa Barbara county.

There is but one imperfect valve of this species in the present collection. It is remarkable for the great prominence of its larger ribs. Height 2½ inches.

PALLIUM, *Conrad.*

PALLIUM ESTRELLANUM, Pl. 3, figs. 3 & 4.—Suborbicular; lower valve ventricose; ribs about 17, broad, flattened, not very prominent, with an intermediate small rib, longitudinal, sulcated below the umbo or bilinear; ears rather small, equal, with 5 or 6 radiating prominent rugose lines. Height 4 inches.

Locality.—Estrella, California.

The flat valve of this species does not accompany the specimen of the other valve. The shell attains a larger size than any fossil janira (which it resembles) I have heretofore seen. The hinge is furnished with 6 distant diverging prominent teeth, and presents a marked contrast to that of the genus PECTEN, more nearly resembling the hinge of SPONDYLUS. The specimens are imperfect and worn, but there are indications on one or two that the ribs were carinated or sub-carinated on the margins. One small specimen has the ribs inferiorly ornamented with fine, rugose, prominent transverse lines, and each rib with three longitudinal prominent striæ, and is also striated longitudinally.

This genus originated in the Miocene period, and there it attained its maximum in size and prominence of the generic character. Hinnites also and pecten have similar gigantic proportions in the strata, which I have considered the equivalents of the English Miocene, and which certainly occupy a stratigraphical position immediately above the Eocene formation.

SPONDYLUS, *Rond. Lam.*

SPONDYLUS ESTRELLANUS, Pl. 1, fig. 3.—Obtusely-ovate, both valves ventricose; ribs about 17, not very prominent, rounded, rugose, interstices convex-depressed; valves with radiating striæ, distinct about the base, obsolete above; posterior side sub-cuniform; cardinal area narrow.

Locality.—Estrella valley, California.

This species has thick valves, is about four inches in height, and has entire or unarmed ribs; the ears are broken, but they are apparently very unequal, and the beaks are not very distant. The lateral tubucles or teeth of the hinge are prominent, conical, and very robust. In some specimens the radiating striæ are very distinct near the posterior margin.

TAPES? *Mühlf.*

Tapes montana, Pl. 5, figs. 3 and 5.—Suboval, ventricose, very inequilateral; posterior margin very oblique and rounded, end obtusely rounded; basal margin slightly contracted medially; disk with concentric impressed lines.

Locality.—San Buenaventura.

Tapes Inezensis, Pl. 7, fig. 1.—Less ventricose than the preceding, with a rounded base, and prominent concentric lines.

Locality.—Santa Inez mountains.

VENUS, *Lin.*

Venus Pajaroana, Pl. 4, figs. 1 and 2.—Obliquely ovate-obtuse, ventricose, very inequilateral; anterior margin obtusely rounded, posterior side sub-cuniform; posterior end truncated obliquely inwards.

Locality.—Pajaro river, Santa Cruz.

ARCOPAGIA, *Brown.*

Arcopagia unda, Pl. 4, figs. 3 and 4.—Subtriangular; right valve profoundly ventricose anteriorly; profoundly sinuous posteriorly, or contracted from beak to beak; anterior end regularly and obtusely rounded; beaks nearly central; valves rugose-striate concentrically.

Locality.—Shore of Santa Barbara county, California.

This species is described from one imperfect valve, which resembles *A. biplicata,* Con. It is somewhat larger than that species, has a much larger umbo, is less curved, being almost straight. In the same rock is a cast of a bivalve resembling a shell I have described under the name of *Carditamon carinata.* There is in the collection another cast of this shell in limestone, from Estrella.

CYCLAS, *Klein.* LUCINA, *Lam.*

Cyclas permacra, Pl. 7, fig. 4.—Compressed, inequilateral; concentrically rugose-striate, striæ distinct and acute.

Locality.—Sierra Monica.

The specimen described is imperfect. It somewhat resembles *C. panduta,* Con., (*Lucina compressa,* Lee,) but differs in having prominent lines.

Cyclas estrellana, Pl. 6, fig. 6.—Sub-oval, inequilaterally ventricose; valves extremely thick; surface with concentric lines, probably mere lines of growth on the middle, but prominent and robust anteriorly.

Locality.—Estrella.

Length, 3¼ inches. A broken cast, with a large portion of the shell of the left valve crystallized, and exhibiting a remarkable thickness over the umbo.

ARCA, *Lin.*

Arca obispoana, Pl. 5, fig. 1.—Oblong, or trapezoidal; very inequilateral, ventricose; ribs about 26, little prominent, flattened; sides rectangular with the back; transversely rugose, or sub-crenulated.

Locality.—San Luis Obispo valley, California.

This species has been described from very perfect casts in an argillaceous gray marl.

PACHYDESMA, *Conrad.*

PACHYDESMA INEZANA, Pl. 5, figs. 2 and 4.—Triangular, equilateral, convex; anterior and posterior margins equally oblique; anterior extremity rounded; posterior extremity acutely rounded; posterior side sub-cuneiform; cardinal and lateral teeth robust.

Locality.—Santa Inez mountains, Santa Barbara county, California.

This species is smaller than *P. crassatilloides*, Con.; proportionally shorter, with straighter lateral outlines, more robust teeth, and a broader cardinal plate. It is the first fossil species of the genus that I have seen. The only recent species inhabits the coast of California. Length, 3 inches.

CRASSATELLA, *Lam.*

CRASSATELLA COLLINA, Pl. 6, figs. 1 and 2.—Triangular, inequilateral, ventricose, thick; anterior and posterior margins very oblique, and nearly equal in slope—the anterior a little incurved, the posterior straight or a little sinuous; umbo contracted or laterally compressed and triangular; summit prominent; posterior side cuneiform.

Locality.—Santa Inez mountains.

A fragment of one valve, the lower portion wanting. Length, 1¾ inch.

OSTREA, *Lin.*

OSTREA SUBJÈCTA, Pl. 2, fig. 3.—Very irregular, valves sometimes subplicated; cardinal area broad and carinated laterally; cartilage pit but slightly impressed.

Locality.—Between Santa Clara river and Los Angeles valley, on the Sierra Monica.

Height, 2 inches. (In plate 2, this fossil is improperly included under the *O. Panzana.*)

OSTREA PANZANA, Pl. 2, fig. 4.—Ovate, thick, lower valve with a few lateral distant radiating plicæ; upper valve thick, concentrically undulated and rugose; hinge area wide and carinated on the margins.

Localities.—Panza and Estrella valleys.

Height, 2¾ inches. The hinge of this shell resembles that of the preceding; and, possibly, it may be the old shell of that species, the specimens of which, in the collection, are evidently all young shells. At Gaviote pass specimens of *O. panzana* occur twice the size of those from the above localities.

DOSINIA, *Scopoli.* AZTHEMIS, *Poli.*

DOSINIA ALTA, Pl.—., fig.—.—Obtusely subovate or suboval, slightly ventricose; elevated; posterior margin curved, profoundly oblique; base irregularly and profoundly rounded; summits prominent, acute; surface marked with numerous fine concentric impressed lines? beaks medial.

Locality.—Salinas river, Monterey county, California.

There is but only one cast in the collection; portions of the shell remaining appear to have concentric sulci. It is quite an elevated species, occurring 4 inches in height at Hill's ranch, Salinas river. (The illustration of this specimen has been accidentally omitted.)

DOSINIA LONGULA, Pl. 7, fig. 2.—Shell regularly ventricose, inequilateral, longitudinally oval, margins and base regularly rounded; summit prominent; anterior margin more obtusely rounded than the posterior.

Locality.—Occurs with the preceding.

Height $1\frac{3}{8}$ inch, length $1\frac{5}{8}$ inch. A cast with a thin chalky coating of the shell, without a trace of external lines.

DOSINIA MONTANA, Pl. 6, fig. 4.—Suboval, inequilateral; length greater than height; convex; anterior margin regularly and obtusely rounded; posterior margin and base regularly rounded; disk concentrically sulcated; beaks.

Locality.—Occurs with the preceding.

DOSINIA SUBOBLIQUA, Pl. 6, fig. 5.—Obtusely subovate, slightly oblique, convex; height exceeding the length; concentrically sulcated.

Locality.—Occurs with the preceding.

With these species of Dosinia occur a small *Venus*, a *Natica*, and *Pecten*, in limestone.

MYTILUS, *Lin.*

MYTILUS INEZENSIS, Pl. 8, figs. 2 and 3.—Subovate-oblong? ventricose anteriorly; compressed posteriorly; ribs radiating, numerous, bifurcated, and trifurcated near the inferior margins.

Localities.—Santa Inez mountains and Santa Inez river.

A few fragments of this species present the character of the ribs well defined, but the outline of the shell is uncertain.

LUTRARIA, *Lam.*

LUTRARIA TRANSMONTANA, Pl. 5, fig. 6.—Longitudinally ovate-triangular, inequilateral, thin; anterior end and base regularly rounded; posterior side cuneiform, extremity rounded; summits prominent; surface concentrically indented or subplicated, umbonal region concentrically plicated; plicae irregular.

Locality.—Ranch Triumpho, Los Angeles.

This shell is allied to *L. papyria*, Con., and is well preserved in a hard, dark-colored limestone. There is another specimen from the shore between San Luis and Santa Barbara.

AXINEA, *Sow.* PECTUNCULUS, *Lam.*

AXINEA BARBARENSIS, Pl. 6, fig. 3.—Subglobose; equilateral; ribs about 35, little prominent, convex-depressed, interstices narrow, square.

Locality.—Occurs with the preceding.

Height $1\frac{1}{4}$ inch.

MACTRA?

MACTRA? GABIOTENSIS, Pl. 7, fig. 4.—Triangular, equilateral; anterior extremity acutely rounded, posterior extremity subangulated; umbonal slope carinated, slightly curved.

Locality.—Gaviote pass.

A cast about one inch long, associated with a species of *Mytilus* and *Infundibulum Gabiotensis.* It may belong to the genus *Schizodesma*, Gray.

GLYCIMERIS, *Lam.* PANOPAEA, *Menand.*

GLYCIMERIS ESTRELLANUS, Pl. 7, fig. 5.—Oblong or inclined to be trapezoidal, ventricose, very inequilateral, irregularly plicated concentrically, plicae more approximate and profound on the umbo, valves profoundly gaping posteriorly, margin obliquely truncated; ligament margin incurved, elevated posteriorly.

Locality.—Panza and Estrella valleys.

A cast, allied to *Panopaea reflexa*, Say; length 3 inches.

PERNA, *Lam.*

PERNA MONTANA, Pl. —, fig. —.—Elevated, anterior margin nearly straight; hinge line slightly incurved.

Locality.—San Buenaventura, Santa Barbara county.

An imperfect cast, about 4½ inches in height, allied to *P. maxillata*, of Virginia, from which it differs in having a straighter front and incurved cardinal margin. (Not illustrated.)

UNIVALVES.

TROCHITA.

TROCHITA COSTELLATA, Pl. 7, fig. 3.—Convex or convex-depressed; volutions 3½; suture distinct; surface irregular, and marked by radiating interrupted ribs, which are obsolete or wanting above, and distinct, though little prominent, towards the periphery; apex not central and slightly prominent.

Locality.—Gaviote pass.

A cast in sandstone. There are two very perfect casts, one more elevated than the other, with a less distinct suture and radii.

TURRITELLA, *Lam.*

TURRITELLA INEZANA, Pl. 8, fig. 4.—Subulate, thick; sides of volutions straight, with an obtuse carina on each side of the suture, and contiguous to it.

Locality.—Santa Inez mountains.

A large species with the last volution 1¾ inch wide. The specimen is an imperfect cast with portions of the crystallized she remaining. There are traces of 2 or 3 revolving lines on one of the volutions.

TURRITELLA VARIATA, Pl. 8, g. 5.—Subulate, volutions with straight sides, each with 4 to 6 revolving prominent ribs, bo ly whorl with a broad furrow revolving above the angle of the base.

Locality.—Santa Inez mountains.

A variable species; one specimen of which shows 2 revolving lines on the upper part of each whorl distant from 3 equidistant ribs beneath, all nearly or quite equal in size. Others have 6 unequal equidistant ribs; but I believe the species is always excavated at base.

NATICA.

NATICA INEZANA, Pl. 10, figs. 5 and 6.—Subglobose; whorls 5; spire prominent; volutions depressed or slightly channelled above, scalariform; umbilicus of ovate-acute outline, patulous towards the base.

Locality.—Santa Inez.

A large species, abundant, but the specimens are imperfect. Portions of the shell remain on the cast, and are crystallized. Height 2¾ inches.

MULTIVALVES.

BALANUS ESTRELLANUS, Pl. 8, fig. 1.—Very large, subconical, not elevated; valves sculptured with close, undulated, or very irregular radiating lines.

Locality.—Estrella.

Height about 2 inches; width 2½ inches. A single specimen is in the collection, with its external characters almost obliterated.

ECHINODERM.

ASTRODAPSIS, *Conrad.*

ASTRODAPSIS ANTISELLI, Pl. 10, figs. 1 & 2.—Pentangular, suboval; disk with 5 broad angular profound depressions; ambulacra not greatly curved, open at the marginal extremities; apex central or subcentral, beneath flat, or slightly depressed, with 5 distinct furrows; anus submarginal.

Locality.—Estrella.

Masses of limestone appear to be composed chiefly of the fragments of this species, and contain many entire, but apparently water-worn specimens. In this respect it resembles a Miocene rock on the Patuxent river, Maryland. Length, $1\frac{3}{4}$ inches.

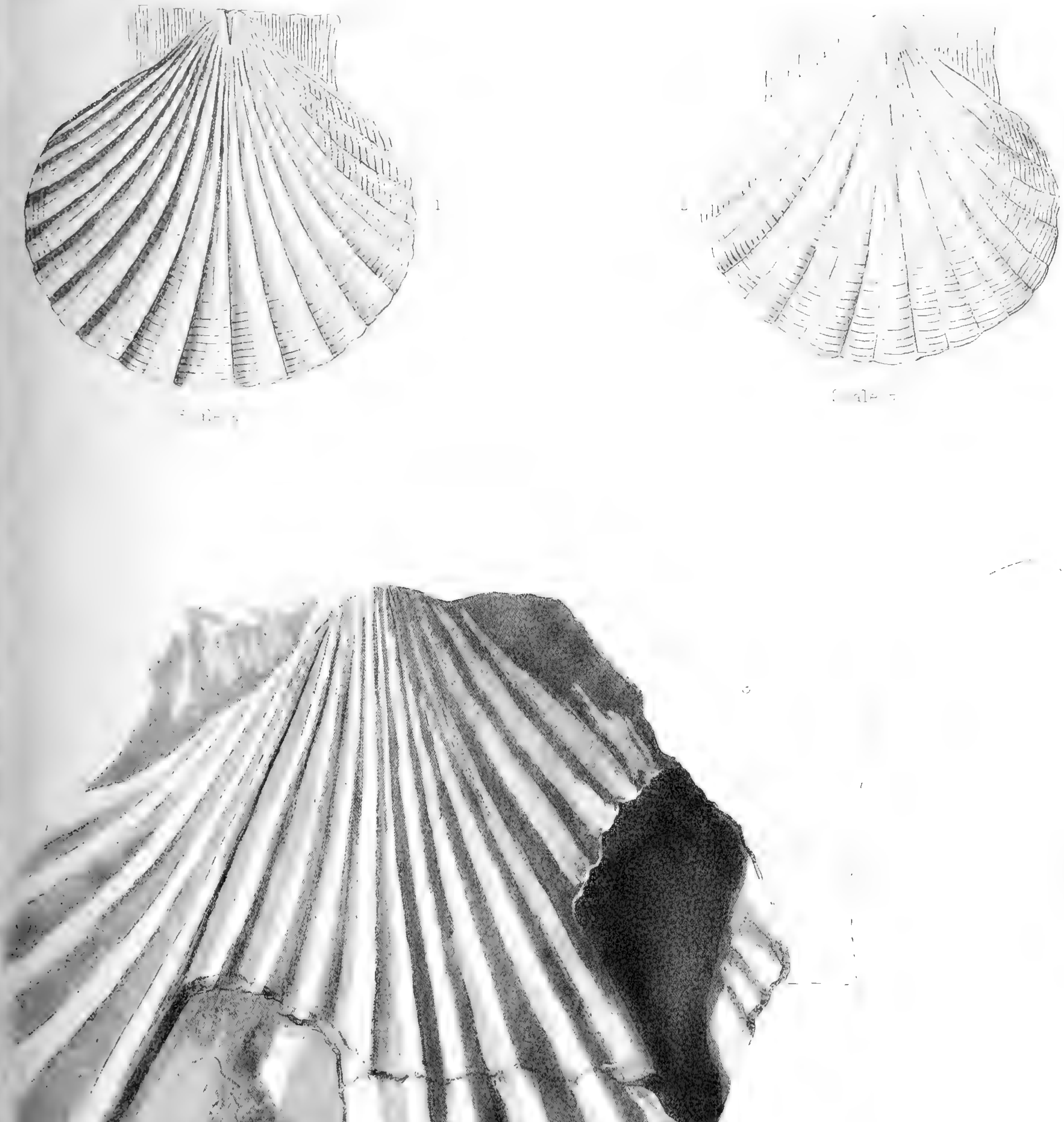

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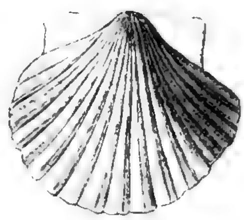
FIG. 1. HINNITES CRASSA FIG. 2. Same — Internal view FIGS. 3, 4. OSTREA PANZANA

1

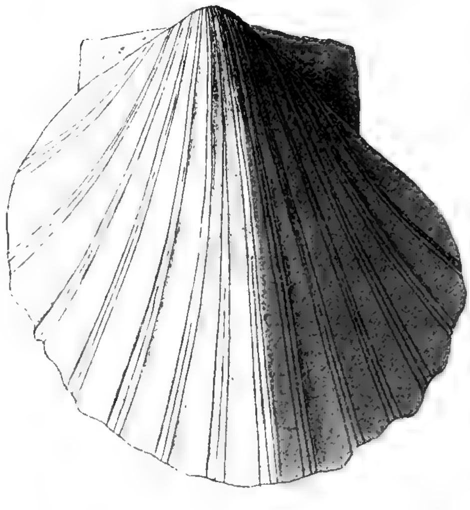


Scale ½

2

Scale ½

3



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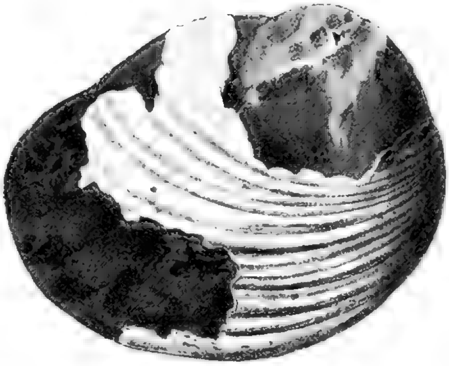
Scale ½

FIG. 1. PECTEN DISCUS. FIG. 2. PECTEN ALTIPLICATUS. FIGˢ 3. 4. PALLIUM ESTRELLANUM.

1



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FIGs 1 2 VENUS PAJAROANA FIGs 3 4 ARCOPAGIA UNDA

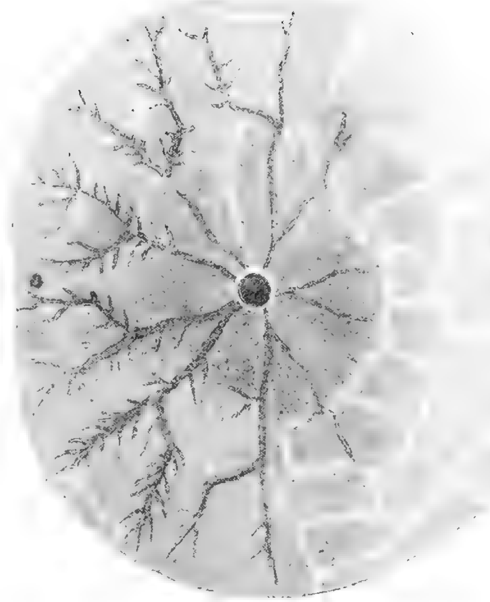
FIG 1 ARCA ...OANA. FIGS 2.4 PACHYDESMA INEZANA FIGS 3 5. TAPES MONTANA FIG 6 LUTRARIA TRANSMONTANA

FIGS 1.2. CRASSATELLA COLLINA FIG. 3. AXINEA BARBARENSIS [illegible]
FIG. 5. DOSINIA SUBOBLIQUA [illegible]

FIG. 1. TAPES INEZENSIS. FIG. 2. DOSINIA LONGULA. FIG. 3. { MACTRA GAVIOTEN-I[illegible] / TROCHITA COSTELLATA

FIG. 4. CYCLAS PERMACRA. FIG. 5. GLYCIMERIS ESTRELLANUS.

FIG. 1 BALANUS ESTRELLANUS. FIG. 2, 3. MYTILUS INEZENSIS. FIG. 4 TURRITELLA INEZANA



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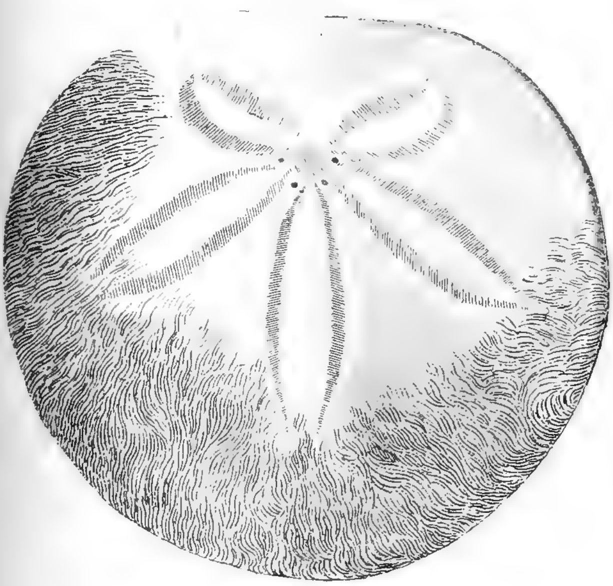


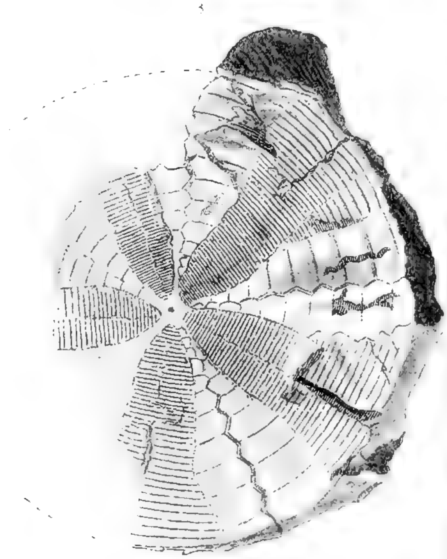
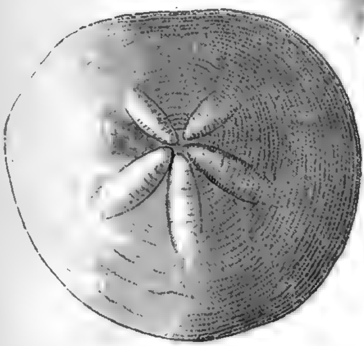


FIG 1 (a, SCUTELLA STRIATULA, fossil
(b " under Surface

FIG. 2. SCUTELLA STRIATULA, recent
FIG. 3 ECHINARACHNIUS .... ?

3



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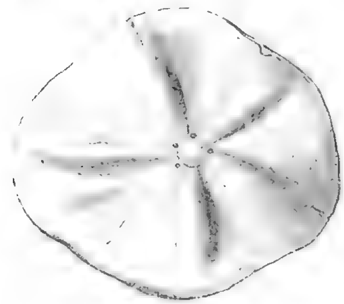
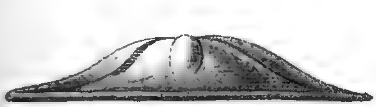


Scale ½



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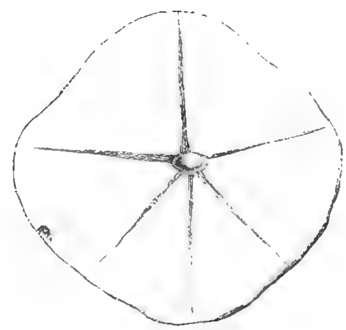

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FIG^S. 1.2. ASTRODAPSIS ANTISELLI. FIG^S. 3.4. SCUTELLA. ———— FIG^S. 5.6. NATICA INEZANA

CHAPTER XXX.

ORDER OF POSITION OF CALIFORNIAN STRATA.

Unconsolidated.

Modern alluvium.—Soil of valleys—present river bottoms.

Ancient alluvium.—Terraces of river beds, raised beaches, deep valley clays, and upper drift; thickness, 400—500 feet.

Consolidated.

MIOCENE.

UPPER.

A.—Bituminous and foraminiferous beds; trappean conglomerate; soft yellow sandstone; foraminiferous layers; argillite beds	400	feet.
MIDDLE.		
B.—Grits and calcareous sandstones, as at Panza and Santa Margarita	360	"
C.—San Antonio sandstones, with dosinia, &c	250	"
LOWER.		
D.—Gypseous and ferruginous sandstones of Santa Inez, Panza, and Gavilan, containing ostrea, turritella, &c	1,200	"
Total thickness of Miocene strata	2,211	"
Metamorphic limestones of Gavilan, &c	400	"
Primary schists, gneiss, and talcose slates	1,500	"
Total thickness of strata	4,111	"

DESCRIPTION OF THE PLATES.

PLATE I.

Fig. 1.—Section across Monterey county, from the Pacific ocean, at Point Pinos, to San Joachin valley, in a line due east. This includes a section of the Salinas valley and the small valley of the cañon San Juan.

a represents the sandstones of Salinas valley, with *Dosinia* reposing on the serpentine and magnesian rocks of Point Pinos.

c, the serpentine crest of Point Pinos range, lying east of

d, the orthose granite of that range; also, the granite of Gavilan.

b, metamorphic limestone, lying on the east edge of the Salinas valley and underlying the whole Cañada San Juan.

e, the alluvial clays and gravels of the Salinas valley, its upper edge worn out so as to afford three levels.

Fig. 2.—Section across San Luis Obispo county, showing the asphaltic group of San Luis valley, the structure of the Santa Lucia mountains, and the strata in Santa Margarita valley.

a represents granitic rocks.

c, serpentine lying at a high angle upon

t, trappean and augitic rock.

w show the veins of asphalt passing up through the bituminous group of San Luis Obispo valley.

The Santa Margarita sandstones are shown included in a basin formed by the San José and Santa Lucia mountains; these sandstones are inferior to the San Luis group.

Fig. 3.—Section of the San Antonio hills, near the mission San Miguel, Salinas valley. The central axis is felspathic granite, *d*, upon which the sandstones *a*, *b*, *c*, of the Gavilan group repose conformably. On the east side of the range a bed of serpentine, *s*, intervenes between the primary rock and the sandstones; both the latter and the serpentine are cut through by dykes of felspathic (augitic) trap. This is the geological position of the auriferous region of these hills, a thin bed of talc slate accompanying the serpentine. In the bed, *c*, is found the four species of Dosinia; this bed, also, has on its lower portions the terraces of the Salinas valley, between missions Solidad and San Miguel.

Fig. 4.—Section across the Santa Margarita valley, from the residence of Don J. d' Estrada to the granitic hills east of the river. The house is on a low terrace on the west side of the valley, the horizontality of which is disturbed by trappean dykes, *c*, *c*. The strata, marked *e*, contain the *Ostrea*, *Hinnites* and *Astrodapsis; f* are the whitish-gray sandstones with *Dosinia; g*, brown and yellow sandstones, with gypsum and oxide of iron; and *h*, the coarse breccia conglomerate which lies next the primary, underlies the whole basin, and rises again on the opposite side near the summit of Santa Lucia.

PLATE II.

Fig. 1.—Section of the beds marked *e*, figure 4, plate I. These are the most recent beds in the valley Santa Margarita.

a, *a*, *a*, the valley level with alluvium.

A, B, C, the three hills containing the fossiliferous beds, dipping S.W.; at *b* the agatic or flinty layers occur 16 inches thick.

1, 1, 1, calcareous layers of comminuted shell and large shells of *Ostrea titan;* this is the first bed of chapter 5.

The second bed, B, has at 2 a broken shell bed, with specimens of *Ostrea* and *Hinnites*. The third bed is represented at *C*, where 3 shows the *Ostrea* and *Hinnites* bed, and 4 the *Ostrea* and *Astrodapsis*, with *Pecten discus*.

At C 5, the upper layer of sandstone, pierced by pholadines, is situated.

Fig. 2. Section of the Santa Lucia mountains. This section was taken where the Santa Maria river cañons through to reach Guadalupe Largo. The rock apparent in the axis is serpentine, *s*, *s*, which is here made to repose on granitoid rock, although no granite was actually observed. The serpentine is cut through by dykes of augitic rock. Conformable to the serpentine on each side is, 1, thick beds of conglomerate, similar to that underlying Santa Margarita valley. 2 and 3 are the brown and yellow sandstones of the same age with the Gavilan and Salinas valley beds.

Fig. 3.—Section of Greater Panza hill; the lesser hill is similarly constituted. They lie with their greatest length N.W. and S.E.; the upheaving rock, *g*, quartzose granite, lying at the southern end; *e*, brown sandstones similar to those of Santa Barbara; *f*, an interval, not observed, probably the heavy conglomerate; *b*, c, *d*, coarse and fine grits and sandstones with views of gypsum and limonite.

a 1 represents the beds containing *Ostrea*, *Pallium* and *Astrodapsis*, &c.

a 2 is the soft argillite, with casts of *Arca*.

Fig. 4.—Outline of Santa Maria valley, with its terraces, from near ranche Cuatro Domingo.

A, the western slope of the San José mountains; C, the slopes of the Santa Lucia; B, the intervening insular mass of strata, a part of the San José range, from which it is separated by denudation; D, present valley of the Santa Maria; E, ancient water bed; D 1, present river bottom and first terrace; 2 and 3, terraces above, the upper one corresponding to the summit of the central islet and somewhat below the terrace level on the Santa Lucia, 4.

Fig. 5.—Section of the San José mountain range, taken from valley San José across to Panza ranch and valley; still more to the east lies Panza hill. The axis of this range is the felspathic granite with epidote, *g;* uplifting the conglomerate, *f*, on each side, this bed forms the summits of the hill range; *e*, green gritty sandstones, fine texture; *d*, coarse conglomerate of porphyry and jasper of a reddish tint; *c*, brown and yellow sandstones, similar to those of Gavilan and Salinas valley; *b*, a bed of green conglomerate made of serpentine and quartz pebble; *a*, whitish sandstones and layers of argillite, with gypsum remains of *Ostrea* and *Pallium*.

PLATE III.

Fig. 1.—Section across the valley of Santa Inez from the direction of La Purissima to Camp 22, at the foot of the north face of the Santa Barbara mountains. The river bed with its most recent terrace is shown at *a; b* represents the second terrace on the northwest side of the river the mission is placed; behind it is *c*, the upper terrace; on the south side of the river the strata rise toward camp, behind which lies a mass of jaspery sandstone and amygdaloidal trap, *t; i*, green grits and conglomerates; *g, h*, brown and yellow sandstones, containing *Turritella, Mytilus*, and *Pachydesma; e, f*, whitish sandstones, with fossils much injured, *Turritella, Tapes, Crassatella, Cyclas*, and *Ostrea; d*, sandstone grit, with calcareous layers, and veins of calcite and *Turritella, Natica, Pecten, Cyclas*, and *Balanus*.

Fig. 2.—Section of the Santa Barbara mountains through the Gaviote pass. This represents the slope of the strata southwards, the beds being almost similar to those on Fig. 1. In the pass the strata are duplicated A and B; only one fold is represented.

a represents the terrace slope lying between the range and the ocean, with the strata dipping S. and contorted.

b, whitish yellow argillite; *c*, fine and coarse grits, imperfect impressions of fuci, no shells; *d*, brown sandstone, with *Ostrea* and *Natica; e*, greenish sandstone, with *Pecten, Ostrea, Turritella*, and *Pachydesma; f*, brown and green conglomerates and gypseous beds.

Fig. 3.—Section on Arroyo Hondo, afforded by the stream cutting deeply through the terrace.

a, talcose and magnesian slate contorting the strata; *b*, greyish sand rock; *c*, foraminiferous rock; *d*, soft yellow slate. These strata belong to the San Luis group.

Fig. 4.—Section showing the constitution of some of the coast ranges. Extent of the section from the mouth of Arroyo Hondo to the eastern slope of San Rafael. These hills are simple in composition, being sandstone strata, uplifted by serpentine, trachyte, and amygdaloidal trap.

a, distorted strata at Arroyo Hondo, with the terrace flat *t*, as above.

v, valley near Santa Barbara.

b, c, d, e, uplifts of volcanic rock, the axes of the ranges.

f, g, g, sedimentary strata of Santa Barbara mountains.

h, i, San Rafael beds.

PLATE IV.

Fig. 1.—View of the Gaviote pass, looking south, showing the slope of the strata forming a synclinal axis.

Fig. 2.—Ideal section of the same; *a, b*, representing the portions removed.

Fig. 3.—Section of asphalt cliff on shore near Santa Barbara. *a, a, a, a, a*, veins of asphalt; *b*, beds with present shore shells; *c*, outflow of bitumen on the surface; *x*, cliff extremity forming cape of bitumen.

Fig. 4.—View of the terrace cliff with asphalt, as seen from shore. *x* represents the cape as at Fig. 3, *x*.

Fig. 5.—Section from Point Dumas to the granitic mass of San Emilio. This section cuts the Sierra Monica and Sierra Susanna, crosses the valleys Triompho and Semee, and touches the Santa Clara at Camul.

A, represents the Sierra Susanna having a trappean axis; *t*, on which repose the red and brown sandstones, similar to those of the Cordilleras and at Buenaventura.

B, the Sierra Monica with its amygdaloid and trachytic axes, *t*, *t*, uplifting; *d*, *e*, *f*, the beds containing *Lutraria*, *Natica*, *Cyclas*, *&c.*

g, the granitic mass of San Emilio, through which the Peyrou cañons. The sandstones *h* on its slope are the same as those of the Susanna hills.

Fig. 6.—A more extended section, taken further north than the preceding; *a*, view of the terraced hills along the San Buenaventura river; *b*, amygdaloid upheave with asphalt; *c*, sandstones of Matilihah similar to Santa Barbara beds; *d*, trachyte and asphalte of Matilihah; *f*, lofty mountain in Santa Lucia range; *h*, Santa Maria valley; *g*, granitoid rocks of San Emilio; *i*, sandstones of Cestek; *k*, granite of Cañada de las Uvas.

PLATE V.

Fig. 1.—Section from the ocean to the Sierra Nevada, across San Luis Obispo county, cutting across Santa Lucia, San José, and Gavilan ranges.

a. Asphaltic veins passing up through the bituminous group of San Luis valley; the strata elevated by upheaves of volcanic rock at *t*, *t*.

'*t*. The volcanic axis of Santa Lucia with the conformable sandstones *g*, *g*′, *g*″, the granite of San José, Monte Diablo, and Sierra Nevada. The sandstones are more recent the more westerly they lie.

Fig. 2.—Section in Santa Barbara county, from the Santa Clara river south to Camp 39 near Ranche Triompho.

a, *a*, *a*. Amygdaloidal trachyte, with chalcedony; *t*, augitic trap; *b*, the red and brown sandstones of San Buenaventura; *c*, *d*, *e*, sandstones of the Monica group, containing *Lutraria*, *Cyclas*, &c. Semee plain is almost wholly of volcanic rock.

Fig. 3.—Section across the plains of Los Angeles and San Fernando to the Cordilleras, showing the deep beds of alluvium, *f*, on the plains; *a*, veins of asphalt near Los Angeles; *b*, intruding volcanic rock; *c*, strata of the San Luis group, almost vertical, or dipping north; *d*, strata of San Pedro; *e*, sandstones of the Cordilleras continuous with the Susanna sandstones.

Fig. 4.—Section of cliff at San Pedro, north of the custom-house; *a*, alluvium, 8 to 12 feet thick; *b*, raised beach with recent shells, 4 feet thick; *c*, argillaceous schist, 6 feet; *d*, yellow clay beds and blue clay, with their stratified beds between, 30 feet.

Fig. 5.—Plan of the junction of the Colorado and Gila rivers as at present, with the probable former course indicated by the dotted lines.

PLATE VI.

This plate is confined to the representation of the strata along the Mojave valley, and to a section of the Cordilleras through Cajon pass. In fig. 1 the mass of Kikal Mungo is not displayed so that the beds in the pass may be recognized. In fig. 3 it is restored, but the lower portion of the pass is obscured.

Fig. 1.—Section through the Cajon pass.

a, *a*, *a*, mica slate; *b*, crystalline felspar rock; *c*, talcose slates; *d*, hornblendic gneiss; *e*, pink sandstones, easily worn into rounded prominences; *f*, *f*, *f*, incoherent sandstone beds, lying with a gentle slope to the northeast; *g*, *g*, axial granitic rocks.

Fig. 2.—Section from the slope of the incoherent sandstones to Soda lake, the debouche of Mojave river.

f, loose sandstone; *a*, bed of Mojave, with alluvium; *b*, conglomerate lying up a hill of granite; *g*, cut through by felspathic porphyry; *o*, deep bed of local drift covering up the sandstones, and forming the surface of the plains and valleys east of the Cordilleras; *c*, second crossing of the Mojave, near Navajo camp; *f'*, loose sandstones uplifted by the porphyry dykes, (red amygdaloidal trachyte;) *g*, albitic granite of the ranges running north and south; *l*, metamorphic limestone lying near granite of Soda lake.

Fig. 3.—This section shows the great slope of San Bernardino plain, *c*, with its deep alluvial beds, and the upper bed of drift conglomerate, *b*, removed; *g*, the granitic mass of Kikal Mungo mountain; *s*, the syenite of its eastern edge; *a*, mica slate and gneiss rock; *f*, the soft sandstones dipping from the Cajon to the Mojave river.

PLATE VII.

Fig. 1.—Section from the mouth of the Santa Clara river to the mouth of the Gila, at Fort Yuma. This section displays the promontory form of southern California, and the low level of the Colorado desert.

a represents the alluvium of the plain on the Pacific slope of the Cordilleras, and *a'* the alluvium of the Colorado basin; *b*, the sandstones of the Cordilleras; *c*, the upper sandstones of the Monica group; *g*, the granitic rock of Kikal Mungo and of Fort Yuma; *t*, trachyte of the Monica range; *v*, unconformable tertiary beds at Carrizo creek.

Fig. 2.—Section from the valley of Santa Margarita to the ocean, through the pass of San Luis Obispo, and across San Luis valley to the sea.

a, *a*, *a*, alluvium; *b*, *b*, *b*, brown and yellow sandstones of the Santa Lucia mountains; *c*, coarse conglomerate; *s*, *s*, serpentine, the axial rock; *f*, *f*, amygdaloidal felspathic trap; *t*, *t*, *t*, augitic trap, in veins and dykes.

d. Conglomerate underlying the San Luis asphaltic group; *e*, soft yellow sandstone; *g*, greenish yellow bituminous rock; *h*, soft white argillite rock, containing casts of *Arca*. The layer *e* often includes layers containing polythalamous shells.

PLATE VIII.

Geological structure from San Diego to Big Horn mountains, east of the Colorado river.

Figure 1. Section from the Pacific ocean across the Sierra Nevada *via* Warner's pass, showing the trappean rock at San Pasqual, the granitic mass of the Cordilleras, and the tertiaries of the desert at Carrizo.

Figure 2. Profile from Sackett's wells to Big Horn mountains: *a*. Alluvium, fine sand and clay; G. Hornblendic granite; S. Sandstone rock, a coarse conglomerate, with pebbles of volcanic rock; T. Trachyte and amygdaloid porphyry.

Figure 3. Enlargement of part of section 2 to show the structure of the Dome hills and Big Horn mountains: *a*. Alluvium, fine gravel and sand; A P. Trachytic porphyry, a felspathic rock; T. Metamorphic quartz rock, with jasper; C. Conglomerate, as in section 2—the desert conglomerate.

Figure 4. Section of an anticlinal axis near camp at Vallecitas: G. Granitic axial rock; M. Gneiss and mica slate dipping away east and west, strike of these rocks N. 75° W.

PLATE IX.

Profiles from Big Horn mountains to near the Maricopas wells.

Figure 1. *a.* Alluvium, desert sand, and deposit of Gila river; G. Granitic basis of Big Horn mountains; *j.* Metamorphic quartz and jasper rock, a conglomerate rock; both strata reposing on the granite and dipping southwest; P. Intruding trachyte porphyry dyke; D. Position of hills containing the vein of native copper; 6. Table land capped with basalt, and *c*, underlying calcareous sandstone.

Figure 2. *b.* Basalt; T. Trap dykes, communicating with the basalt overflow. The central hill may be looked upon as the source whence the basalt flowed east and west over an area of thirty-six miles wide. Other figures correspond to strata marked in section 1.

Figure 3. Hills over which the trail runs, in the Jornada, to the Maricopas and Pimas villages: G. Central granitic axis, with veins of quartz *q,* containing titanium ore; and *f,* dykes of felspar, crossing the quartz at right angles; *c.* Desert conglomerate.

PLATE X.

Profiles from Pimas villages to entrance of the cañon of the Gila river.

Figure 1. *a.* Alluvium of Pimas plains; *b.* Basalt overflow; *p.* Isolated hill of protogine; P. Porphyry dyke. This section is along the course of the river.

Figure 2. Profile of hill near camp, July 6. Basal rock is leucite, merging into trachyte. The capping is amygdaloid trachyte, overlying a coarse sandstone grit.

Figure 3. Ten mile profile along the Gila river, July 6: *a a a.* Coarse porphyritic granite; *b.* Felspar rock; *c c c.* Red felspar porphyry; *d.* Basalt; *e.* Augitic trap.

Figure 4. Profile of anticlinal axis entering the cañon: *a.* Primary rock, (*vide* section 5;) *b.* Yellow sandstone conglomerate; *c.* Metamorphic sandstones; *d.* Basaltic and trachyte lavas.

Figure 5. Structure of axial rock; *a.* Amygdaloid trachyte; *b.* Felspar and hornblende, a porphyritic rock; *c.* Felspathic rock; *d.* Basalt.

PLATE XI.

Profiles of the strata along the Gila where it cañons to the mouth of the San Pedro river.

Figure 1. *a.* Porphyritic jasper, beds running north and south—a stratified rock; *b.* Thick vein of sulphate of barytes; *d.* Basalt dykes and overflow; *c.* Syenitic mass in the amphibolic granite.

Figure 2. Outline of the Spire hills, with distant lava capped hills north of the Gila; portions of the Pinaleno hills. The Spire hills are of amphibolic granite, passing into felspar, porphyry, and trachyte.

Figure 3. Cross section of Spire hills, showing the summits formed of dykes of felspar, which traverse the mass.

Figure 4. *a.* Sandstone conglomerate on each side of the river, probably connected beneath; *b.* Porphyry conglomerate; *c.* Lava capping; *d.* Alluvial drift; *e.* Felspar porphyry and trachyte; *f.* Granite.

Figure 5. Alluvium of San Pedro; *b.* Unconformable gypseous strata of cretaceous period; *c.* The conglomerates marked *b* in section 4; *d.* Trachyte and red felspar rock; *e f.* Metamorphic quartz and sandstones; *g.* Outline of Sierra Calitro, with exposed edges of yellow sandstone, a layer of limestone on the summit, with a capping of trachytic lava.

Figure 6. Gypseous layers; *a.* White marl, soft and friable; *b.* Greenish aluminous shale; *c.* Brownish clay, with crystals of gypsum; dip 4° east. These beds have all been denuded.

PLATE XII.

Profiles across the district of basin troughs.

Figure 1. C. Devonian sandstone of Calitro mountains; S. Upper beds of same; D. Desert conglomerate of San Pedro river; L. Carboniferous limestone; *Se.* Serpentine, auriferous; T. Trap and augitic dykes.

Figure 2. A P. Trachytic rock; E P. Felspar porphyry; F. Felspathic dykes; L*a.* Basalt and trappean lavas; L. Carboniferous limestone; S S. Permian sandstones.

Figure 3. R S. Red sandstone, (Permian;) S. Whitish grit, (Permian.) The other letters are similar to those in sections 1 and 2. In the three profiles, fig. 1, Quaternary alluvium; fig. 5, clay beds; Nos. 2, 3, 4, connect the beds of different sections together.

PLATE XIII.

Profile from Burro mountains to Cook's spring.

Figure 1. A. Amygdaloid and trachyte; C. Sandstone conglomerate, with agatized pebbles; F. Felspar rock; *m.* Talcose strata; Q. Opaque quartz, with chalcedonic layers; S. Coarse, yellow, metamorphic sandstone.

Figure 2. E P. Trachyte and porphyry buttes on the Mimbres; fig 1. Quaternary alluvium; R S and S. Red and white Permian sandstones.

Figure 3. Q. Compact quartz, metamorphic sandstone; R S and W. Red and white sandstones, Permian; G. Trachytic stratified layer, a white clay rock.

Figure 4. T. Greenstone and trap dykes; P *p.* Trachytic felspar, and chalcedonic rock. Other letters correspond with those in foregoing sections.

Figure 5. Plan of ancient beds of Colorado and Gila rivers at their junction, half a mile west of the present junction.

PLATE XIV.

Profiles from Cook's spring to the Organ mountains.

Figure 1. B B B. Dykes and overflows of basalt; *c c c c.* Contorted and dislocated Permian grits and sandstones; *s s s.* Do. unfractured; P. Felspar porphyry and trachyte; D. Quaternary alluvium of Rio Grande valley.

Figure 2. D. Quaternary alluvium and detritus; 4. Carboniferous limestone; S S. Overlying sandstones and grits, Permian; O. Axis of Organ mountains—granitic porphyry and leptinite; *t.* Trap dyke; *x.* Veins of argentiferous galena; Q. Greenish gray sand, with silicified wood, cretaceous. This bed is made to appear too vertical in the drawing.

Figure 3. L. Carboniferous limestone, underlying the river at the rapids near El Paso, and forming the hills on each bank; D. Alluvium; P. Primary granitoid rock.

Figure 4. B S. Thin band of black shale, 60 feet; W S R S. Red and white overlying sandstones; L. Carboniferous limestone; *d.* Alluvium; A. Synclinal axis of valley of elevation.

Fig. 1.

Section from the Pacific across Salinas Valley to San Joachim

Fig. 2.

Section across San Luis Obispo & Santa Margarita Vallies

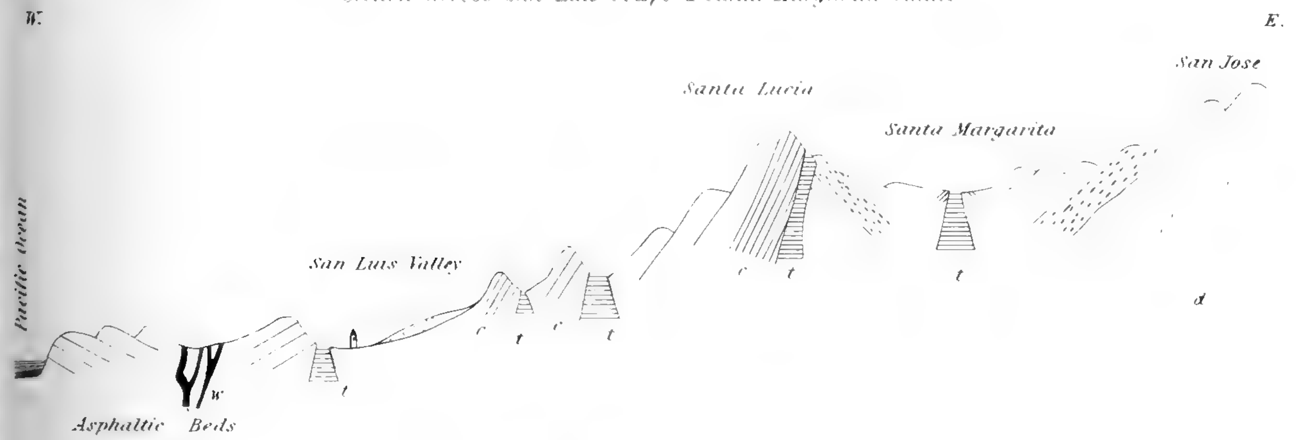


Fig. 3.

Section of San Antonio Hills

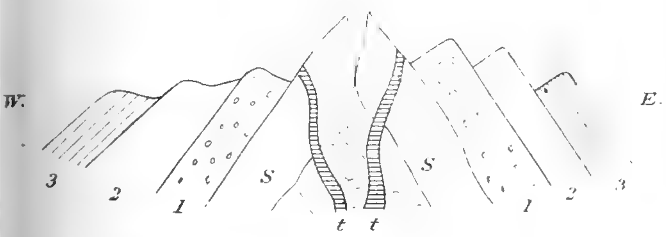
Fig. 4.

Section of Valley Santa Margarita

Fig. 1.

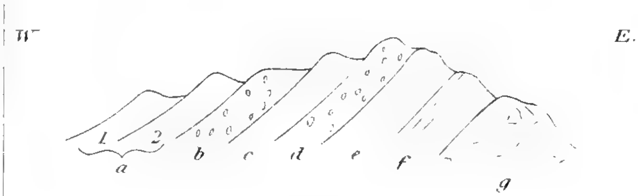
Section of Ostrea & Hinnites layers Santa Margarita

Fig. 2.



Section of Santa Lucia Range

Fig. 3.



Panza Hill

Fig. 4.

Terraces on the Santa Maria River

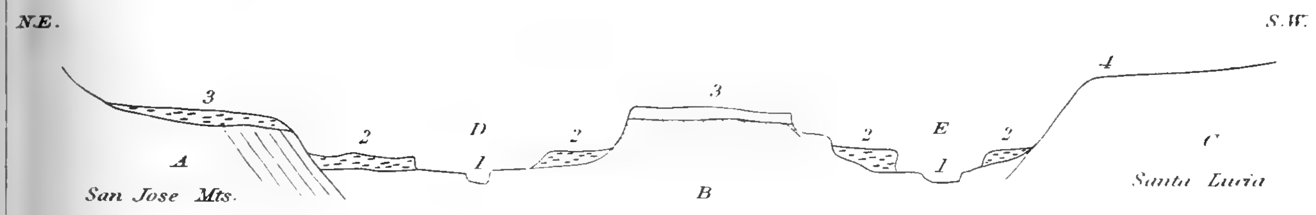


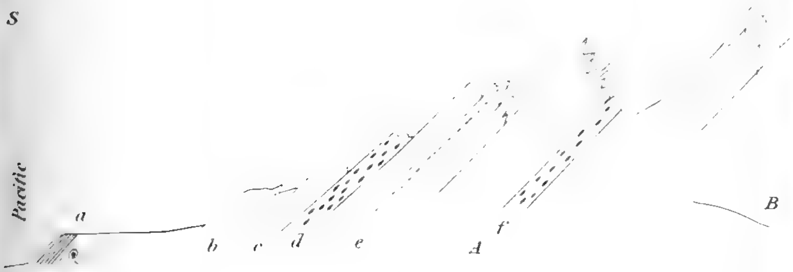
Fig. 5.

Section of San Jose Range

Fig 1

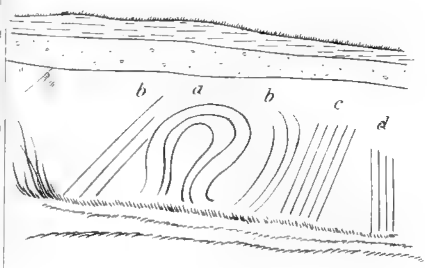
Section across Valley Santa Inez to Camp 22

Fig 2



Santa Barbara Range at Gaviote Pass

Fig 3



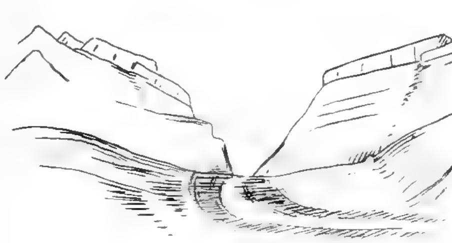
On Arroyo Hondo

Fig 4

Santa Barbara Mts

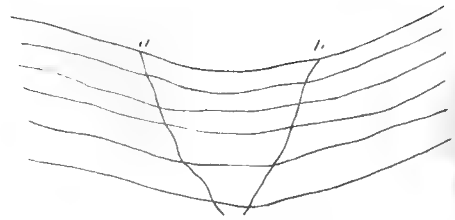
Section from shore at Arroyo Hondo across the Santa Inez & San Rafael Mts

Fig. 1.



Gaviote Pass looking south

Fig. 2.



Ideal section of pass

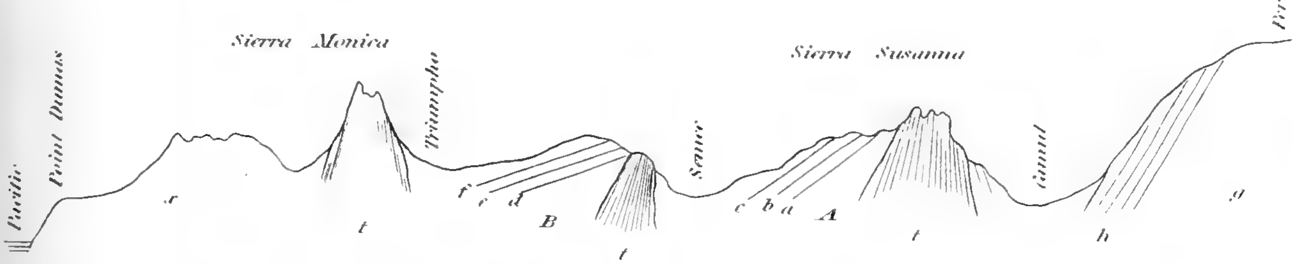
Fig. 3.

Asphalte Cliff Santa Barbara

Fig. 4.

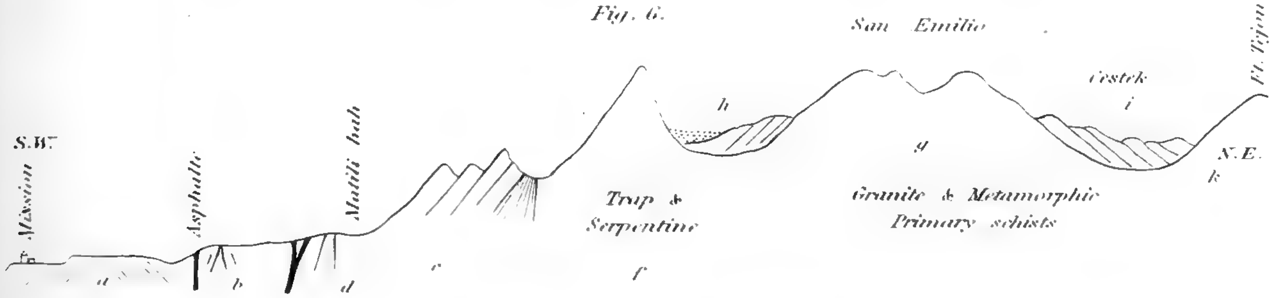
Asphalte Cliffs Santa Barbara

Fig. 5.



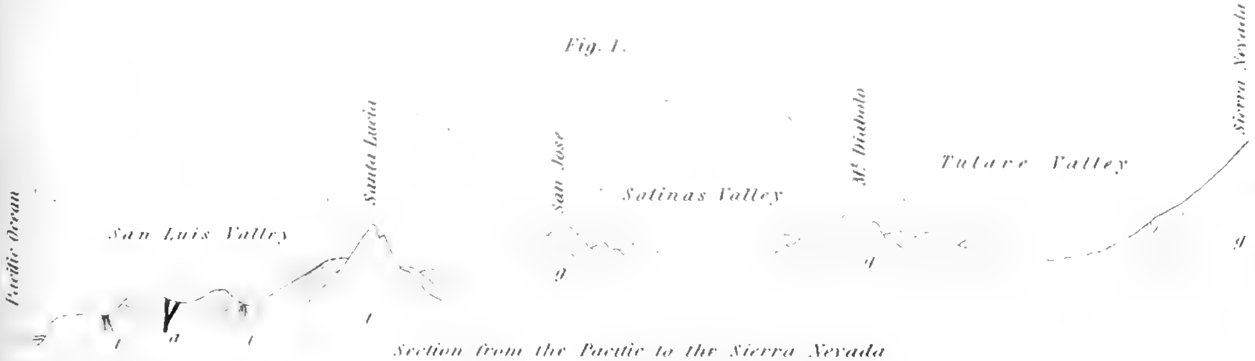
Section from Point Dumas to Perou river across Sierra Monica & Susanna

Fig. 6.



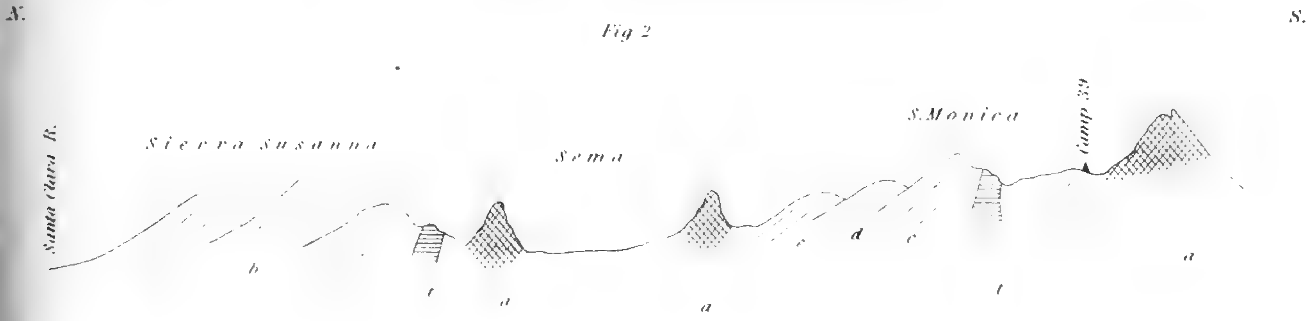
Section from San Buenaventura to Canada de las Was

Fig. 1.



Section from the Pacific to the Sierra Nevada

Fig 2

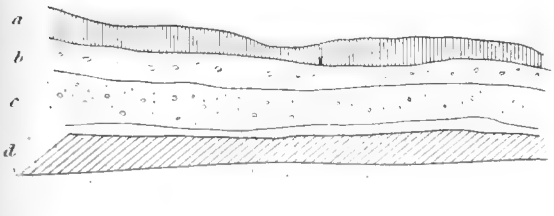


Section from Susanna Hills to Camp 39

Fig. 3.

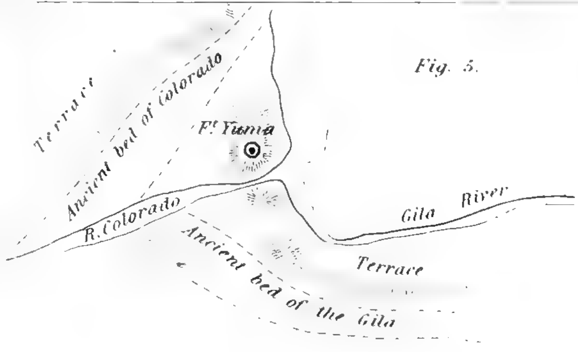
Section from San Pedro to the Cordilleras

Fig. 4.



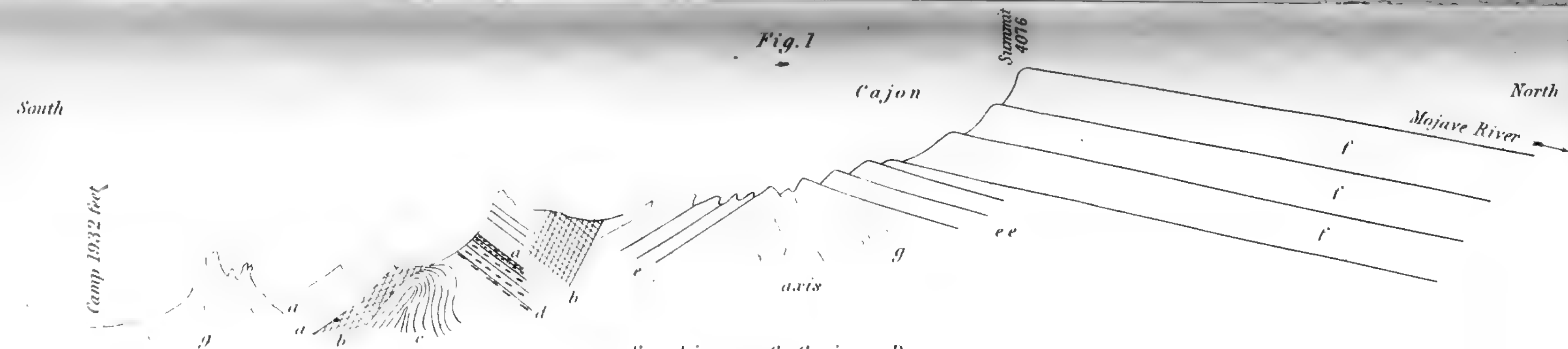
Cliff at San Pedro

Fig. 5.



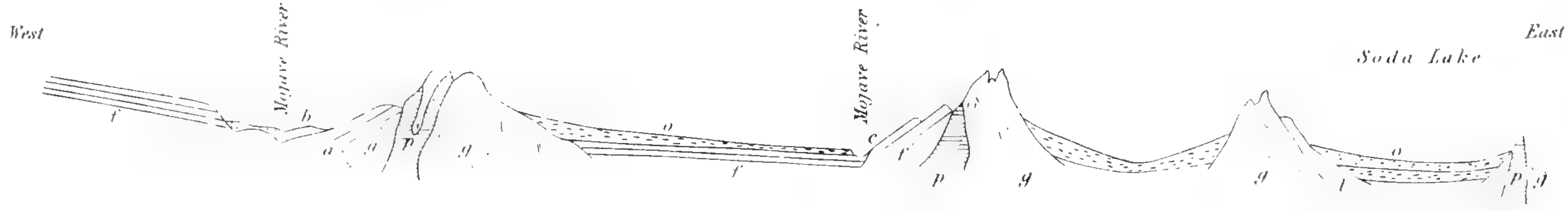
Junction of Gila & Colorado Rivers

Fig. 1



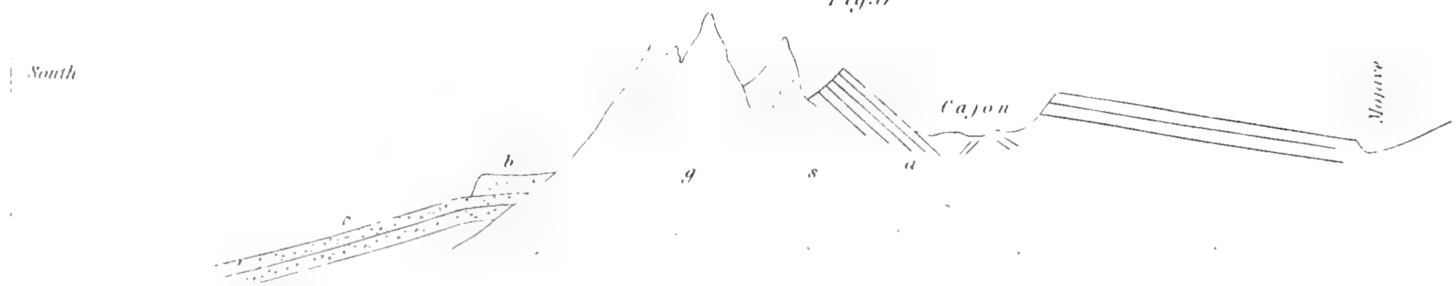
Section of Cajon Pass

Fig. 2



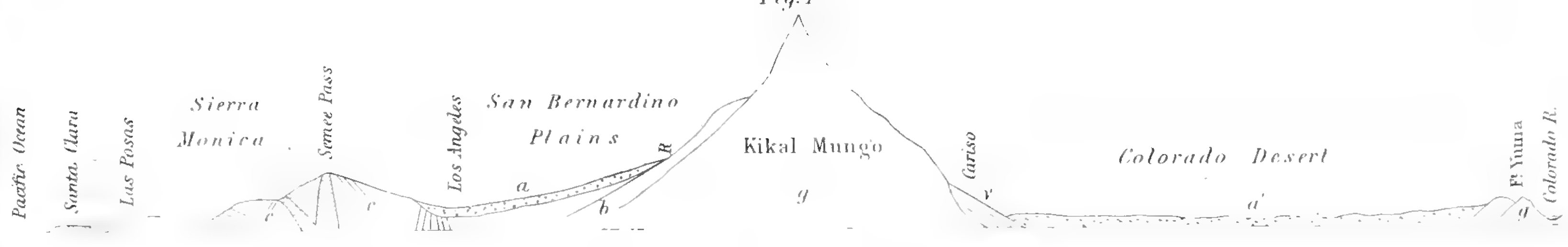
Section from Mojave River to Soda Lake

Fig. 3



Section from Valley Santa Anna to Mojave River

Fig. 1



Section from Pacific Ocean to Colorado River

Fig. 2

Section from Santa Margarita through Santa Lucia range to the Pacific

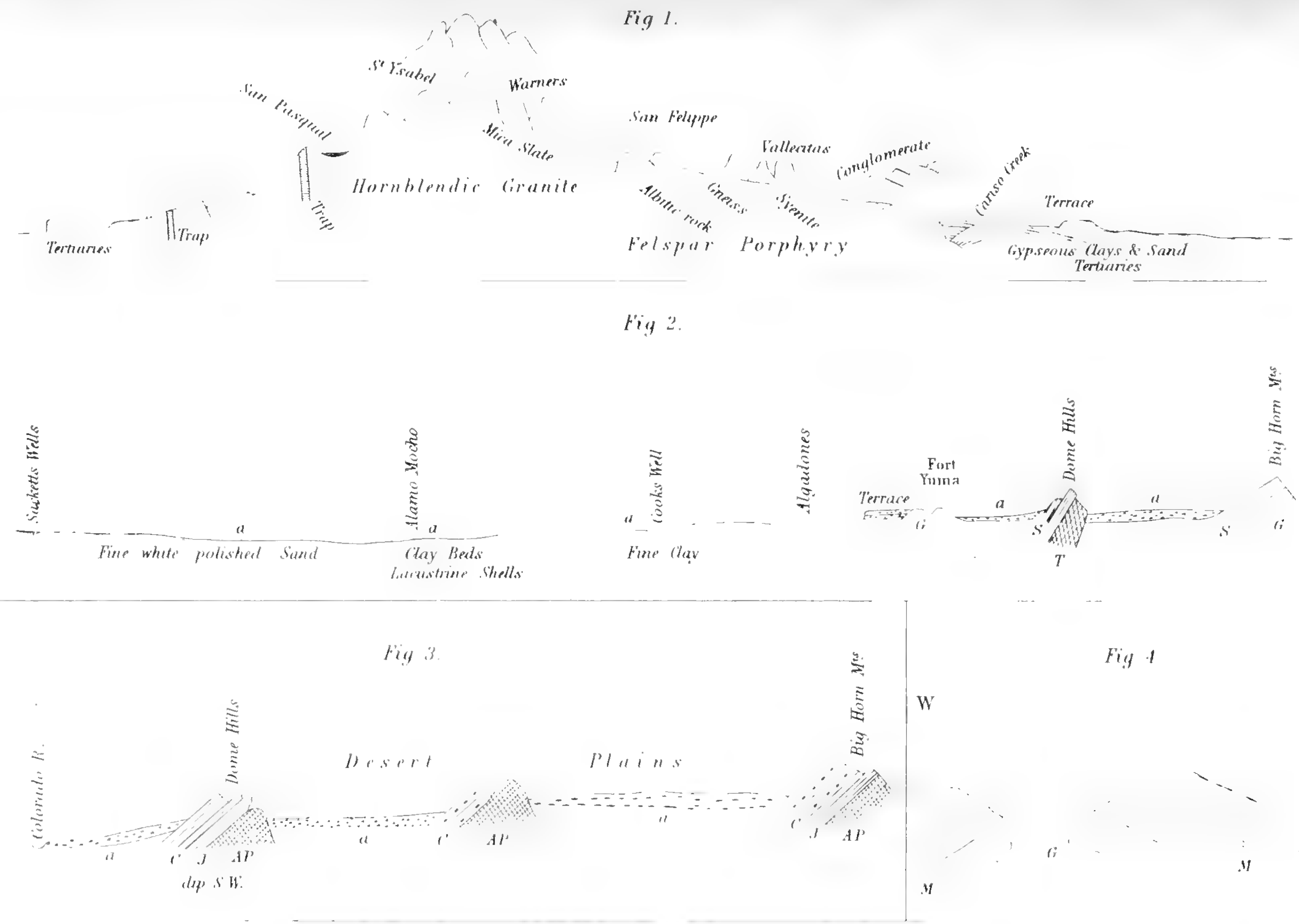


Figure 1 Geological Structure from San Diego to the Desert
2 " " Sacketts Wells to Big Horn Mts.
3 " " From Colorado River to Big Horn Mts. Enlarged Section
4 Anticlinal Axis & upheaval of Gneiss near Vallecitas

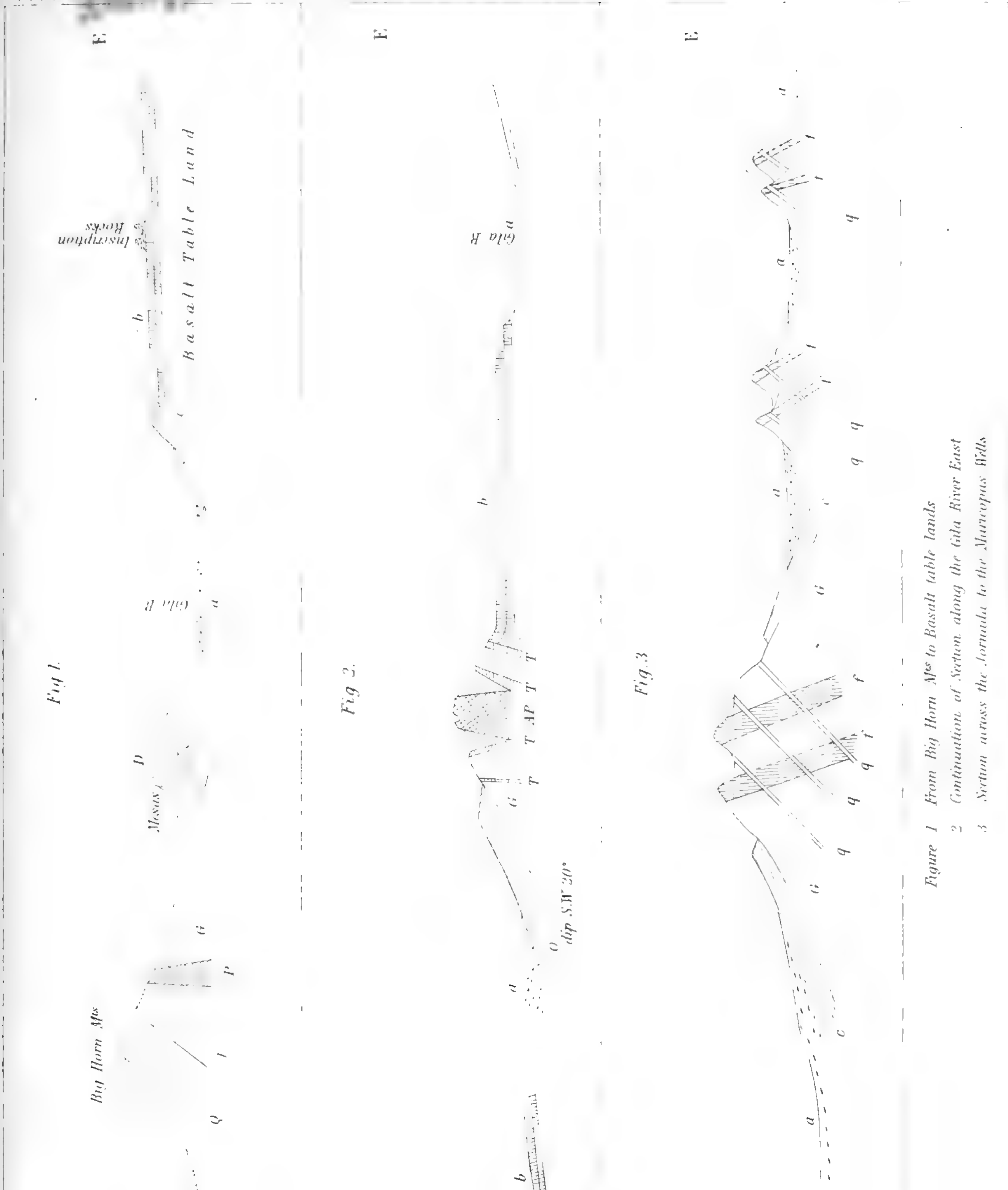


Figure 1 From Big Horn Mts to Basalt table lands
2 Continuation of Section along the Gila River East
3 Section across the Jornada to the Maricopas Wells

Figure 1.

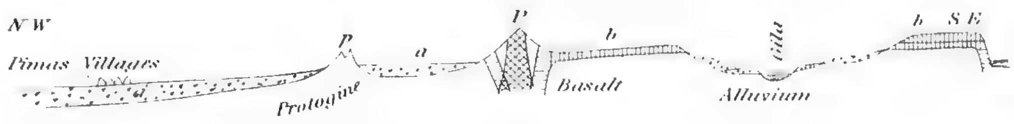


Figure 2.

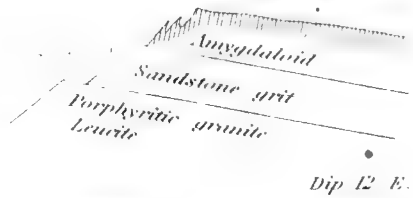


Figure 5.

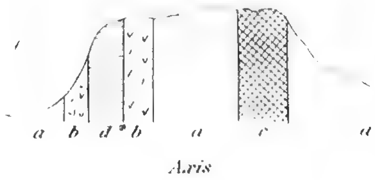
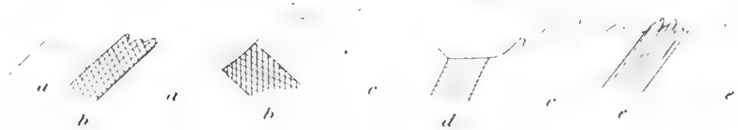


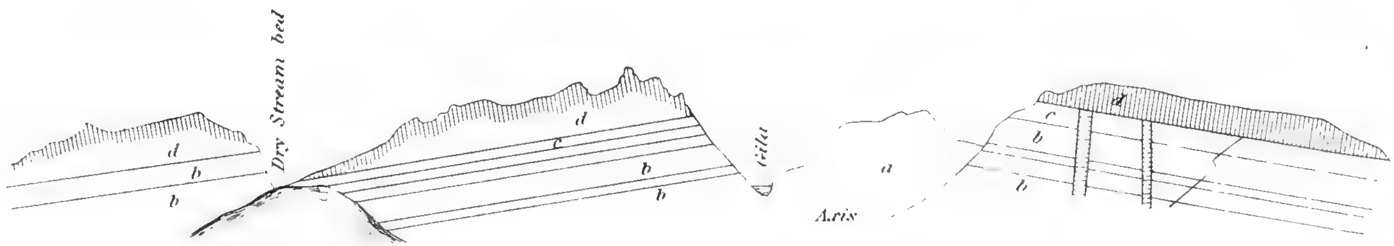
Figure 3.

10 mile Section



Igneous & Plutonic rocks on Gila July 6

Figure 4.



Section at Gila River Entering the Canon

Figure 1. From Pimas Villages to River Gila July 4.
2. Section of Hill near Camp July 6
3. 10 mile Section along the Gila
4. Anticlinal Axis entering the Canon
5. Structure of Axis rock

Figure 1.

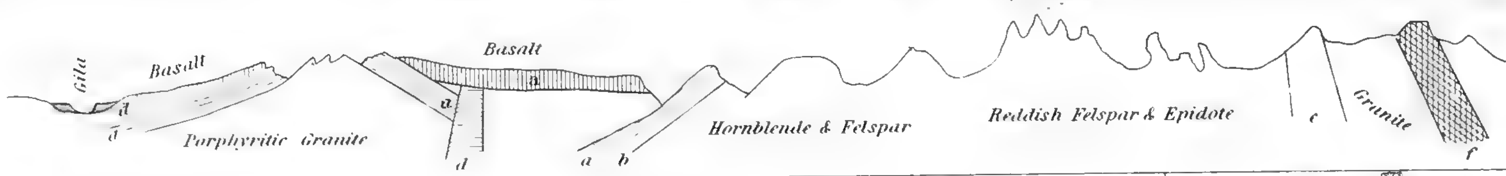
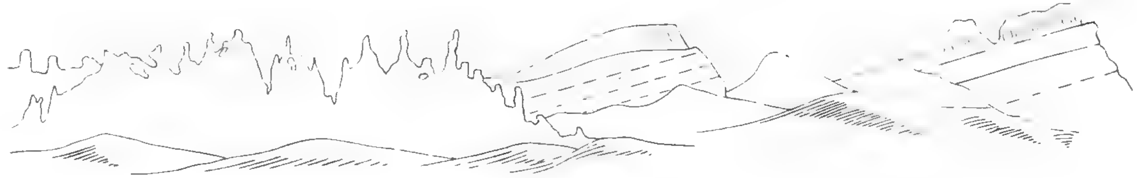


Figure 2.



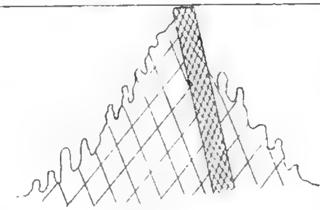


Figure 3

Figure 4.

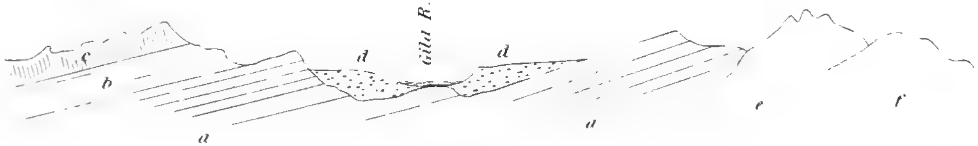


Figure 6.

Figure 5

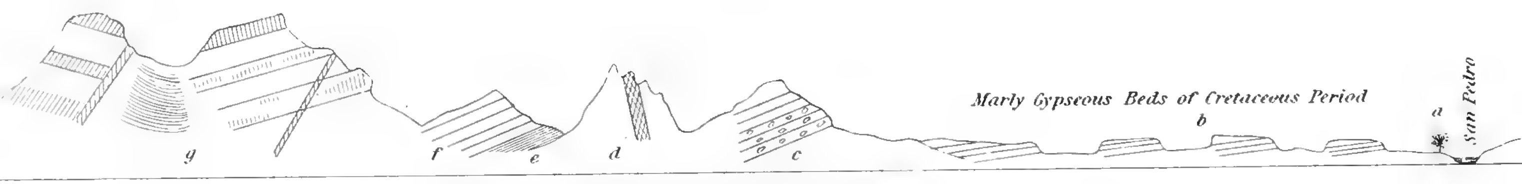


Figure 1. Structure along the Gila in Cañons
2. Outline of the Spire Hills & distant basalt Capped Hills
3. Cross section of the Spire Hills
4. Section of Gila bed at Camp July 7 looking S.E.
5. Section from San Pedro Eastward across the Calitro Mountains
6. Gypseous strata on River side

Fig. 1.

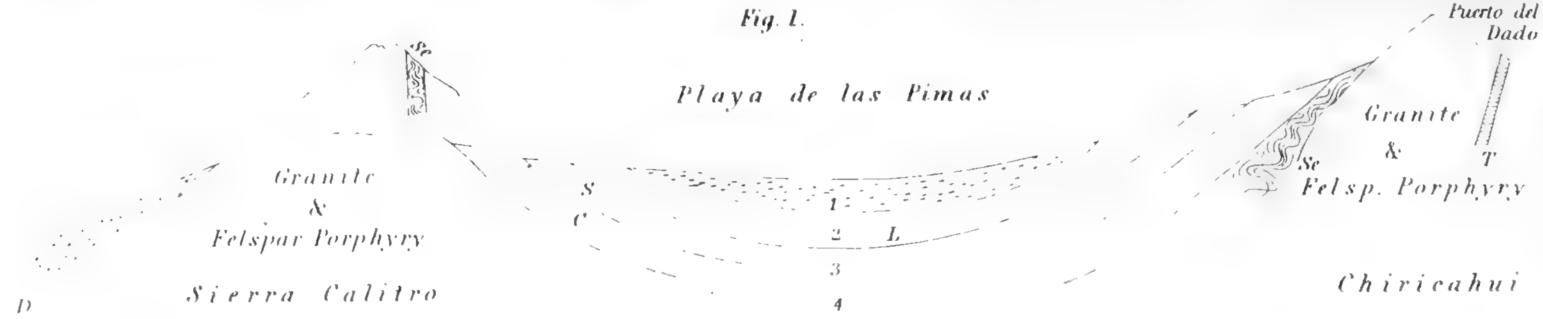


Fig 2

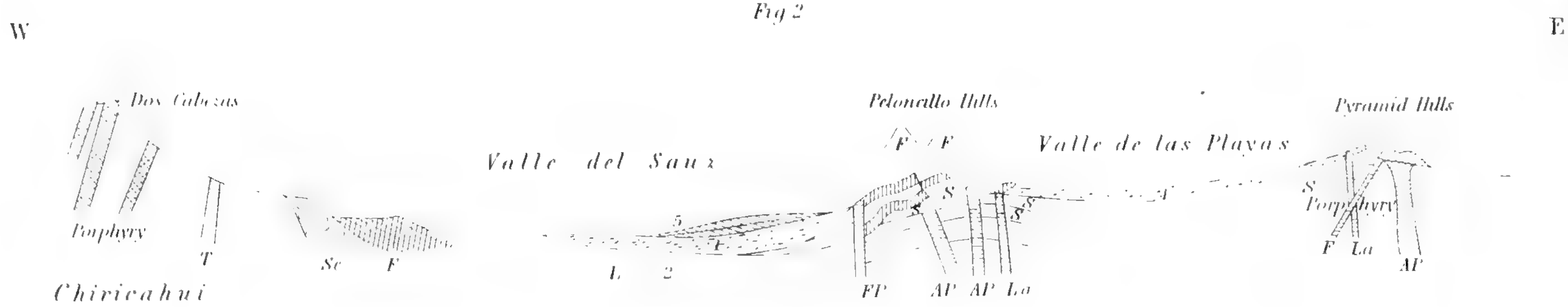


Fig 3.

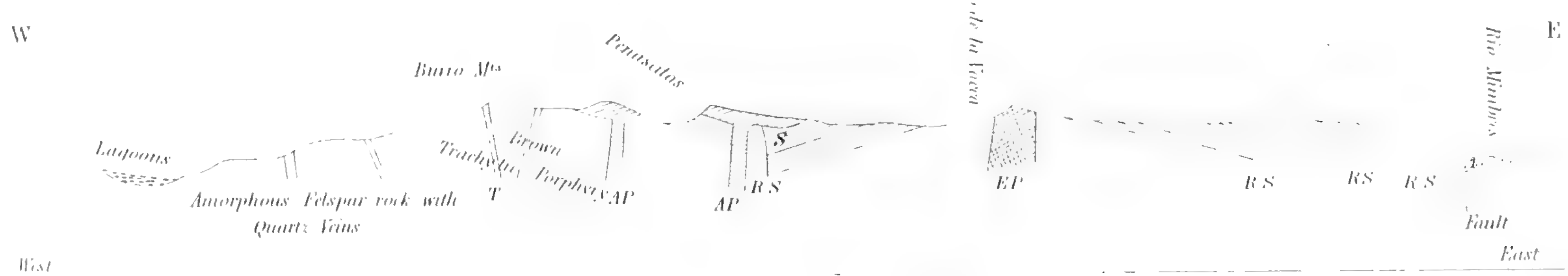


Figure 1. Profile from San Pedro River to Chiricahui Mountain
2. Chiricahui Mt to Valle de las Playas
3. Valle de las Playas to Rio Mimbres

Fig 1.

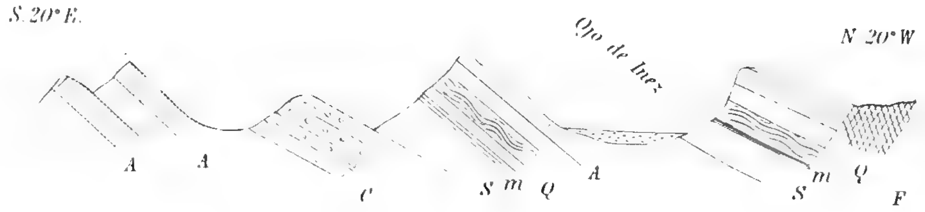


Fig 5.

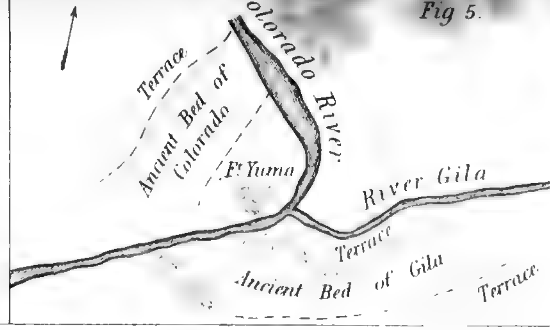


Fig 3

Fig 2

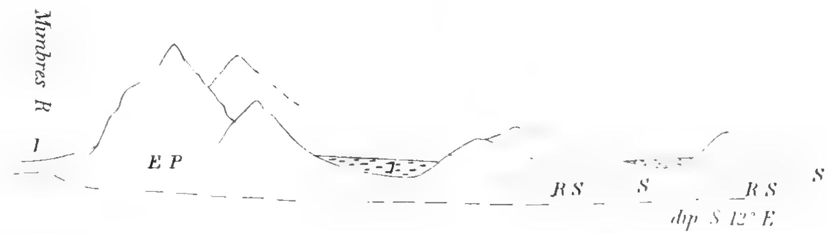


Fig 4

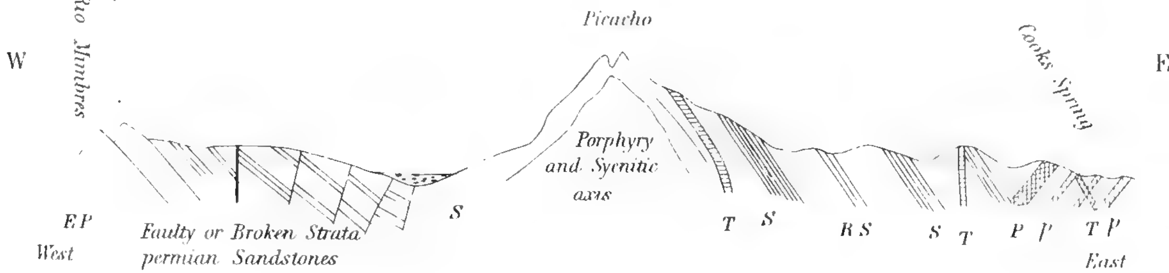


Figure 1 Strata metamorphosed near Penasatas
2 Along left bank of Mimbres. Camp. August 10
3 From Ojo de Vaca to Mimbres on the Terrace
4 From Rio Mimbres to Cooks Spring
5. Ancient river bottoms of Colorado & Gila at their junction

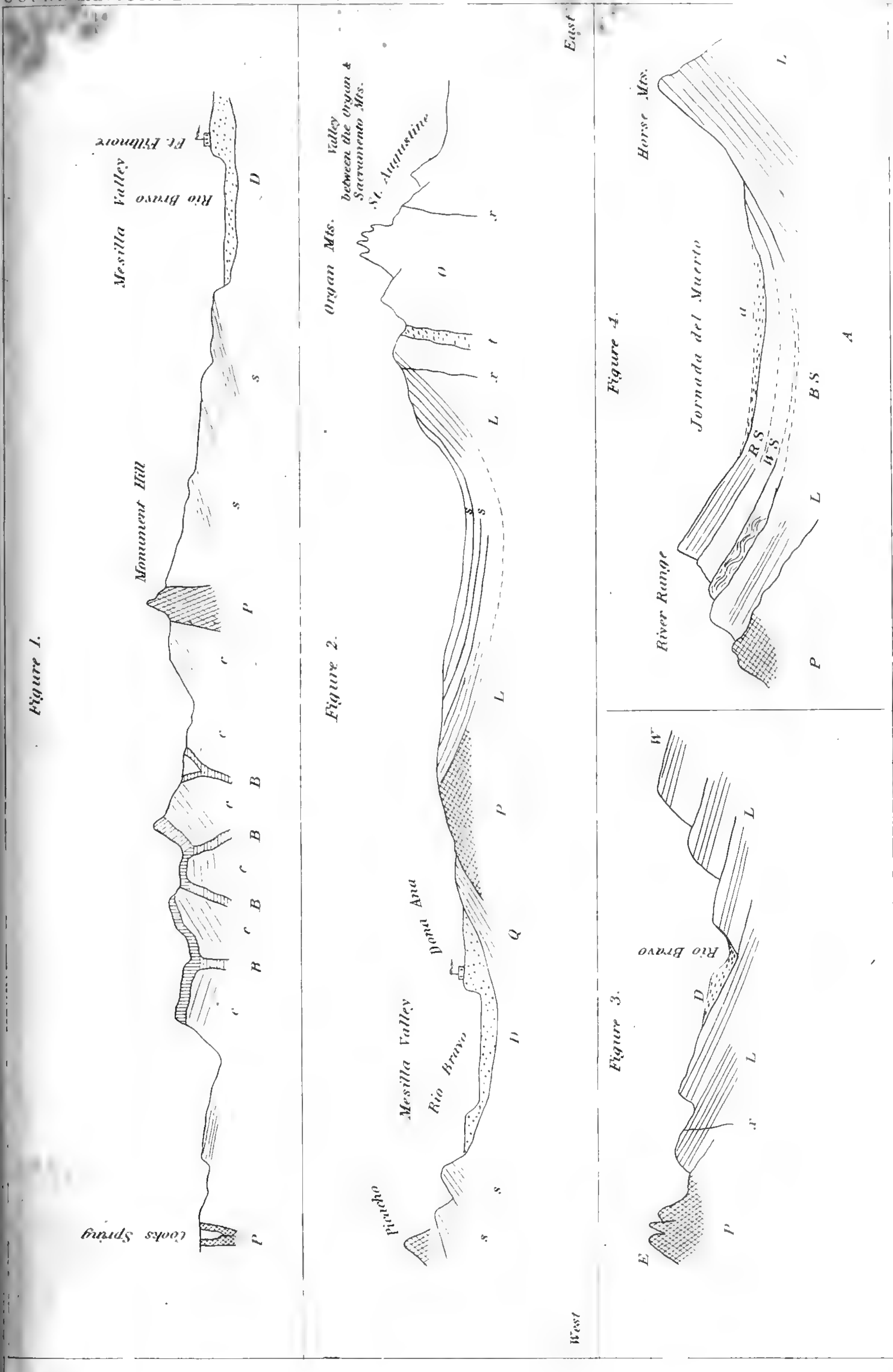
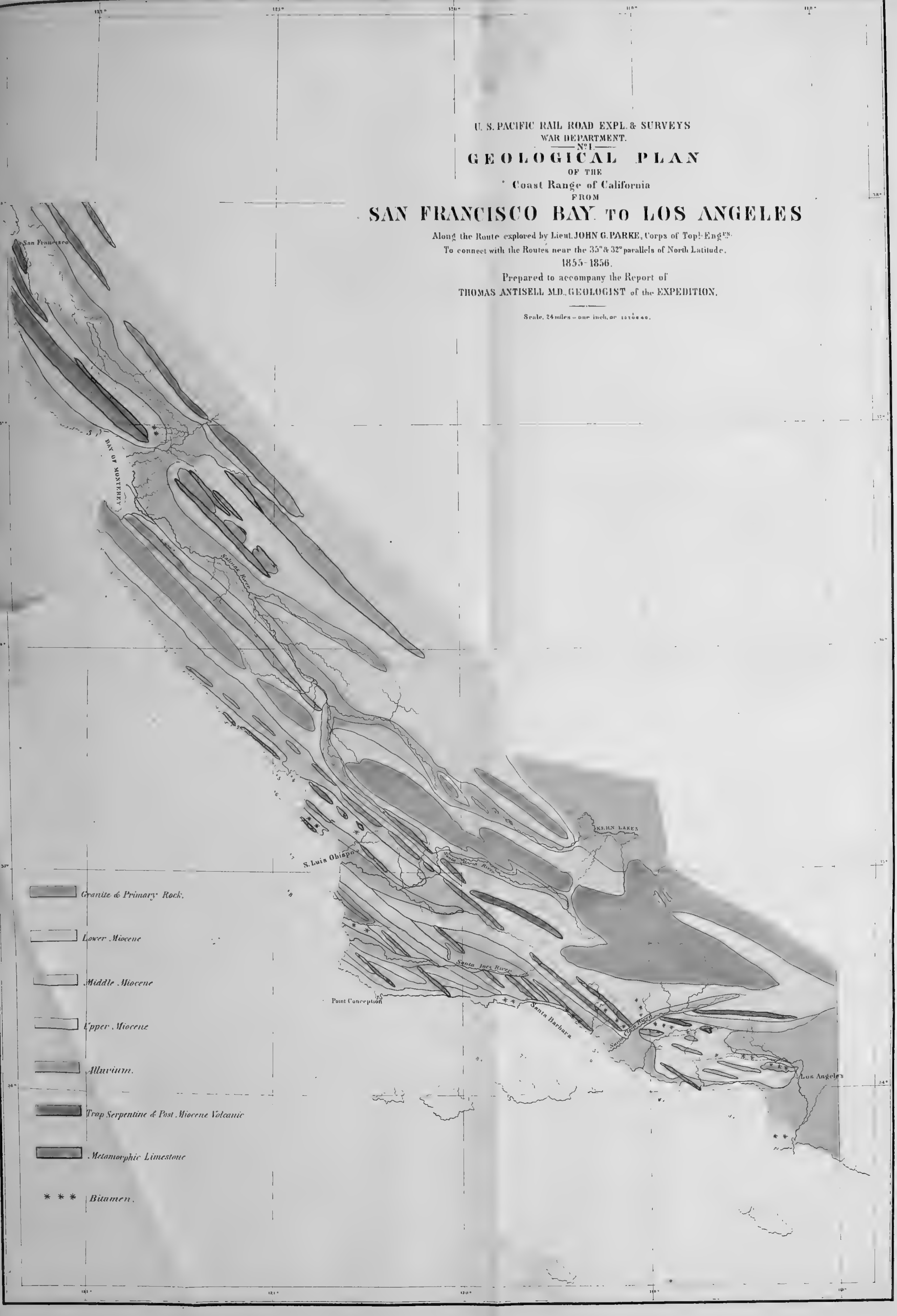
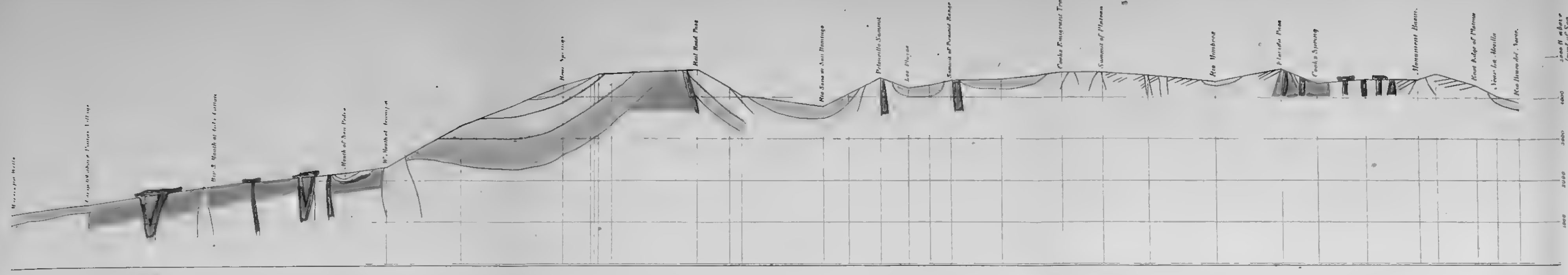


Plate 7.

Figure 1. From Cooks Spring to Fort Fillmore
2. From picacho Dona Ana to Valley of Sacramento Mts.
3. Pass at El Paso Looking South
4. Section of Jornada del Muerto


U. S. PACIFIC RAIL ROAD EXPL. & SURVEYS
WAR DEPARTMENT.
Nº 1.
GEOLOGICAL PLAN
OF THE
Coast Range of California
FROM
SAN FRANCISCO BAY TO LOS ANGELES
Along the Route explored by Lieut. JOHN G. PARKE, Corps of Topl. Engrs.
To connect with the Routes near the 35° & 32° parallels of North Latitude.
1855-1856.
Prepared to accompany the Report of
THOMAS ANTISELL M.D., GEOLOGIST of the EXPEDITION.
San Francisco
BAY OF MONTEREY
Salinas River
KERN LAKES
S. Luis Obispo
Santa Maria River
Santa Ines River
Point Conception
Santa Barbara
Santa Clara River
Los Angeles
Granite & Primary Rock.
Lower Miocene
Middle Miocene
Upper Miocene
Alluvium.
Trap Serpentine & Post Miocene Volcanic
Metamorphic Limestone
* * * Bitumen.



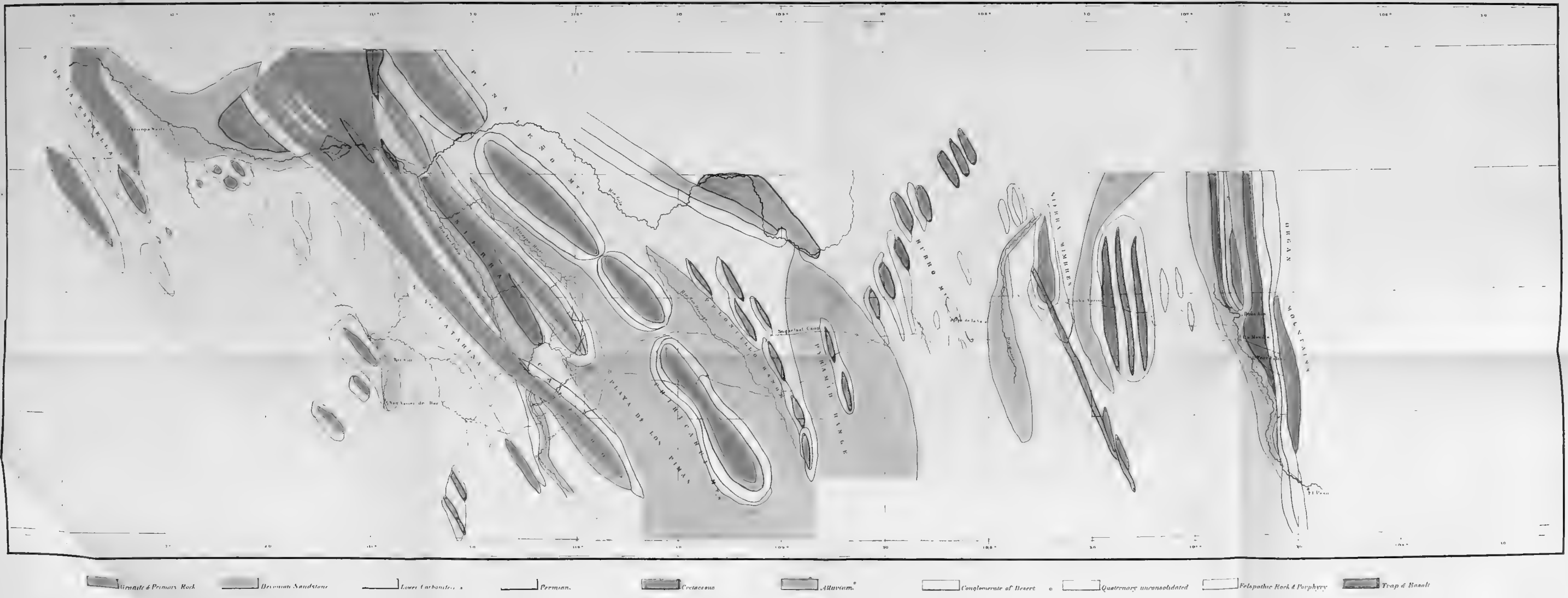
U.S. PACIFIC RAIL ROAD EXPL. & SURVEYS
WAR DEPARTMENT.
— Nº 2 —

GEOLOGICAL PLAN & SECTION
FROM THE
RIO GRANDE TO THE PIMAS VILLAGES

Along the Route explored by Lieut. JOHN G. PARKE, Corps of Top! Eng!s
Near the Parallele of 32° North Latitude.
1856

Prepared to accompany the Report of
THOMAS ANTISELL M.D. GEOLOGIST of the EXPEDITION.

Scale, nearly 1/1000000



PART III.

EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.
WAR DEPARTMENT.

ROUTES IN CALIFORNIA TO CONNECT WITH THE ROUTES NEAR THE THIRTY-FIFTH AND THIRTY-SECOND PARALLELS, AND ROUTE NEAR THE THIRTY-SECOND PARALLEL, BETWEEN THE RIO GRANDE AND PIMAS VILLAGES, EXPLORED BY LIEUTENANT JOHN G. PARKE, CORPS OF TOPOGRAPHICAL ENGINEERS, IN 1854 AND 1855.

BOTANICAL REPORT:

BY

JOHN TORREY, M. D.

WASHINGTON, D. C.
1856.

CONTENTS.

LIST OF PLATES.

CHAPTER I.

LIST AND DESCRIPTION OF THE PLANTS COLLECTED.

BY JOHN TORREY, M. D.

RANUNCULUS CALIFORNICUS, *Benth. Pl. Hartw. p.* 295. Santa Clara to Los Angeles; February to March. The sepals of this species are frequently partly or entirely white.

DELPHINIUM DECORUM, *Fisch. & Mey. Index sem.* (3) *Tetrop. p.* 33. Cajon Pass; April.

PAEONIA BROWNII, *Dougl. in Hook. Fl. Bor.-Amer.* 1, *p.* 27. P. californica, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 664. In the dried specimens the lower surface of the leaves is of a much lighter green color than the upper.

ARGEMONE HISPIDA, *Gray, Pl. Fendl. p.* 5. Burro mountains, New Mexico; August. The specimens seem to confirm the characters of this species.

ESCHSCHOLTZIA CALIFORNICA, *Hook & Arn.; Torr. & Gray, Fl.* 1, *p.* 664. Santa Barbara and San Diego; February and March. Variable in the size of the flowers. This is the well known "Californian Poppy," now a common plant in gardens.

ESCHSCHOLTZIA DOUGLASII, *Hook. & Arn.; Torr. & Gray, l. c.* Valley of the Salinas river, California; November. The only specimen has a thick ligneous root, like a perennial, which is often seen in the autumnal state of this plant.

DENDROMECON RIGIDUM, *Benth.; Torr. & Gray, Fl.* 1, *p.* 64. San Diego; May, (flowers and fruit.) A low and rather ornamental shrub.

PLATYSTEMON CALIFORNICUM, *Benth.; Torr. & Gray, Fl.* 1, *p.* 65. Tulare valley and San Bernardino; April.

PLATYSTEMON CALIFORNICUM, var. LEIOCARPUM, *Torr. & Gray, l. c.* Los Angeles and San Isabel; March—May. Pedicels and calyx very villous, with long white hairs.

NASTURTIUM CURVISILIQUA, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 73. San José; November, (in fruit.)

CARDAMINE ANGULATA, *Hook.; Torr. & Gray, Fl.* 1, *p.* 84. C. paucisecta, *Benth. Pl. Hartw. p.* 297. Santa Barbara; January.

SISYMBRIUM CANESCENS, *Nutt.; Torr. & Gray, Fl.* 1, *p.* 92. Santa Barbara county; February, (in flower.)

ERYSIMUM ASPERUM, *DC.; Torr. & Gray, Fl.* 1, *p.* 96. Puerto del Dado, New Mexico; July.

ERYSIMUM ASPERUM, var. ELATUM. E. elatum, *Nutt. in Torr. & Gray, l. c.* Santa Inez; January. S. arkansanum, *Nutt.*, is another form of this variable species.

SISYMBRIUM DEFLEXUM, *Harvey Mss.; Torr. in Whipple's Rep.* Santa Clara valley; February.

Sinapis arvensis, *Linn.* San Buenaventura ranch; February. Found also by Rev. A. Fitch. Probably introduced from Europe.

Sinapis nigra, *Linn.* Tulare valley; February. This also is an introduced species.

Lepidium nitidum, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 116. Santa Clara valley; February.

Lepidium montanum, *Nutt. l. c.* Sauz valley, and Playa de los Pimas; July. The specimens show a decidedly annual root.

Dithyraea Wislizeni, *Engelm. in Wislizen, N. Mex. p.* 95; *Torr. in Sitgreave's Rep. p.* 280, *t.* 2. On the Gila river; June, in flower and fruit. Not observed before so far west. The silicles, even when young, are frequently quite smooth; in other respects agreeing with the character of the plant given by Dr. Engelmann, who has well contrasted this species with D. Californica.

Wislizenia refracta, *Engelm. in Wisliz. N. Mex. p.* 99; *Gray, Pl. Wright.* 1, *p.* 11, *t.* 2. On the Gila river. The leaves of these, and of other specimens from the same region, are minutely scabrous.

Isomeris arborea, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 124; *Bot. Mag. t.* 3842. Santa Clara valley and near San Diego; February—May. This interesting shrub is not found east of the coast range.

Viola pedunculata, *Torr. & Gray, Fl.* 1, *p.* 141. Santa Clara to Los Angeles; March. As stated in Whipple's Report, this species, V. præmorsa, *Dougl.*, V. linguæfolia, *Nutt.*, and V. Nuttallii, *Pursh*, should, perhaps, be united.

Silene Californica, *Durand. in Jour. Acad. Philad.* (*n. ser.*) 2, *p.* 83. S. pulchra, *Torr. & Gray, Fl.* 1, *p.* 675, (in part.) San Diego; May.

Talinum aurantiacum, *Engelm. in Pl. Lindh.* 2, *p.* 54; *Gray, Pl. Wright.* 2, *p.* 20. On San Pedro river, tributary of the Gila; July.

Talinum aurantiacum, var. angustissimum, *Gray, Pl. Wright.* 1, *p.* 14, *and* 2, *p.* 20. Burro mountains; August.

Calandrinia Menziesii, *Hook. Fl. Bor.-Amer. p.* 223 *t.* 70. Los Angeles; March.

Claytonia perfoliata, *Donn; Bot. Mag. t.* 1336; *Torr. & Gray, Fl.* 1, *p.* 200 *and* 676. Los Angeles; March. The typical form of the species.

Sidalcea malvæflora, *Gray, Pl. Wright.* 1, *p.* 16. S. Neo-Mexicana, *Gray, Pl. Fendl. p.* 23. Rio Mimbres; August.

Sidalcea humilis, *Gray, Pl. Fendl. p.* 20. Santa Clara to San Diego; February to April.

Malvastrum coccineum, *Gray, Pl. Fendl. p.* 24. On the Gila river; June.

Sphaeralcea incana, *Torr. in Gray, Pl. Fendl. p.* 23; *Gray, Pl. Wright.* 1, *p.* 21. With the last.

Sphaeralcea incana, var. dissecta, *Gray, l. c.* Chiricahui mountains.

Sphaeralcea angustifolia, *Spach*, var. foliis lanceolatis inferioribus nunc hastato-subtrilobatis, *Gray, Pl. Wright.* 2, *p.* 21. San Pedro of the Gila; July.

Sphaeralcea Fendleri, *Gray, Pl. Wright.* 1, *p.* 21. On the Gila river; July.

Hibiscus denudatus, *Benth.* var. involucellatus, *Gray, Pl. Wright.* 1, *p.* 22. Puerto del Dado; July.

Erodium cicutarium, *Herit.; Torr. & Gray, Fl.* 1, *p.* 208. Tulare valley and Kikal Mungo; March.

Erodium moschatum, *Willd.; DC. Prodr.* 1, *p.* 647. Los Angeles; March. Probably introduced from Europe; but De Candolle states that it grows in Peru.

Linum perenne, *Linn.; Torr. & Gray, Fl.* 1, *p.* 204. Valley of Los Playas, New Mexico; August.

Oxalis stricta, *Linn.; Torr. Fl. New York*, 1, *p.* 123. San Luis Obispo and Salinas valley; December.

Larrea Mexicana, *Moricand; Torr. in Emory's Rep. p.* 138, *t.* 3; *Gray, Gen. Ill.* 2 *p.* 119, *t.* 147. Cook's well, west of the Colorado, and from thence east to the Rio Grande. May, in flower and fruit.

Ceanothus divaricatus, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 266. San Diego; May, in flower.

Ceanothus spinosus, *Nutt. l. c.* Santa Inez; February, in flower. The specimens are scarcely at all spiny.

Frangula Californica, var. tomentella, *Gray, Pl. Wright*, 2, *p.* 28. Rhamnus tomentellus, *Benth. Pl. Hartw.* Puerto del Dado; in fruit.

Janusia gracilis, *Gray, Pl. Wright*, 1, *p.* 37 *and* 2, *p.* 30. Burro mountains, New Mexico; August, in flower. By the aid of excellent fruiting specimens, from Dr. Bigelow's collections, we are able to give a good figure of this plant.—(Tab. I.)

Rhus trilobata, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 219. Puerto del Dado. July, in fruit.

Styphonia integrifolia, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 220; *Nutt. Sylv.* 3, *p.* 4, *t.* 82. S. serrata, *Nutt. l. c.* Santa Barbara and Santa Inez. August, in fruit. Both entire and serrate leaves occur on the same specimens.—(Tab. II.)

Vitis æstivalis, *Michx.; Torr. & Gray, Fl.* 1, *p.* 244? On the Mimbres. The specimens are without flowers or fruit. The leaves are smaller and less deeply toothed than in the plant of the northern States.

Ampelopsis quinquefolia, *Michx.; Torr. & Gray, Fl.* 1, *p.* 245. With the last; also in fruit. August.

Polygala cucullata, *Benth. Pl. Hartw. p.* 299, *No.* 1661; *Torr. & Gray, in Emory's Report, ined. tab.* —. P. cornuta, *Kellogg, in Proceed. Calif. Acad. N. Sc.* 1, *p.* 62. San Buenaventura ranch; February.

Krameria lanceolata, *Torr. in Ann. Lyc. Nat. Hist. N. York*, 2, *p.* 168, *Gray, Gen. Ill.* 2, *t.* 185 *and* 186. Sauz valley; August, in flower.

Krameria canescens, *Gray, Pl. Wright*, 1, *p.* 42. Desert west of the Colorado; May, flower and fruit.

Lathyrus venosus, *Muhl.; Torr. & Gray, Fl.* 1, *p.* 274. Cajon Pass, March.

Lathyrus vestitus, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 276. San Gabriel and Santa Inez; January and February.

Vicia Oregana, *Nutt. in Torr. & Gray, Fl. l. c.* V. truncata, *Nutt. l. c.* San Juan, California; November.

Dalea spinosa, *Gray; Pl. Thurb. p.* 315. Cariso creek, and on the Colorado river; June. In favorable situations this remarkable species attains the height of 12 or 15 feet. The trunk is sometimes 4 inches in diameter, and the wood is hard and close-grained. The specimens are in full flower, a state in which we have rarely received the plant. The leaves are very deciduous.—(Tab. III.)

Amorpha fruticosa, *Linn.; Torr. & Gray, Fl.* 1, *p.* 304. San Pedro of the Rio Gila; July, flowers and young fruit. A very glabrous form of the plant, with scattered glands on the under side only. Calyx with short obtuse teeth.

Melilotus parviflorus, *Desf.; Torr. & Gray, Fl.* 1, *p.* 321. Los Angeles; March. Probably introduced from Europe.

MEDICAGO DENTICULATA, *Willd.; Torr. & Gray, l. c.* With the last, and also a naturalized plant.

HOSACKIA PUBERULA, *Benth. Pl. Hartw. p.* 305; *Gray Pl. Wright,* 1, *p.* 50. Chiricahui mountains, New Mexico; August.—(Tab. IV.)

HOSACKIA CYTISOIDES, *Benth.; Torr. & Gray, Fl.* 1, *p.* 324. Salinas valley, California; November. Foliage only.

HOSACKIA SCOPARIA, *Benth.; Torr. & Gray, Fl.* 1. *p.* 325. Kikal Mungo and Warner's ranch; March to May.

HOSACKIA STRIGOSA, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 326. San Gabriel and Los Angeles; March.

ASTRAGALUS (PHACA) DENSIFOLIA. Phaca densifolia, J. E. Smith; *Torr. & Gray, Fl.* 1, *p.* 344 *and* 693; *Hook. Ic. t.* 2 *and* 3. P. Nuttallii, *Torr. & Gray, l. c.* San Gabriel and San Bernardino; March.

HOMALOBUS MULTIFLORUS, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 350. Santa Inez. January, flower and young fruit. This agrees very well with Nuttall's specimens, but better with Phaca nigrescens, Hook., which we refer to H. multiflora.

LUPINUS HIRSUTISSIMUS *Benth.; Torr. & Gray, Fl.* 1, *p.* 372. San Gabriel and Santa Clara valley; February and March.

LUPINUS ORNATUS, *Dougl.; Torr. & Gray, Fl.* 1, *p.* 380. San Juan, California; November. A fine shrubby species, well deserving a place in the flower garden.

HOFFMANSEGGIA STRICTA, *Benth. in Gray, Pl. Wright,* 1, *p.* 56. Ojo de Vaca; August.

CASSIA LINDHEIMERIANA, *Scheele; Gray, Pl. Lindheim.* 2, *p.* 179. San Pedro and Burro mountains, New Mexico; July and August. In all the specimens the leaves have but three pairs of leaflets, and they are smaller than in the ordinary form of the plant.

OLNEYA TESOTA, *Gray, Pl. Thurb. p.* 328. On diluvial hills of the Colorado river, near Fort Yuma; March. This, according to Mr. Thuber, is the *Tesota* of the Mexicans, but Mr. Schott informs us that its more common name is *Arbol de hierro,* and that the Acacia Greggii is the true Tesota. There is, however, but little dependence to be placed on the common names of plants, especially among rude and ignorant people.—(Tab. V.)

ACACIA GREGGII, *Gray, Pl. Wright,* 1, *p.* 65. Vallecitas, west of the Colorado; May, in flower; Burro mountains; August, in fruit.

ACACIA CONSTRICTA, *Benth. in Gray, Pl. Wright, l. c.* On the San Pedro, a tributary of the Gila; July.

ACACIA CUSPIDATA, *Schlecht.; Gray, Pl. Wright,* 1, *p.* 66. San Pedro river, and Chiricahui mountains; July.

STROMBOCARPA PUBESCENS, *Gray, Pl. Wright,* 1, *p.* 60. Prosopis (Strombocarpa) pubescens, *Benth.* P. (Strombocarpa) Emoryi, *Torr. in Emory's Rep. p.* 139. P. odorata, *Torr. in Frém. 2d Report, p.* 313 (the fruit only.) Common along the Gila and about San Felipe, &c., California. This is the *Screwbean* or *Screw Mesquite.* The Sonora Mexicans call it *Tornillo.* The figure in Frémont's second report is made up of the foliage and flowers of Algarobia glandulosa and the fruit of Strombocarpa; an error that arose from a mixing of the specimens in the original collections. I have, therefore, in the botany of Williamson's report, given a new figure of this important tree, the fruit of which yields food to man and beast.

ALGAROBIA GLANDULOSA, *Torr. & Gray, Fl.* 1, *p.* 399. Prosopis glandulosa, *Torr. in Ann. Lyc. N. York,* 2, *p.* 192, *t.* 2. Common along the Gila river. Fine specimens, with pods 9 or

10 inches long, are in the collection. This is the tree so well known under the name of *Mesquite* or *Mesquit.* A gum, resembling gum arabic, exudes from the bark.

CERASUS SEROTINA, *DC.; Torr. & Gray, Fl.* 1, *p.* 410. Sauz valley; August. In fruit.

ADENOSTOMA FASCICULATA, *Hook. & Arn. Bot. Beechey, p.* 139, *t.* 139, *and p.* 338. Near San Diego; not rare. May.

HORKELIA FUSCA, *Lindl. Bot. Reg. t.* 1997; *Torr. & Gray, Fl.* 1, *p.* 435. Near Los Angeles and San Gabriel; March. The petals vary in breadth in different states of the flower.

RUBUS URSINUS, *Cham. and Schlecht. in Linnæa,* 2, *p.* 11. Near Santa Barbara; January.

ROSA BLANDA, *Ait.; Torr. & Gray, Fl.* 1, *p.* 459. On the Mimbres. In fruit; August. The stipular prickles are straight and slender, and there are scattered stiff bristles on the stem.

ROSA CINNAMOMEA, *Linn.; Torr & Gray, Fl.* 1, *p.* 459. On the Salinas, and near San Bernardino; April. Our specimens agree with the European plant in most respects. The leaflets are pulverulent, rusty underneath. The prickles are all stipular and stout.

ZAUSCHNERIA CALIFORNICA, var. α and β. *Torr. & Gray, Fl.* 1, *p.* 486. San Juan, California, and Puerto del Dado; August and November.

ŒNOTHERA CORONOPIFOLIA, *Torr. & Gray, Fl.* 1, *p.* 495. On the Gila river; June.

ŒNOTHERA VINOSA, *Lindl.; Torr. & Gray, Fl.* 1, *p.* 503. Near San Diego; April.

ŒNOTHERA VIMINEA, *Dougl. in Hook. Bot. Mag. t.* 2873. San Isabel; May.

ŒNOTHERA BISTORTA, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 508. With the last; May.

ŒNOTHERA ALBICAULIS, *Nutt.*, var. integrifolia? Kikal Mungo; March. A low form, with leaves on long tapering petioles, and the lamina repand-dentate at the base. It seems to be one of the numerous varieties of Œnothera albicaulis.

ŒNOTHERA CHEIRANTHIFOLIA, *Hornem.; Lindl. Bot. Reg. t.* 1040. Santa Clara, Tulare valley, San Gabriel, &c.; March.

ŒNOTHERA STRIGULOSA, *Torr. & Gray, Fl.* 1, *p.* 512. Los Angeles, &c.; common; March.

APODANTHERA? UNDULATA, *Gray, Pl. Wright.* 2, *p.* 60. San Pedro of the Gila; July. Male flowers only.

CUCURBITA DIGITATA, *Gray, l. c.* On the Burro mountains; August. Flowers or peduncles nearly two inches long. Dr. Gray (l. c.) remarks that the calyx-lobes of the male flowers are obsolete; but they are quite conspicuous in Dr. Antisell's specimens. Santa Barbara and Los Angeles.

MEGARRHIZA CALIFORNICA, *Torr. in Whipple's Rep.;* January and March. This is one of the plants known in California by the name of *big-root* or *giant-root*, of which a more detailed account is given in the work just quoted.

RIBES CALIFORNICUM, *Hook. & Arn. Bot. Beechey, p.* 346. Salinas valley and Santa Inez; January. Some of the specimens have only small sub-axillary species, without scattered prickles; others have strong stipular spines and scattered retrorse prickles. To this species we refer R. occidentale and subvestitum. See Whipple's Report.

RIBES MALVACEUM, *Smith; Torr. & Gray, Fl.* 1, *p.* 552. San Luis Obispo; January.

ECHINOCACTUS LECONTEI, *Engelm. in Proceed. Amer. Acad. Sc.* 3, *p.* 19, *and in Whipple's Pacific R. R. Rep.* Colorado desert, California.

FOUQUIERIA SPLENDENS, *Engelm. in Wisliz. N. Mex. p.* 98; *Gray, Pl. Wright,* 1, *p.* 76, *and* 2, *p.* 63. F. spinosa, *Torr. in Emory's Rep.* 147, *t.* 8, excl. syn. Cariso creek, California; May.

LITHOPHRAGMA CYMBALARIA, *Torr. & Gray, Fl.* 1, *p.* 585. Santa Clara and Santa Barbara; February.

SANICULA BIPINNATIFIDA, *Dougl. in Hook. Fl. Bor.-Amer.* 1, *p.* 258, *t.* 92. Santa Inez and Los Angeles; February and March. Leaves almost pedate.

ERYNGIUM PETIOLATUM, *Hook. Fl. Bor.-Amer.* 1, *p.* 251. E. articulatum, *Hook. Lond. Jour. Bot.* 6, *p.* 232. Salinas valley; November. A dwarf form of the plant; only 2 to 3 inches high.

PEUCEDANUM UTRICULATUM, *Nutt. in Torr. & Gray, Fl.* 1, *p.* 628. Santa Clara to Los Angeles; February.

SAMBUCUS GLAUCA, *Nutt. in Torr. & Gray, Fl.* 2, *p.* 13. Tulare valley; March. This species occurs also in New Mexico and Oregon.

CEPHALANTHUS OCCIDENTALIS, *Linn.; Torr. & Gray, Fl.* 2, *p.* 31. On the Gila and San Pedro rivers; June and July.

CORETHROGYNE INCANA, *Nutt.; Torr. & Gray, Fl.* 2, *p.* 98. Santa Barbara and Santa Inez; February.

CORETHROGYNE FILAGINIFOLIA, *Nutt.; Torr. & Gray, l. c.; Gray, Pl. Wright.* 1, *p.* 98. C. virgata, *Benth. Bot. Sulphur, p.* 23. San Antonio and San Luis Obispo, California; December and January. Suffrutescent, with a thick woody base.

MACHÆRANTHERA CANESCENS, *Gray, Pl. Wright,* 1, *p.* 89. Dieteria canescens, *Nutt.; Torr. and Gray, Fl.* 1, *p.* 101. Ojo de Vaca; August.

M. CANESCENS, var. LATIFOLIA, *Gray, Pl. Wright,* 2, *p.* 75. Dieteria latifolia, *Torr. in Emory's Rep. p.* 142. Gila river; June.

MACHÆRANTHERA TANACETIFOLIA, *Nees; Gray, Pl. Wright,* 1, *p.* 90. Dieteria coronopifolia, *Nutt.* Mimbres; August. A form with nearly all the leaves bipinnately divided.

ERIGERON CANADENSE, *Linn.; Torr. & Gray, Fl.* 2, *p.* 167. Mission of San Miguel, California; December.

ERIGERON SUBDECURRENS, *Gray, Mss.* Conyza subdecurrens, *DC.? Gray, Pl. Fendl. p.* 78, *and Pl. Wright,* 1, *p.* 102. Salinas river; November.

ERIGERON PHILADELPHICUM, *Linn.; Torr. & Gray, Fl.* 2, *p.* 171. Los Angeles and other places near the Pacific coast; March.

ERIGERON DIVERGENS, *var. cinereum. Gray, Pl. Wright,* 2, *p.* 91. Los Playas valley, New Mexico; August.

ERIGERON DOUGLASII, *Torr. & Gray, Fl.* 2, *p.* 177. Los Angeles; March.

DIPLOPAPPUS ERICOIDES, *Torr. & Gray, Fl.* 2, *p.* 182. Ojo de Vaca, New Mexico; August.

GUTTIERREZIA MICROCEPHALA, *Gray, Pl. Fendl. p.* 74, *(adnot.)* Sauz valley, New Mexico; August.

SOLIDAGO CALIFORNICA, *Nutt.; Torr. & Gray, Fl.* 2, *p.* 203. San Luis Obispo and other parts of California; March and April.

SOLIDAGO SEMPERVIRENS, *Linn.? Torr. & Gray, Fl.* 2, *p.* 211, var.? with crowded, nearly erect paniculate racemes. It may be only a form of S. Mexicana. Santa Barbara county, California.

APLOPAPPUS GRACILIS, *Gray, Pl. Fendl. p.* 76. Puerto del Dado, New Mexico; July.

APLOPAPPUS MENZIESII, *Torr. & Gray, Fl.* 2, *p.* 242. SantaBarbara, California; February. A form with pubescent leaves; the same that is noticed in Emory's Report, p. 142.

APPLOPAPUS (§ ACAMPTOPAPPUS) SPHÆROCEPHALUS, *Harv. & Gray, Pl. Fendl. p.* 76, *(adnot.)* San Felipe; May. This rare plant is a shrub, from one to two feet high, with elongated branches which bear from one to four large heads. The scarious margins of the involucral scales are lacerate-fimbriate. The pappus and the very villous achenium are of a brilliant silvery white. Cauline leaves linear-lanceolate, somewhat crowded, six to eight lines long and about two wide, mucronate; those of the branches shorter and more distant; all perfectly smooth. Stem and older branches whitish. We believe that this interesting plant has not been found before, since it was discovered in California by Coulter.—(Tab. VI.)

TESSARIA BOREALIS, *Torr. & Gray; Gray Pl. Fendl. p.* 75; *Torr. in Sitgr. Rep. p.* 162, *t.* 5. On the Colorado, Gila, &c.; June. The stems of this plant are used by the Indians for making their arrows.

BACCHARIS CŒRULESCENS, *DC. Prodr.* 5, *p.* 402. On the Gila river, &c.; June.

BACCHARIS DOUGLASII, *DC.*; *Torr. & Gray, Fl.* 2, *p.* 259. San Bernardino; March.

BACCHARIS CONSANGUINEA, *DC.; Torr. & Gray, Fl.* 2, *p.* 259. Near San Jose, and banks of the Salinas; November. Some of the specimens have mature fertile heads, which we had not seen before. The branches often bear gall-like excrescences, similar to those occurring on B. pilularis, to which this species is, perhaps, too nearly allied.

ZINNIA PUMILA, *Gray, Pl. Fendl. p.* 81, (*adnot.*) *& Pl. Wright*, 1, *p.* 105. Sauz valley; August. A stout and much-branched form, 6 to 8 inches high. Another dwarf variety, with longer leaves and shorter rays than usual, was found on the Chiricahui mountains and on the R. Mimbres.

HYMENOCLEA SALSOLA, *Torr. in Smithson. Contrib.* (*Pl. Frémont*) *p.* 14, *t.* 8. San Felipe. This, I fear, is only a monstrous state of H. monogyra.

HELIANTHUS PETIOLARIS, *Nutt.; Torr. & Gray*, 2, *p.* 309. On the Salinas river, and near Los Angelos.

XIMENESIA ENCELIOIDES, *Cavan.; Torr. & Gray, Fl.* 2, *p.* 359. Gila river, &c.; rather common; June.

HELIOMERIS.—San Bernardino, San Gabriel, &c.; February.

ENCELIA CALIFORNICA, *Nutt. in Trans. Amer. Phil. Soc.* (*n. ser.*) 7, *p.* 357. Santa Inez Mission; December.

RIDDELLIA TAGETINA, *Nutt. l. c.; Torr. & Gray, Fl.* 2, *p.* 362. Burro and Chiricahui mountains; August.

GAILLARDIA PULCHELLA, *Foug.; Torr. & Gray, Fl.* 2, *p.* 366. Los Playas; August.

CHENACTIS TENUIFOLIA, *Nutt.; Torr. & Gray, Fl.* 2, *p.* 370. San Diego; May. Much stouter than Nuttall's original specimens, and more than two feet high.

HYMENOPAPPUS FLAVESCENS, *Gray, Pl. Fendl. p.* 97*; & Pl. Wright*, 1, *p.* 121. Burro mountains; August.

BAHIA CONFERTIFLORA, *DC.; Torr. & Gray, Fl.* 2, *p.* 374. Near San Diego, and on the Salinas river; December, April.

BURRIELIA TENERRIMA, *DC.; Torr. & Gray, Fl.* 2, *p.* 385. On the Salinas river; November,

ACTINELLA LINEARIFOLIA, *Torr. & Gray, Fl.* 2, *p.* 383. *Gray, Pl. Wright.* 1, *p.* 122, *and* 2. *p.* 96. Along the Gila river; June.

LAYIA ELEGANS, *Nutt.; Torr. & Gray, Fl.* 2, *p.* 394. Kikal Mungo, California; March.

LAYIA GLANDULOSA, *Hook. and Arn. Bot. Beechey, p.* 358. Near Los Angelos; March.

LAYIA PLATYPHYLLA, *Gray, Pl. Fendl. p.* 103 (*adnot.*) Callichroa platyphylla, *Fisch. & Mey.; Torr. & Gray, Fl.* 2, *p.* 395. Santa Clara to Los Angelos; March.

HEMIZONIA RUDIS, *Benth. Bot. Sulphur, p.* 31. San Jose valley; November. Frémont collected the same plant in California in his expedition of 1845–'47. The root is decidedly annual in Dr. Antisell's specimens.

BAILEYA MULTIRADIATA, *Harv. & Gray, in Emory's Rep. p.* 144, *t.* 6, *& in Pl. Fendl. p.* 106, *Gray, Pl. Wright.* 1, *p.* 123. Sauz valley; August.

Venegasia carpesioides, *DC. Prodr.* 6, *p.* 43; *Torr. & Gray, Fl.* 2, *p.* 410. San Buenaventura ranch, and near San Gabriel; February. A rare plant, which only Douglas and Nuttall had previously collected.

Matricaria discoidea, *DC.; Torr. & Gray, Fl.* 2, *p.* 413. Near Los Angeles; March. Introduced from Europe, and now common in California, New Mexico, and in many other places.

Artemisia pycnocephala, *DC.; Torr. & Gray, Fl.* 2, *p.* 416. Salinas valley; November. Our plant agrees well with the description of De Candolle, except that the segments of all the leaves are narrowly linear.

Artemisia biennis, *Willd. Sp.* 3, *p.* 1842; *Torr. & Gray, Fl. l. c.* Rio Pajaro and on the Salinas; November. Not found before west of the Rocky Mountains.

Gnaphalium Californicum, *DC.; Prodr.* 6, *p.* 224. San Gabriel; March. A variety with broader leaves, and the scales of the involucre more obtuse, was found at San Juan and in other places; November.

Gnaphalium Sprengelii, *Hook. & Arn. Bot. Beechey, p.* 150. Burro mountains; common; August.

Antennaria margaritacea, *R. Br.; Torr. & Gray, Fl.* 2, *p.* 429. Salinas valley; November. Rare in California.

Senecio longilobus, *Benth. Pl. Hartw. p.* 18; *Gray, Pl. Fendl. p.* 108. Solidad Mission; December.

Senecio Californicus, *DC. Prodr.* 6, *p.* 426. San Gabriel; March. Leaves varying from pinnatifid to nearly entire.

Calais linearifolia, *DC.; Torr. & Gray, Fl.* 2, *p.* 471. Near San Gabriel; March.

Calais macrachaeta, *Gray, Pl. Fendl. p.* 112, (*adnot.*) *and in Whipple's Rep. ined.* With the last.

Stephanomeria minor, *Nutt.; Torr. & Gray, Fl.* 2, *p.* 472. Colorado desert; April.

Lobelia Texensis, *Raf.; DC. Prodr.* 7, *pars* 2, *p.* 383? River Mimbres; August. Very near L. cardinalis, but with smaller flowers: perhaps only a variety of that species.

Arctostaphylos tomentosa, *Dougl. in Lindl. Bot. Reg.* A. cordifolia, Lindl. No. 1791, (*adnot.*) Santa Inez, California; February.

Dodecatheon Meadia, *Linn.* var. D. integrifolium, *Michx.* D. frigidum, *Cham.; Hook. Fl. Bor. Am.* 2, *p.* 118. San Gabriel, California; March.

Anagallis arvensis, *Linn.* Common about Los Angeles and in many other places in California. A native of Europe, but now completely naturalized; March, April.

Plantago Patagonica. *Jacq.* var. gnaphalioides. P. gnaphalioides, *Nutt. Gen.* 1, *p.* 100. Los Playas, New Mexico, August. A low form, with short few-flowered heads, was found near San Gabriel, California.

Chilopsis linearis, *DC. Prodr.* 9, *p.* 227. *Engelm. in Wisliz. N. Mex. p.* 94. Vallecitas, California, and Puerto del Dado, New Mexico; May, July. Leaves variable in breadth and not always glutinous. There appears to be but one species.

Antirrhinum glandulosum, *Lindl.; Benth. in DC. Prodr.* 10, *p.* 291. San Isabel, California; May.

Pentstemon spectabilis, *Thurb. Mss.; Gray, in Bot. Whipple's Rep.* San Isabel, California; May. Mr. Thurber found it near San Pasqual, and Mr. Wallace in the same region It was collected, also, by Dr. Bigelow on San Francisco mountain, New Mexico.

Pentstemon Thurberi: shrubby, much branched, very smooth; tube of the corolla very short, tubular-funnelform; lobes of the limb ovate; sterile filament smooth. Burro mountains, New Mexico; August. This is No. 1056 of the collection of Mr. Thurber, who found it in Sonora and indicated to me the characters in which it differs from P. ambiguus. The tube of the corolla in the latter is nearly three-fourths of an inch long, and curved, while the whole length of the flower of the former is not half an inch.

Pentstemon linarioides, *Gray, Mss.* Chiricahui mountains, New Mexico; August. This species will be described in the botany of Capt. Whipple's Pacific Railroad Report. It belongs to the section Cepscosmus, and is No. 1472 of Wright's New Mexican collection, and No. 331 of Thurber's.

Pentstemon centranthifolius, *Benth. Scroph. Ind. p.* 7, (*adnot.*) *& in DC. Prodr.* 10, *p.* 323. Kikal Mungo mountain and Solidad; March and December. A handsome scarlet-flowered species.

Scrophularia nodosa, *Linn.; Benth. in DC. Prodr.* 10, *p.* 309. San Bernardino and Los Angeles; March and April. Leaves varying from serrate to deeply lobed, with the lobes sharply toothed.

Diplacus glutinosus, *Nutt. in Tayl. Ann. Nat. Hist.* 1, *p.* 138; *Benth. in DC. Prodr.* 10, *p.* 368. D. leptanthus, *Nutt. l. c.* San Isabel, &c.; May. A beautiful flowering shrub with red or orange yellow flowers. It is variable in the breadth of the leaves as well as in the length of the peduncles.

D. glutinosus var. pubescens: branches and under surface of the leaves pubescent; peduncles many times shorter than the calyx. D. longiflorus, *Nutt. l. c.; Benth. l. c.* Between San Bernardino and San Diego; April. Peduncles, 2–3 lines long. Calyx, nearly an inch in length. The corolla in this variety is pale yellow or, sometimes, almost cream color.

Mimulus luteus, *Linn.; Benth. in DC. Prodr.* 10, *p.* 370. Near Los Angeles; March.

Mimulus brevipes, *Benth. Scroph. Ind. p.* 28. *& in DC. Prodr. l. c.* San Isabel, and from San Luis Rey to San Diego; May. The specific name is not appropriate, for the peduncles are one third of an inch long. This and several other species resemble Diplacus in the placentae remaining adnate to the valves of the capsule after dehiscence.

Eunanus Fremonti, *Benth. in DC. Prodr.* 10 *p.* 374, *var. major;* larger, more branching and whitish pubescent. Kikal Mungo mountain; March.

Collinsia bicolor, *Benth. in Hort. Trans. Lond.* 1, *p.* 480. San Diego, &c.; March—April.

Orthocarpus purpurascens, *Benth. Scroph. Ind. p.* 13 *& in DC. Prodr.* 10, *p.* 536. San Bernardino, Los Angeles, &c.; March—April

Castilleja foliolosa, *Hook. & Arn. Bot. Beechey, p.* 154. San Bernardino to San Gabriel; April. The specimens are decidedly annual, but the plant is described as suffruticose!

Castilleja affinis, *Hook. & Arn. l. c.; Benth. l. c.* Cajon Pass and Santa Barbara; February and March.

Verbena bipinnatifida, *Nutt.; Schauer in DC. Prodr.* 11, *p.* 553. Los Playas, &c.; August.

Verbena Aubletia, *Linn.; Schauer, l. c.* Chiricahui mountains, New Mexico; August. A showy species; often seen in gardens.

Verbena prostrata, *R. Brown; Schauer, l. c.* V. lasiostachys, *Link; Hook & Arn.* Banks of the Salinas river and Santa Barbara; December.

Verbena hastata, *Linn.; Pursh, Fl.* 2, *p.* 416. V. paniculata, *Lam.* River Mimbres, New Mexico; August.

MICROMERIA DOUGLASII, *Benth. in DC. Prodr.* 12, *p.* 223. Salinas valley, California; November.

SALVIA CARDUACEA, *Benth. Lab. p.* 302. S. Gossypina, *Benth. Pl. Hartw. p.* 330. Los Angeles; March.

SALVIA COLUMBARIÆ, *Benth. l. c.* With the last. Commonly not more than a foot high, but often smaller and sometimes much larger. All the specimens have annual roots.

AUDIBERTIA POLYSTACHYA, *Benth. Lab. p.* 414, *and in DC. Prodr.* 12, *p.* 360. San Luis Rey and San Diego; April. Stem nearly four feet high, simple, the upper half of the plant bearing opposite spikes, which are about two inches in length. Lower leaves two and a half inches long and an inch wide, conspicuously petioled. The whole plant is canescent.

AUDIBERTIA STACHYOIDES, *Benth. l. c.* Santa Clara and San Diego; April. A branching shrub, with the foliage resembling that of the common garden sage.

AMSINCKIA SPECTABILIS, *Fisch. & Mey. Ind. Hort. Petrop.* 1835. Los Angeles and Santa Clara valley; March. A slender form of the plant was collected near Santa Barbara.

ERITRICHIUM FULVUM, *Alph. DC. Prodr.* 10, *p.* 132. Santa Barbara, San Bernardino, and other places in California; April.

PLAGIOBOTRYS CANESCENS, *Benth. Pl. Hartw., p.* 326. San Gabriel, &c.; April. A common Californian plant. The genus is hardly distinct from Eritrichium.

ERITRICHIUM CHORISIANUM, *DC. l. c.* Myosotis Chorisiana, *Cham. and Schlecht.* Salinas valley; November.

HELIOTROPIUM CURASSAVICUM, *Linn.; DC. Prodr.* 9, *p.* 539. On the Gila river; common; June.

NEMOPHILA PARVIFLORA, *Benth. Linn. Trans.* 7, *p.* 275. San Gabriel and Los Angeles; March.

NEMOPHILA INSIGNIS, *Benth. l. c.* Santa Barbara; also between Santa Clara and Los Angeles; March.

NEMOPHILA AURITA, *Lindl. Bot. Reg. t.* 1601; *Alph. DC. Prodr.* 9, *p.* 290. Los Angeles; March.

PHACELIA (EUTOCA) PARRYI, *Torr. in Bot. Mex. Bound. ined.* San Isabel, California; May. This species connects Whitlavia with Phacelia, agreeing with the former in the scales at the base of the stamens, and with Phacelia (Eutoca) in the form of the corolla.

WHITLAVIA GRANDIFLORA, *Harv. in Hook. Lond. Jour. Bot.* 5, *p.* 311, *t.* 11. San Bernardino and Kikal Mungo mountain; March and April. Flowers varying from eight lines to an inch and a half in length. The cultivated plant is also variable. We think that W. minor, *Harv. l. c. t.* 12, is only a small form of W. grandiflora.

PHACELIA CIRCINATA, *Jacq. Ecl.* 1, *t.* 91; *Alph. DC. Prodr.* 9, *p:* 299. San Gabriel, &c.; May.

PHACELIA TANACETIFOLIA, *Benth. in Linn. Trans.* 17, *p.* 280. Santa Barbara to San Isabel; February, May.

ERYTHRÆA FLORIBUNDA, *Benth. Pl. Hartw., p.* 322. Banks of the Salinas river; November. Plant 5—7 inches high. This and the other species of the genus are known in California by the name of *Canchalagua*, a bitter tonic of considerable celebrity.

ERYTHRÆA TRIACHANTHA, *Griseb. in DC. Prodr.* 9, *p.* 60. On the Gila river, above the Pimas villages; June.

CONVOLVULUS LOBATUS, *Engelm. & Gray, Pl. Lindh.* 1, *p.* 44, (*adnot.*) C. hastatus, *Nutt. in Trans. Amer. Phil. Soc.* (*n. ser.*) 5, *p.* 194; *not of Thunb.* Burro mountains; August.

Ipomaea Nil, *Roth;* Pharbitis Nil, *Choisy in DC. Prodr.* 9, *p.* 343. On the Organ mountains, New Mexico; August.

Calystegia sepium, *R. Brown; Choisy in DC. Prodr.* 9, *p.* 433. Santa Barbara; February. With much smaller leaves and flowers than usual.

Evolvulus argenteus, *Pursh, Fl.* 1, *p.* 187. *Nutt. Gen.* 1, *p.* 174. *E. pilosus, Nutt. in Trans. Amer. Phil. Soc.* (*n. ser.*) 5, *p.* 194. Ojo de Vaca; August.

Nama biflora, *Choisy in DC. Prodr.* 10, *p.* 183., var.? spathulata: annual, erect when young, but finally prostrate or diffuse, pubescent; leaves linear or oblong, spatulate, obtuse; flowers solitary in the axils, or 2—3 together in terminal leafy racemes; sepals spatulate-linear; corolla nearly twice as long as the calyx. N. Jamaicensis? *Engelm. and Gray, Pl. Lindh.* 1, *p.* 183. On the Gila river; June. A common plant in New Mexico and in southern California. It is variable in the breadth of the leaves, and is probably distinct from N. Jamaicensis. N. undulata, *H. B. K.*, grows in New Mexico, unless what I have so called may be only another form of this species.

Gilia tricolor, *Benth. in Bot. Reg. sub* No. 1622. Los Angeles; March. A small early form.

Gilia micrantha, var. aurea, *Benth. Pl. Hartw.*, *p.* 325. G. aurea, *Nutt. Pl. Gamb.*, *p.* 155, *t.* 22? Santa Clara to Los Angeles; March.

Gilia longiflora, *Don.; Torr. in Sitgreave's Rep.*, *p.* 165, *t.* 7. Cantua longiflora, *Torr. in Am. Lyc. N. York*, 2, *p.* 221. Los Playas and Sauz valley; August.

Gilia inconspicua, *Dougl. in Bot. Mag.*, *t.* 2883. Between Santa Clara and Los Angeles; February and March.

Gilia densifolia, *Benth. in DC. Prodr.* 9, *p.* 311. San Felipe and Cariso creek; May—June.

Gilia dianthoides, *Endl. Atakt.*, *t.* 29; *Benth. l. c.* Santa Barbara, Los Angeles, &c.; March. Taller than usual.

Gilia androsacea, *Steudel, Nomencl.; Benth. l. c.* Warner's ranch; May. Calyx yellow, Corolla pale lilac.

Gilia Californica, *Benth. in DC. Prodr.* 9, *p.* 316. Leptodactylon Californicum, *Hook. & Arn. Bot. Beechey*, *p.* 369, *t.* 89. Santa Inez Mission and Santa Clara valley; February. A shrubby species, sometimes attaining the height of four or five feet.

Navarretia squarrosa, *Hook. and Arn. l. c.; Benth. l. c.* var. diffusa: Stems diffusely branching; cells of the capsule 7–8 seeded. Salinas valley; November.

Solanum umbelliferum, *Eschsch. Mem. Acad. St. Petersb.* 10, *p.* 281; *Dunal in DC.* 13, *pars* 1, *p.* 93. S. genistoides, *Dunal, l. c.?* San José valley; November.

S. umbelliferum, var. glabrescens: nearly glabrous; leaves oblong-lanceolate, acute or attenuate at the base. Santa Inez; also between San Bernardino and San Gabriel; January.

S. umbelliferum, var. incanum: hoary-pubescent; leaves oblong, small, (6–10 lines long,) entire. S. Californicum, *Dunal, l. c.?* Head-waters of San Antonio river, California; December. Berry the size of a small musket ball, black when dry.

S. umbelliferum, var. trachycladum: branches angular and somewhat winged, the angles denticulate-scabrous, otherwise smooth; leaves ovate, smoothish, repandly toothed, abruptly narrowed to a petiole at the base; racemes on long peduncles, somewhat umbellate; calyx 5-cleft to the middle, the segments semiovate and rather acute. Santa Inez and San Buenaventura ranch; February. Stem shrubby, 2–3 feet long, apparently prostrate, fistular. Leaves $1\frac{1}{2}$–2 inches long, exclusive of the petiole, which is about half the length of the lamina, nearly smooth, green on both sides. Flowers apparently white, about as large as in S. nigrum. We are constrained to refer all the forms here noticed to one species, having specimens of intermediate characters that seem to unite them. The last variety may, however, prove to be a distinct species.

SOLANUM FLAVIDUM, *Torr. in Ann. Lyc. N. York*, 2, *p.* 227; *and in Marcy's Rep. p.* 292. Base of the Chiricahui mountains; July. Berries orange, the size of a small rifle ball. This is near S. elæagnifolium, *Cavan.*

PHYSALIS PUMILA, *Nutt. Trans. Amer. Phil. Soc.* (*n. ser.*) 5, *p.* 193. Los Playas; August. This species is omitted by Dunal in De Candolle's Prodromus.

DATURA METEL, *Linn. var?* QUINQUECUSPIDA: limb of the corolla 5–cuspidate with intermediate more or less acute angles, otherwise as in D. metel. San Bernardino and San Gabriel; April. A common plant in New Mexico, and west to the Pacific. It is called *Toloachi* by the Mexicans, who are acquainted with its narcotic powers. The leaves vary from entire to coarsely repand-toothed, and are pubescent on both surfaces, especially on the under. The corolla is white or pale purple, 6–8 inches long, and the limb often 4 inches in diameter. The 5 points of the limb are sometimes produced into subulate processes, and there are intermediate folds which are often rather acute, but not running out into a distinct tooth. It may be a distinct species from D. Metel.

LEPTOPHRAGMA PROSTRATA, *Benth. in D. C. Prodr.* 13, *pars* 1, *p.* 578. Salpiglossis? prostrata, *Hook. & Arn. Bot. Beechey, p.* 153. Salinas river; November. Common in southern California and eastward to the Rio Grande. The plant is an annual.

ASCLEPIAS TUBEROSA, *Linn.* Rio Mimbres; August. A narrow leaved form of the plant.

FRAXINUS VELUTINA, *Torr. in Emory's Rep. p.* 149. On the San Pedro river of the Gila; also abundant on the Rio Grande and some of its tributaries. Variable in the pubescence of the leaves. It sometimes attains the height of 30 feet.

MENODORA SCABRA, *Gray in Sill. Journ.* (2*d ser.*) 14, *p.* 44. Valley of Sauz; August. A low plant with a shrubby base and yellow flowers, well characterized by Dr. Gray.—(Tab. VII.)

OBIONE CANESCENS, *Moq. Chenop., p.* 74; *Torr. in Sitgreaves' Rep., p.* 169. Santa Cruz valley; August, (fem.;) Cariso creek, (mas.) A variety with narrow leaves and small toothed bracts.

CHENOPODINA LINEARIS, *Moq. in DC. Prodr.* 13, *pars* 2, *p.* 164, (*in part.*) Salsola linearis, *Ell. Sk.* 1, *p.* 322. S. Salsa? *Michx. Fl.* 1, *p.* 74. On the Gila river; June. This is, with little doubt, Elliott's plant, and also the common species of the Atlantic salt marshes. It is an annual, throwing up several erect branches from the base. Moquin has included two species in his C. linearis; one a shrubby plant, which may be called C. Moquini, and is C. linearis, *Torr. in Stansbury's Report, p.* 394.

CHENOPODIUM AMBROSIOIDES, *Linn.; Moq. l. c.* Banks of the Salinas river; November. Probably introduced from tropical America.

BLITUM BONUS-HENRICUS, *Reichenb.; Moq. l. c.* San Gabriel and Santa Inez; March. Introduced from Europe.

QUAMOCLIDION MULTIFLORUM, *Torr.; Gray in Sill. Journ.* (2*d ser.*), 15, *p.* 320. Nyctaginea? Torreyana, *Choisy in DC. Prodr.* 13, *p.* 430. Warner's ranch.

MIRABILIS LONGIFLORUS, *Linn.; Moquin in DC. Prodr.* 13, *pars* 2, *p.* 428. San Pedro river of the Gila; July. Differs from the Moquin's description in not being "viscidly pubescent." The lobes of the involucrum also are not linear, but lanceolate, and the tube of the perigonium is pubescent. It is the same plant as 1702 of Wright's New Mexican collection.

Oxybaphus glabrifolius, *Vahl, Enum.* 2, *p.* 40; *var. crassifolius, Moq. in DC. Prodr. l. c.* Santa Barbara; February. Stems numerous, from a woody base (as in O. angustifolia and in some other North American species). Involucre 1-flowered, 5-cleft; segments triangular-ovate, acute. Perianth campanulate-rotate. Stamens 5, exserted.

Abronia arenaria, *Menz. in Hook. Exot. Fl. t.* 193; *Moquin in DC. Prodr.* 13, *pars* 2, *p.* 435. San Louis Obispo; January.

Abronia mellifera, *Dougl. in Hook. Bot. Mag. t.* 2879; *Moq. l. c.* On the Gila river and in the California desert; May to June.

Polygonum acre, *H. B. K.; Gray, Manual ed.* 2, *p.* 373. P. punctatum. *Ell. Sk.* 1, *p.* 455. Salinas valley; November.

Rumex maritimus, *Linn. Pursh. Fl.* 1, *p.* 248; *Hook. Fl. Bor. Am.* 2, *p.* 130. Banks of the Salinas river; November. A common plant in Oregon.

Chorizanthe (Ptilosepala) fimbriata, *Nutt. in Pl. Gamb.* (*Journ. Acad. Sc. Philad.*, [*n. ser.*] 1, *p.* 168.) *Torr. in Williamson's Rep. t.* 8. San Diego, in sandy soils; April.

Chorizanthe (Ptilosepala) laciniata, (n. sp.): annual, erect; leaves all spatulate; scape trichotomously branched; segments of the involucre about half as long as the tube; sepals triangular acute, deeply cut into filiform segments. San Felipe; May. Very much like C. fimbriata, but in the latter the spine-like segments of the involucre are nearly as long as the tube, and the sepals are oblong and obtuse. Both are remarkably prone to separate at the joints of the scape.

Eriogonum angulosum, *Benth. Eriog. in Linn. Trans.* 17, *p.* 406, *t.* 18, *fig.* 1. San Filipe; May. The exterior sepals are nearly orbicular, remarkably concave, and one-half shorter than the interior ones. All of them glandularly ciliolate on the margin. Ovary and achenium glabrous. Embryo curved, with a long radicle. Allied to E. Abertianum, *Torr.*

Eriogonum trichopodum, *Torr. in Emory's Report, p.* 150 (incorrectly E. trichopes); *Benth. in D. C. Prodr.* 14, *pars* 1, *p.* 20. Sauz valley; August. The leaves are in a radical cluster, roundish-ovate, very obtuse, mostly cordate, entire or obscurely repand, somewhat hairy on both sides; the petioles are nearly twice as long as the lamina. Peduncles capillary, 4–8 lines long, spreading horizontally, or somewhat refracted. Involucre turbinate-infundibuliform, obtusely 4-toothed, about 5-flowered. Bracteoles linear-spatulate, shorter than the pedicel. Achenium triquetrous, glabrous. This species is rather common on the Gila and lower Colorado. The specimens collected by Dr. Antisell are nearly two feet high.

Eriogonum nudum, *Dougl.; Benth. l. c.* Plentiful on the head-waters of San Antonio river, California; December.

Eriogonum polifolium, *Benth. in herb Torr., and in DC. Prodr.* 14, (*ined.*) San Louis Rey to San Diego; also in Santa Clara valley; February to April. A low shrubby species near E. fasciculatum. It is variable in pubescence, being sometimes almost smooth.

CENTROSTEGIA, Gray, Nov. Gen.

"Involucrum papyraceum, (demum coriaceum,) 1–2 florum, tubulosum, venosum, apice inequaliter 5-dentatum; dentibus mucronato-aristulatis, basim juxta tricalcaratum, calcaribus magnis, divaricatis, breviter subulato-aristatis. Perigonium 6-partitium, petaloideum; laciniis tenuibus, lineari-spathulatis, ungue hirsutulo. Stamina 9. Ovarium trigonum; styli 3, graciles; stigmatibus capitatis. Achenium triquetrum. Embryo curvatum. Herba annua, demissa, glabra, a basi ramosa; ramis diffusis, floriferis flexuosis; foliis radicalibus spathulatis; ramealibus bracteisve minimis oppositis et alternis, sepius 2–3-fidis, segmentis subulatis; involucris ad nodis solitariis sessilibus."—Gray.

"C. Thurberi." On sandy hill-sides, near San Filipe, where it was first discovered by Mr. Thurber, in 1852, May. A remarkable genus of the tribe Eriogoneae, the characters of which were drawn by Dr. Gray, and have only been slightly enlarged and modified, as the specimens collected by Dr. Antisell are more complete than those of Mr. Thurber. The plant is from 3–4 inches high, with a small cluster of spatulate leaves at the base. There are no proper rameal leaves, but only bracts, which are often 2–3-cleft, with mucronate segments. The upper portion of the involucre is triquetrous; the 3 processes or horns near the base are widely spreading, and usually a little curved. Sometimes there is a fourth smaller horn. I have found most of the involucres to contain two flowers.—(Tab. VIII.)

Oreodaphne Californica, *Nees, Syst. Laur. p.* 463. Umbellularia Californica and Drymophyllum pauciflorum, *Nutt. Sylv.* 1, *p.* 85 *and* 87. Santa Inez; February. This is the celebrated California laurel or bay tree.

Anemopsis Californica, *Nutt. in Tayl. Ann. Nat. Hist.* 1, *p.* 136; *Hook. and Arn. Bot. Beechey, p.* 390, *t.* 92. Los Angeles; April.

Simmondsia Californica, *Nutt. in Hook. Lond. Jour. Bot.; Torr. in Mex. Bound. Rep. cum tab. (ined.)* Banks of the San Pedro of the Gila; July.

Juglans rupestris, *Engelm. var.?* major, *Torr. in Sitgreave's Rep. p.* 171, *t.* 16. Puerto del Dado; July. In fruit.

Platanus Mexicana, *Moricand, Pl. Rar. d'Amer. t.* 26. P. racemosus, *Nutt. in Audub. Birds of Amer. t.* 362, *and Sylv.* 1, *p.* 47, *t.* 15. P. Californicus, *Benth. Bot. Sulph. p.* 54. Near San Luis Rey, and San Diego; April.

Quercus agrifolia, *Née; Hook. Ic. t.* 377, *Nutt. Sylv.* 1, *p.* 5, *t.* 2. Salinas valley. One of the most common oaks of California. It varies much in the size and form of its leaves and acorns, but is, in general, easily recognized.

Urtica urens, *Linn.; Pursh, Fl.* 1, *p.* 113. Rio Pajaro; November. Introduced from Europe, probably by the Spaniards.

Ephedra antisiphilitica, *Berland.; Endl. Syn. Conif. p.* 263. Common on the Gila.

Agave Americana, *Linn.; Kunth Enum.* 5, *p.* 821. Vallecitas, California; May. The *Maguay* of the Mexicans, affording the beverage called by them *pulqué*. It has probably been brought from Central America.

Zigadenus Douglasii, *Torr. in Bot. Whipple's Rep.* Z. chloranthus, *Hook. and Arn. Bot. Beechey p.* 402*? excl. syn.* Near Santa Barbara; February. Near Amianthium Nuttallii of Gray, who now refers that plant to that section of the genus Zigadenus, which has the gland. of the perianth obscure. (See Manual of Botany, ed. 2, p. 476.)

Calochortus venustus, *Benth. in Hort. Trans. Lond. (n. ser.)* 1. *p.* 412, *t.* 15, *fig.* 3; *Lindl. Bot. Reg. t.* 1669. San Isabel to Los Angeles; March. A beautiful species, with large white flowers which are singularly marked with yellow and blood-red at the base.

Calochortus splendens, *Benth. l. c. t.* 15, *f.* 1. *Lindl. Bot. Reg. t.* 1676. Los Angeles; March. Also a very beautiful plant; the large flowers being pale lilac, with purple spots at the base.

Sisyrinchium Bermudiana, *Linn.;* var. anceps, *Torr. Fl. New York,* 2 *p.* 291. Los Angeles; March.

Dichelostemma congesta, *Kunth, Enum.* 4, *p.* 47. Brodiæa congesta, *J. E. Smith.* Los Angeles to Santa Barbara; March.

Commelyna erecta, *Linn.; Ell. Sk.* 1, *p.* 48. Los Playas; August. The specimens agree in almost every particular with Elliott's description, (l. c.,) except that the larger petaloid sepals are reniform rather than cordate. The small inner sepal is lanceolate, and placed between the two connate exterior sepals.

Phalaris arundinacea, *Linn.; Torr. Fl. New York,* 2, *p.* 418. On the Gila; June.

Paspalum distichum, *Linn.? Ell. Sk.* 1, *p.* 108. Banks of the San Pedro of the Gila; July. Widely spread over the warmer parts of North America. P. vaginatum, *Swartz,* seems to be hardly distinct from this species.

Panicum lachnanthum (n. sp.): culm ascending, and with the leaves glabrous; panicle oblong, erect, the branches alternate and loosely racemose; all the spikelets ped icellate, oblong; inferior glume very short, glabrous; the superior and the inferior palea of the abortive flower much attenuate, and somewhat awned at the tip, densely covered with very long white silky hairs; perfect flower ovate-lanceolate acuminate, and mucronate, glabrous, finely striate and dotted longitudinally. Paspalum sericeum, *Scheele, in Linnœa,* 23, *p.* 341? On the Burro mountains; August. Plant about 18 inches long; the panicle 3–6 inches. A very remarkable species.

Setaria viridis, *Beauv.; Kunth, Enum.* 1, *p.* 151. Pennisetum viride, *R. Br.* Burro mountains; August.

Gastridium australe, *Beauv.; Steudel Gram. p.* 185. Milium lendigerum, *Linn.* San José valley; November. This has not before been noticed as a North American plant. Steudel states that it has been found in Chili. It is a common grass in southern Europe. Very probably it has been brought to America in grain.

Sporobolus airoides. Agrostis airoides, *Torr. in Ann. Lyc. N. York,* 2, *p.* 151. A. (Sporobolus) airoides, *Torr. in Marcy's Rep. p.* 30. Valley of the Mimbres; August.

Poa annua, *Linn.; Kunth, Enum.* 1, *p.* 349. Banks of the Salinas river; November. This little grass has become quite extensively naturalized in California.

Poa compressa, *Linn.; Kunth, Enum.* 1, *p.* 355. Los Angeles; March. A slender form, with a loose, open panicle.

Uniola spicata, *Linn.* Brizopyrum spicatum, *Hook. & Arn. Fl. Bor.-Amer.* 2, *p.* 254, excl. the synonyms of Uniola stricta, *Torr.*, and U. multiflora, *Nutt.* San Felipe. It is found also in Oregon, and is in all essential characters like the plant of the Atlantic States.

Avena fatua, *Linn.; Kunth, Enum.* 1, *p.* 302. Abundant in various parts of California, being the common *wild oat* of that country.

Andropogon nutans, *Linn.; Kunth, Enum.* 1, *p.* 504. Sorghum nutans, *Gray, Man. ed.* 2. On the river Mimbres; August.

Polypodium intermedium, *Hook. & Arn. Bot. Beechey, p.* 405; *Hook. Fl. Bor.-Amer.* 2, *p.* 258. Santa Inez, and plains of the Salinas.

Adiantum Chilense, *Kaulf. Fil. p.* 207; *Hook. and Grev. Ic. Fil. t.* 183. Shore of Santa Inez and Santa Barbara. Some of our botanists have named this A. tenerum. It is common in California and New Mexico.

Aspidium argutum, *Kaulf. Enum. Fil. p.* 242. Temecula Hill, and valley of the Salinas, California.

Pteris lanuginosa, *Kaulf. Enum. Fil. p.* 189; *Hook. and Arn. Bot. Beechey, p.* 405. Valley of the Salinas.

HYPOLEPIS CALIFORNICA, *Hook. Fil.* 2, *p.* 71, *t.* 88 (*A.*) Between San Bernardino and San Gabriel. A neat little form, growing in bunches.

GYMNOGRAMMA TRIANGULARIS, *Kaulf.; Hook. & Arn. Bot. Beechey, p.* 161 *and* 405. Shore of Santa Inez.

AZOLLA CAROLINIANA, *Willd. Sp.* 5, *p.* 541; *Torr. Fl. New York,* 2, *p.* On stagnant water; Salinas valley.

PARMELIA CAPERATA, *Ach.; Tuckerm. Syn. Lich. N. States, p.* 29. Rocks and trees on the Salinas river.

RAMALINA MENZIESII, *Taylor; Tuckerm. Lich. Exsicc. No.* 57. R. retiformis, *Tuck. Syn. Lich. p.* 13. Abundant on oak trees on the Rio Pajaro, and in many other parts of California. It is a beautiful and singular species, and is called *Lace Lichen.* Cattle are said to eat it with avidity.

RAMALINA SCOPULORUM var. TENUISSIMA. *Hook. & Arn. in Bot. Beechy's Voy., p.* 163. Plains of the Salinas river.

USNEA BARBATA, var. RUBIGINEA, *Tuckerm. Syn. Lych. N. States, p.* 8. With the last.

MACROCYSTIS PYRIFERA, *Agardh; Harv. Nereis Bor.-Amer.* 1, *p.* 84. Sea shore south of Santa Barbara. Dr. Hooker and Prof. Harvey admit but one species of this genus.

HALIDRYS OSMUNDACEA, *Harv. l. c. t.* 2. Cystoseira osmundacea, *Agardh.* With the last.

FUCUS CERANOIDES, *Linn.; Harv. l. c.* The specimens are in fruit. With the last.

PHYLLOSPORA MENZIESII, *Agardh; Harv. l. c. t.* 3, *B.* With the last.

CHAPTER II.

SYNOPTICAL TABLES OF BOTANICAL LOCALITIES.

BY THOMAS ANTISELL, M. D.

[The following tabulated catalogue of plants, arranged according to the habitat, will, it is hoped, serve as an useful adjunct to the botanical report.—T. A.]

SALINAS VALLEY.

Escholtzia Douglasii.
Oxalis stricta.
Hosackia cytisoides.
Rosa cinnamomea.
Ribes Californicum.
Eryngium petiolatum.
Erigeron canadense.
subdecurrens.
Baccharis consanguinea.
Helianthus petiolaris.
Bahia confertiflora.
Burrielia tenerrima.
Artemisia pycnocephala.
biennis.
Gnaphalium Californicum.
Antennaria margaritacea.
Senecio longilobus.
Pentstemon centranthifolius.
Verbena prostrata.
Micromeria Douglasii.
Eritrichium chorisianum.
Erythrea floribunda.
Navaretia squarrosa.
var. diffusa.
Solanum umbellif. var. in canum.
Leptophragma prostrata.
Chenopodium androsoides.
Polygonum acre.
Rumex maritimus.
Quercus agrifolia.
Poa annua.
Avena fatua.
Polypodium intermedium.
Aspidium argutum.
Pteris lanuginosa.
Azella Caroliniana.
Parmelia coperata.
Ramalina menziesii.
Ramalina retiformis.
o o o o ?
Usnea barbata.

LOS ANGELES, SAN GABRIEL, AND SAN BERNARDINO PLAINS.

Ranunculus Californicus.
Platystemon Californicum.
var. leiocarpum.
Viola peduncula.
Calandrinea menziesii.
Claytonia perfoliata.
Erodium cicuticum v. moschata.
Lathyris vestitus.
Melilotus parviflorus.
Medicago denticulata.
Hosackia strigosia.
Astragalus densifolia.
Lupinus hirsutissimus.
Horkelia fusca.
Rosa cinnamomea.
Œnothera strigulosa.
Megarhiza Californica.
Sanicula bipannitifida.
Peucedanum utriculatum
Erigeron Philadelphicum.
Douglasii.
Baccharis Douglasii.
Helianthus petiolaris.
Heliomeris.
Lagia glandulosa.
platyphylla.
Matricaria discoidea.
Gnaphalium Californicum.
Senecio Californicus.
Calais linearifolia.
Dodecatheon Meadii.
Anagallis arvensis.
Plantago patagonica.
Pentstemon centranthifolius.
Scrophularia nodosa.
Diplacus glutinosus, var. pubescens.
Mimulus luteus.
Eunanus.
Collinsia bicolor.
Orthocarpus purpurascens.

Castilleja foliolosa.
Salvia carduaca.
columbaria.
Audibertia polystachia.
stachyoides.
Amsiuckia spectabilis.
Eritrichium fulvum.
Plagiobotrys canescens.
Nemophylla parviflora.
aurita.
Whitlavia grandiflora.
Nama biflora.
Gilia tricolor.
micrantha.
inconspicua.
deanthoides.
Datura Metel var. quinquecuspida.
Blitum bonus-Henricus.
Chorizanthe fimbriata.
Eriogonum polifolum.
Anemopsis Californica.
Platanus Mexicana.
Calochortus venustus.
splendens.
Sisyrinchium Bermudiana.
Dichelosteuma congesta.
Poa compressa.
Hypolepis Californica.

SAN LUIS OBISPO VALLEY.

Oxalis stricta.
Ribes malvaceum.
Corethrogyne filagenifolia.
Solidago Californica.
Abronia arenaria.

TULARE VALLEY.

Sinapis nigra.
Erodium cicuterium.
Onothera cheiranthifolia.
Sambucus glauca.

DESERT OF THE COLORADO.

Krameria lanceolata v. canescens.
Dahlea spinosa.
Olnea tesota.
Echinocactus Lecontii.
Fouquieria splendens.
Stephanomeria minor.
Gilia densifolia.
Obione canescens.
Abronia mellifera.
Agave Americana.

VALLEY OF SANTA CLARA OR SAN JOSÉ.

Nasturtium curvisiliqua.
Solanum umbelliferum.
Obione canescens.
Quercus agrifolia.
Gastridium australe.
Avena fatua.
Ramalina retiformis.

SAN JUAN VALLEY.

Vicia Oregana.
Lupinus ornatus.
Zauschneria Californica.
Urtica urens.
Ramalina retiformis.

SAN BUENAVENTURA AND VALLEY OF SANTA CLARA RIVER.

Sisymbrium deflexum.
Sinapis arvensis.
Isomeris arborea.
Viola peduncula.
Sidalcea malvaflora, v. humilis.
Polygala cucullata.
Œnothera cheiranthifolia.
Lithophragma cymbelaria.
Peucedanum utriculatum.
Gilia micrantha.
inconspicua.
Californica.
Solanum umbellif: var. trachycladium.
Eriogonum polifolium.
Avena fatua.

SANTA INEZ, SANTA BARBARA TO SAN DIEGO.

Escholtzia Californica.
Dendromecon rigidum.
Cardamine angulata.
Sisymbrium canescens.
Ersymum hesperum, var. latum.
Isomeris arborea.
Silene Californica.
Ceanothis divaricatus.
v. spinosus.
Styphonia integrifolia.
Lathyris vestitus.
Homalabus multiflorus.
Adenostoma fasciculata.
Rubus ursinus.
Ribes Californicum.
Lithophragma cymbelaria.
Sanicula bipinnatifida.
Corethrogyne incana.
Solidago sempervirens.
Aplopappus Menziesii.
Encelia Californica.
Chenactes tenuifolia.
Bahia confertiflora.
Arctostaphylos tomentosa.
Castilleja affinis.
Verbena prostrata.
Amsiuckia spectabilis.
Eritrichium fulvium.
Whitlavia tanacetifolia.
Calystegia sepium.

Gilia dianthoides.
Californica.
Solanum umbellif. var. glabrescens.
Blitum bonus-Henricus.
Oxybaphus glabrifolius.
Oreodaphne Californica.
Zigadenus Douglasii.
Dichelostemma congesta.
Avena fatua.
Polypodium intermedium.
Adianthum chilense.
Gymnogramma triangularis.
Ramalina retiformis.
Macrocystis pyrifera.
Halydrys osmundacea.
Fucus ceranoides.
Phyllospora Menziesii.

GILA RIVER AND DISTRICT BETWEEN SAN PEDRO AND RIO GRANDE.

Argemonia hispida.
Erysimum hesperum.
Lepidium montanum.
Dithyrea Wizlizenii.
var. refracta.
Telinum aurantiacum.
Sidalcea malvaeflora.
Malvastrum coccineum.
Sphæralea incana.
v. angustifolia.
Fendleri.
Hibiscus denudatus.
Linum perenne.
Larrea Mexicana.
Frangula Californica.
Fanucia gracilis.
Rhus trilobata.
Vitis æstivalis.
Ampelopsis quinquefolia.
Krameria lanceolata.
Amorpha fruticosa.
Hosackia puberula.
Hoffmantsegia stricta.
Capsia Lindheimeriana.
Acacia Greggii.
constricta.
cuspidata.
Strombo-carpa pubescens.
Algarobia glandulosa.
Cerasus serotina.
Rosa blanda.
Œnothera coronapefolia.
vinosa.
Apodanthera undulata.
Cucurbita digitata.
Cephalanthus occidentalis.
Macherantera canescens.
v. latifolia.
tanacetifolia.

Erigeron divergens, v. cinereum.
Diplopappus ericoides.
Gutierrezia microcephala.
Aplopappus gracilis.
Tessaria borealis.
Baccharis coerulescens.
Zinnia pumila.
Ximenisia encelioides.
Ridellia tagetina.
Gaillardia pulchella.
Hymenopappus flavescens.
Actinella linearifolia.
Baileya multiradiata.
Gnaphalium sprengelii.
Lobelia Texensis.
Plantago patagonica.
Chilopsis linearis.
Pentstemon Thurberi.
linarioides.
Verbena bipinnatifida.
aubletia.
hastata.
Heliotropium curassavicum.
Erythrea tricantha.
Convolvulus lobatus.
Ipomœa nil.
Evolvulus argenteus.
Nama biflora.
Gilia longiflora.
Solanum flavidium.
Physalis pumila.
Asclepias tuberosa.
Fraxinus velutina.
Menodora scabra.
Obione canescens.
Chenopodina linearis.
Mirabilis longiflorus.
Abronia millifera.
Eriogonum filipes.
Simmondsia Californica.
Juglans rupestris.
Ephedra antisiphilitica.
Commelyna erecta.
Phalaris arundinacea.
Paspalum distichum.
Panicum lachuanthum.
Setavia viridis.
Sporobolus airoides.
Androspogum nutans.

CORDILLERAS.

Delphinium decorum.
Platystemon Calif. var. leiocarpum.
Erodium cicuterium.
Larrea Mexicana.
Lathyris venosus.
Hosackia scoparia.
Strombocarpa pubescens.
Ænothera viminea.

Ænothera bistorta.
albicolis.
Aplopappus sphærocephalus.
Hymenoclea salsola.
Lagia elegans.
Chilopsis linearis.
Anterrhinum glandulosum.
Pentstemon spectabilis.
Diplacus glutinosus.
Mimulus brevipes.
Castilleja affinis.
Phacelia eutoca.
Phacelia circinata.
tanacetifolia.
Gilia densifolia.
Androsacea
Quamoclidum multiflorum.
Eriogonum angulosum.
nudum.
Centrostegia Thurberi.
Agave Americana.
Calochortus venustus.
Uniola spicata.

CHAPTER III.

DESCRIPTION OF THE PLATES.

BY JOHN TORREY, M. D.

Plate I. JANUSIA GRACILIS, (page 9.)

Fig. 1. A flower, from which two of the petals and one of the sepals have been removed; magnified.
Fig. 2. A sepal, showing the two glands at its base; more magnified.
Fig. 3. A petal; magnified.
Fig. 4. The two stamens; one of them showing the back, the other the front of the anther.
Fig. 5. The pistil; considerably magnified.
Fig. 6. One of the carpels with its cavity laid open, showing the seed in its natural position; moderately magnified.
Fig. 7. The seed removed, and magnified.
Fig. 8. The embryo; equally magnified.

Plate II. STYPHONIA SERRATA, (page 9.)

Fig. 1. A leaf from an old plant; of the natural size.
Fig. 2. The calyx, with bracts at its base; enlarged.
Fig. 3. An expanded flower; also enlarged.
Fig. 4. A sepal; more enlarged.
Fig. 5. A petal; equally enlarged.
Fig. 6. A stamen; considerably magnified.
Fig. 7. The pistil; equally magnified.
Fig. 8. The same, with the cavity laid open and exhibiting the ovule; more enlarged.
Fig. 9. A berry; somewhat magnified.

Plate III. DALEA SPINOSA, (page 9.)

Fig. 1. A flower; enlarged.
Fig. 2. The calyx; also enlarged.
Fig. 3. Parts of the corolla: *a*, the standard; *b, b*, the wings; *c, c*, petals of the keel; enlarged.
Fig. 4. Monadelphous stamens; more enlarged.
Fig. 5. A separate stamen, with only the free portion of its filament; still more magnified.
Fig. 6. The pistil; magnified.
Fig. 7. A pod, partly enclosed in the persistent calyx.
Fig. 8. An ordinary cauline leaf; moderately enlarged.
Fig. 9. Leaves from a young seedling plant.

PLATE IV. HOSACKIA PUBERULA, (page 10.)

Fig. 1. The calyx; enlarged.
Fig. 2. Parts of the corolla: *a*, the standard; *b*, *b*, the wings; *c*, *c*, the keel-petals; equally enlarged.
Fig. 3. Monadelphous stamens, with the pistil enclosed in the stamineal sheath; also magnified.
Fig. 4. Part of a stamen; more magnified.
Fig. 5. The pistil; enlarged.
Fig. 6. A pod of the natural size; part of one valve removed to show the seeds.

PLATE V. OLNEYA TESOTA, (page 10.)

Fig. 1. A separate flower; a little enlarged.
Fig. 2. The calyx; more enlarged.
Fig. 3. Parts of the corolla: *a*, the standard; *b*, *b*, the wings; *c*, *c*, the keel-petals; equally enlarged.
Fig. 4. The diadelphous stamens; enlarged.
Fig. 5. Part of a separate stamen; magnified.
Fig. 6. The pistil; magnified.
Fig. 7. The ovary laid open; showing the numerous ovules.

PLATE VI. APLOPAPPUS SPHÆROCEPHALUS, (page 12.)

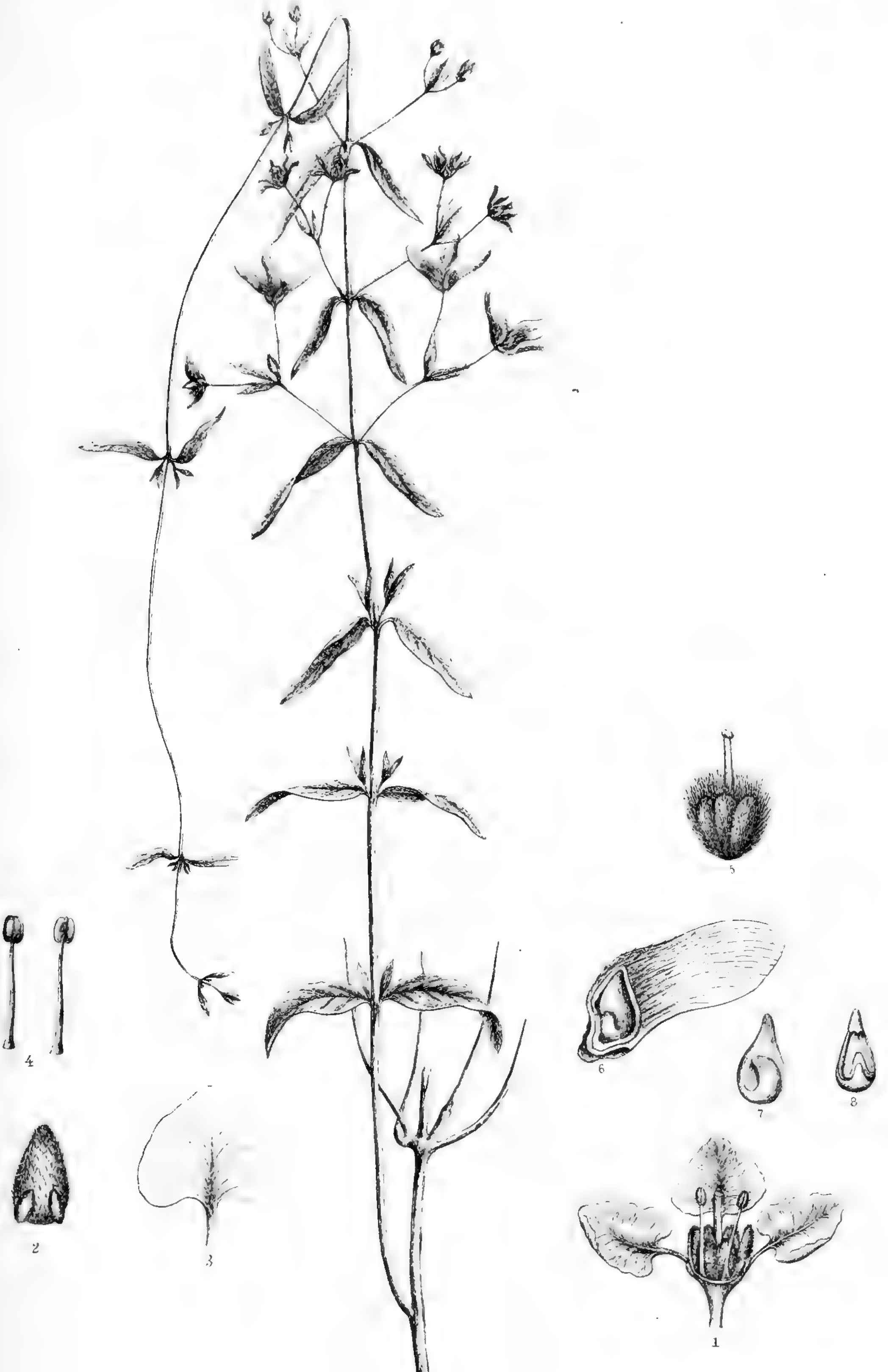
Fig. 1. A head of flowers; somewhat enlarged.
Fig. 2. A separate flower; considerably magnified.
Fig. 3. The corolla laid open, showing the stamens and style.
Fig. 4. A separate stamen.
Fig. 5. Branches of the style, showing the stigmatic lines; much magnified.
Fig. 6. A ripe achenium with its pappus; considerably enlarged.

PLATE VII. MENODORA SCABRA, (page 18.)

Fig. 1. A flower; enlarged.
Fig. 2. The corolla laid open; more enlarged.
Fig 3. A stamen; still more enlarged.
Fig. 4. The pistil; equally magnified.
Fig. 5. The ovary, longitudinally opened; more enlarged.
Fig. 6. Ripe pod, showing the dehiscence; moderately enlarged.
Fig. 7. Longitudinal section of the seed; more magnified.

PLATE VIII. CENTROSTEGIA THURBERI, (page 20.)

Fig. 1. Involucre; considerably magnified.
Fig. 2. Limb of the same laid open, and more enlarged.
Fig. 3. Flower; still more enlarged.
Fig. 4. A sepal, with a stamen attached to the claw; highly magnified.
Fig. 5. The pistil; moderately magnified.
Fig. 6. A ripe achenium; more enlarged.
Fig. 7. A mature seed; equally magnified.
Fig. 8. The embryo; also equally magnified.



Ackerman Lith. 379 Broadway N.Y.

JANUSIA GRACILIS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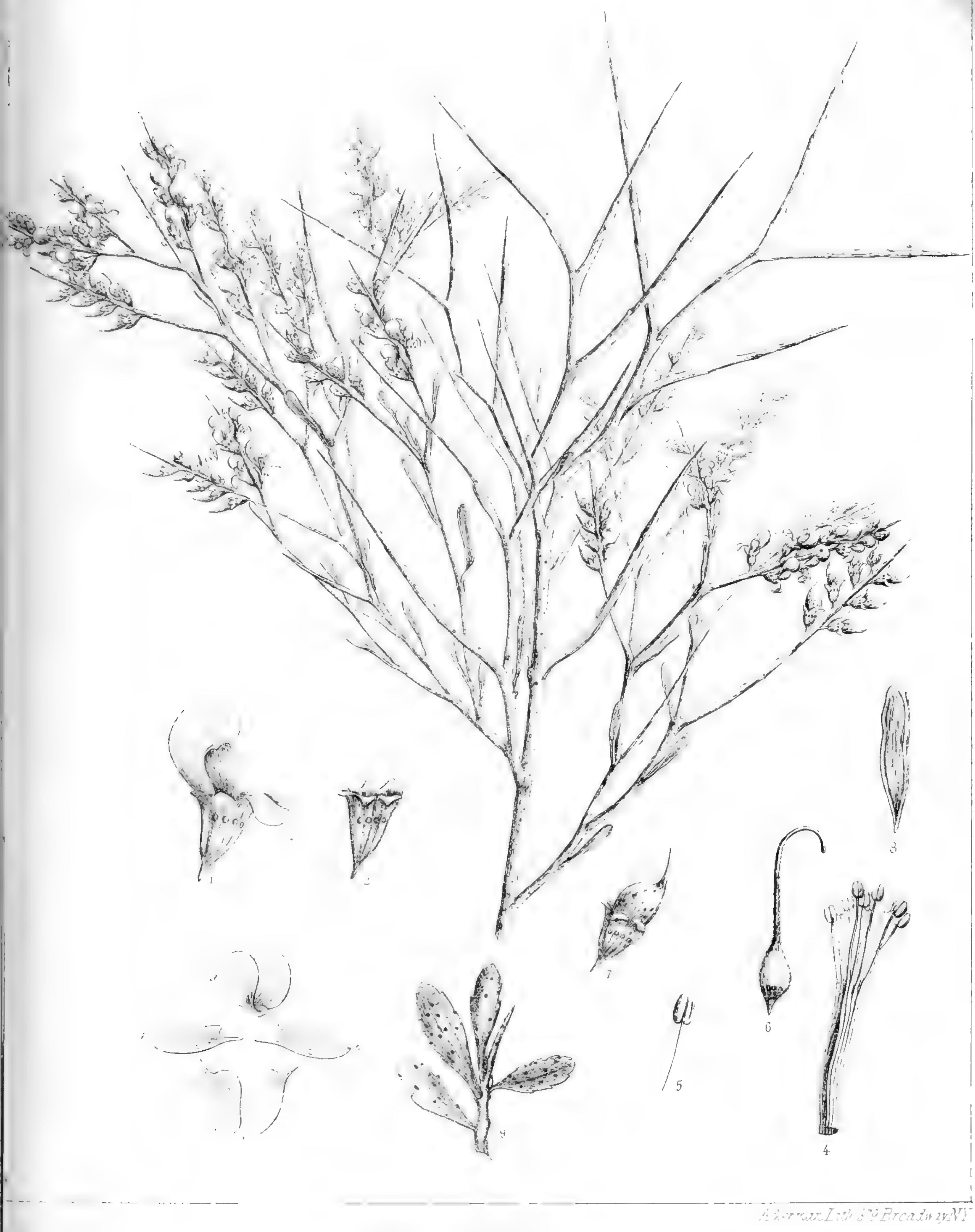
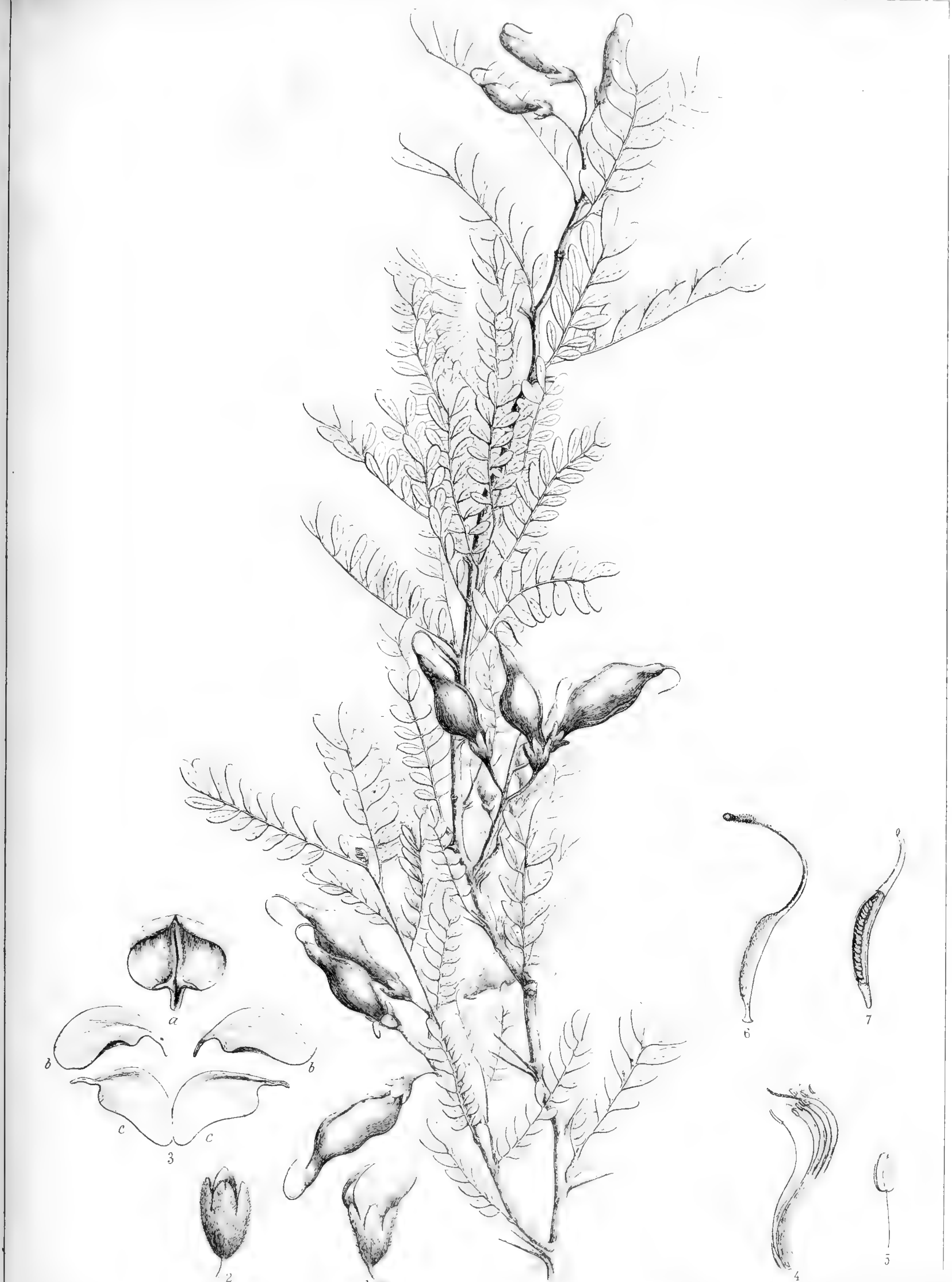


A. Sonrel, Lith 599 Broadway N.Y.

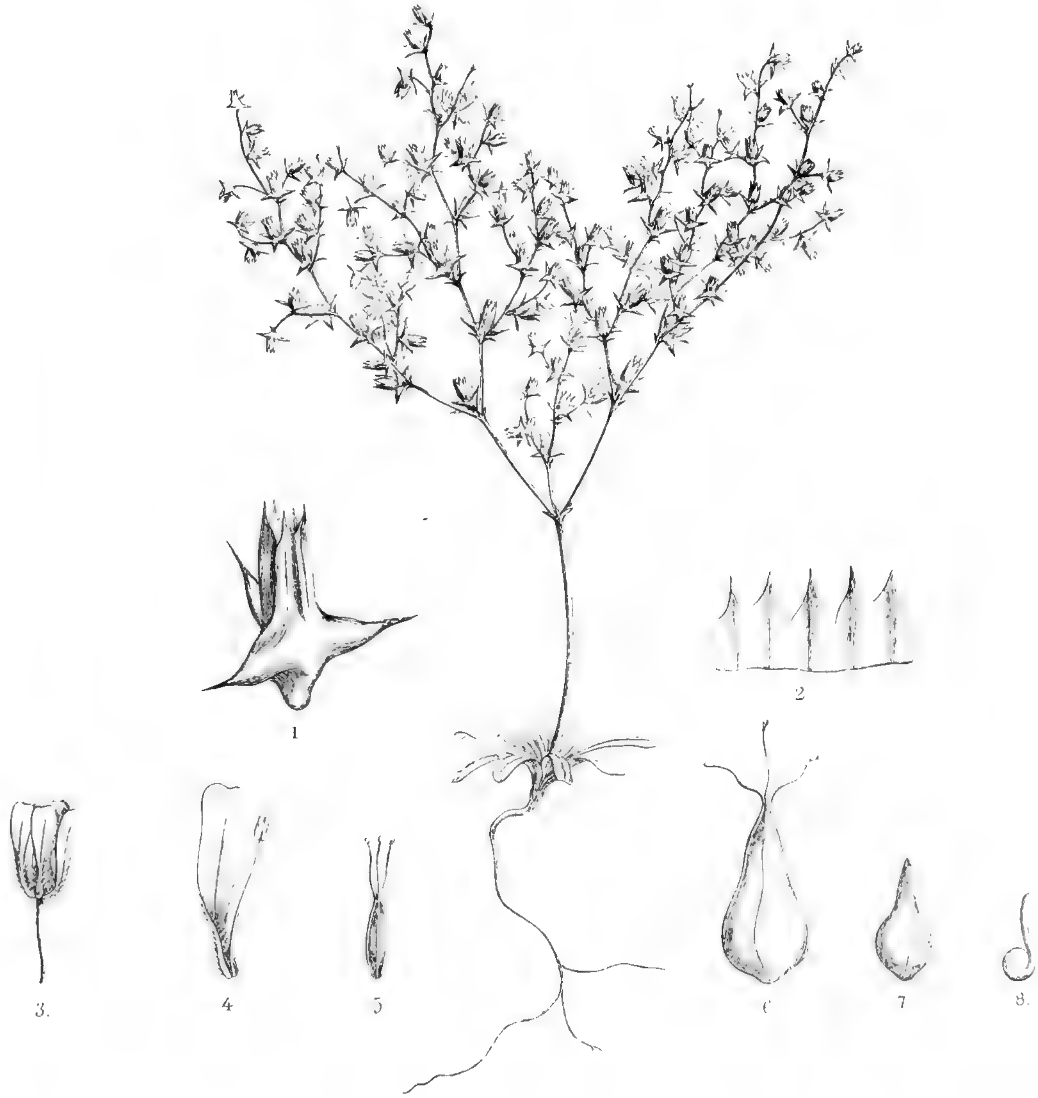
HOSACKIA PUBERULA.



OLNEYA TESOTA.

APLOPAPAPPUS SPHÆROCEPHALUS

MENDORA SCABRA



CENTROSTEGIA THURBERI

APPENDICES.

APPENDIX A.

REMARKS ON METEOROLOGY AND BAROMETRIC RESULTS, WITH METEOROLOGIC PLATES.

BY ALBERT H. CAMPBELL, A. M.
CIVIL ENGINEER TO THE EXPEDITION.

WASHINGTON, *January* 1, 1857.

SIR: I herewith transmit the results of a cursory discussion of the barometric observations taken during the progress of your surveys and explorations to determine the practicability of a railroad from the Mississippi river to the Pacific ocean, both in California, from the Bay of San Francisco to Los Angeles, and near the 32d parallel of north latitude.

Respectfully, your obedient servant,

ALBERT H. CAMPBELL,
Civil Engineer and Surveyor.

Lieut. JOHN G. PARKE, *Corps U. S. Top. Engineers,*
In charge of Pacific Railroad Explorations, &c., &c., &c.

METEOROLOGICAL.

DATA FOR THE PROFILES.

The corrections for the temperature of the mercury were obtained from the tables of the Smithsonian Institution, prepared by Professor Guyot.

The corrections for constant error were obtained by mutual comparisons among all the barometers at almost every camp between the Pueblo de San José and the city of Los Angeles. At the latter place was obtained barometer No. 790, (Green's cistern,) which was left there by Captain A. W. Whipple, United States Topographical Engineers, after the completion of his explorations near the 35th parallel, and by long comparisons with it and those of our own at San Bernardino and Jarupa, a chain of connexion through all the work in California, and a favorable reference to Green's standard at New York, was secured, No. 790 having differed but .001 from its former reading, after an interval of two years and five months. All the observations were, therefore, referred directly to the standard. From a careful discussion of these comparisons, it appears there is still a small but appreciable error, the source of which it is difficult to determine on account of its variableness, and which is probably due, in part, to a want of perfect adjustment, at the time of observation, of the index point; partly to personal error, and in part to the unequal bore of the tubes, causing an increase or decrease of capillary attraction, for it not unfrequently happens that two barometers, at a pressure of about 30 inches, will read with a given difference uniformly; but when subjected to a less pressure—27 inches, for example—other things being equal, this difference will often vary as much as 0.010. This fact is observable even during the diurnal range of the barometer, though to a less appreciable extent.

The correction for horary oscillation was obtained from frequent hourly observations taken for that purpose. Those used for determining the hourly corrections for the hours of the day, to apply to observations made in connexion with the survey, are given in Table No. 1. In Table No. 2 are the observations for the twenty-four hours at the places indicated. For the construction of these curves, see *Plate* 1, *Figs. Nos.* 1 *and* 2. By reference to these tables and diagrams, it will be perceived that this phenomenon is marked by irregular oscillations as to the maximum and minimum point. This is probably due to the peculiarity of the season of winter on the California coast, it being the period when greater fluctuations of the atmosphere take place, and also to the want of a sufficiently long series of observations. In several instances, during remarkable changes of atmospheric condition, the diurnal oscillations were completely broken up. An example of this occurred on the 1st and 4th of January, 1855, at Camp 14′, at the headwaters of the Salinas river, when a great storm occurred. For a comparison of this storm at several other places along the coast, see *Plate No.* 5. At Camp 17, January 16 and 17, the atmosphere was in a remarkably quiescent state, and the curve for those days is probably very near the true measure for the time and place, the tropical hours occurring at 10 A. M. and 4 P. M.—(See *Plate* 1, *Fig.* 3.)

The correction for abnormal oscillation, by far the most important element of error in barometric discussion, and hitherto the most difficult of measurement, was obtained by a careful comparison of nine months' daily simultaneous observations at Benicia barracks and at the mission of San Diego, taken under the direction of the medical department of the United States army, with those taken during the progress of the survey. * This comparison was made in accordance with the plan of Captain A. W. Whipple, to whom the credit of the suggestion with reference to the determination of barometric heights is due, and its results are satisfactory and confirmatory of the plan pursued by him in the discussion of the meteorological observations pertaining to his exploration near the thirty-fifth parallel. The diagrams (*Plates Nos.* 2—10) will illustrate the intimate relations of this abnormal effect upon the mercurial column for places widely remote. By a combination of the observations at the above named places, and with those along the line of survey, a scale of correction was obtained, which, when applied to each observation, has produced interesting and accurate results. The manner in which this combination was made may be briefly stated and the plates explained. The Benicia and San Diego observations for nine months, from October, 1854, to June, 1855, inclusive, were plotted in their relative positions; the hours being by regulation, sunrise, 9 A. M., 3 P. M., and 9 P. M. These were sufficient to indicate the direction of the curve of pressure from one day to another; a line was therefore

* There is a paragraph on this subject in Kaemtz Meteorology, p. 292, where the sensible parallelism of the curves is recognized, but no satisfactory results are given, nor any reference to their application to obtaining correct altitudes for an extended barometric profile.

drawn connecting these observations. The observations at the Presidio de San Francisco, made under the direction of Lieutenant W. P. Trowbridge, United States Engineers, of the Coast Survey, and permitted to be used for this comparison by Captain W. R. Palmer, United States Topographical Engineers, in charge of that office, are plotted in their relative positions, as are the various observations taken during the survey, and also those on Colorado river, taken under the direction of Lieutenant N. Michler, United States Topographical Engineers, of the Mexican Boundary Commission, and kindly offered to be used in this discussion by Major W. H. Emory, commissioner. The horary correction was not eliminated from most of these observations, which will account for the *minor* irregularities observed in the several curves. When the combination for the scale of correction was made all the proper corrections were applied. The mean line expressed in the plates is about the mean of the Benicia and San Diego observations, combined, viz: 29.650.* The horizontal scale of the diagrams is one-tenth of an inch to three hours, and the vertical scale one inch to one inch of the barometer. On *Plate* 5 the arrows represent the direction of the wind and the state of the weather at the specified hours, during a remarkable storm on the 1st and 4th of January, 1855.

It is not proposed to go into a discussion of this principle of compensation for abnormal effects, or to draw any general conclusions from the results obtained; the facts are simply stated, and this task is left to the able and zealous meteorologists who are now engaged in tracing the finger that points the storm.

To the observations at Benicia the horary corrections applied were deduced from the long series of hourly observation of Lieutenant Trowbridge, taken at the Presidio de San Francisco, (see *Plate* 1, *fig.* 5,) and those applied to the San Diego observations were taken from Table No. 2.

SEA LEVEL.†

The mean of nine months observation at Benicia barracks, 81.5 feet above tide, with all the corrections applied, including correction due to 81.5 feet, gave for the mean pressure of sea level 30.057. At San Jose, at the southern extremity of the bay of San Francisco, the estimated height of that place above tide, applied to the observations taken there, gave as a base 30.040. This base was used as far as the middle waters of the Salinas, (Camp 8.) The mean of thirteen observations on the beach in the bay of San Luis Obispo, with an average air temperature of 63°, gave a result of 30.031. (See general table.) The mean of eight observations at the sea level between the Gaviote pass and San Buenaventura, with a mean air temperature of 68°, gave for the sea level east of Point Concepcion 30.023, and a single observation with air temperature of 64° gave 30.022, and another at 65°.2 gave 30.023. To the above observations it should be born in mind that all the corrections were first applied, including the abnormal error, as determined by the method above referred to. There are many other points along the coast, situated from 10 to 40 feet above mean tide, which are *correctly fixed* by the barometic observations. From these results it appears that the maximum pressure for the Pacific coast attains a higher latitude than on the Atlantic, and will probably be found, by subsequent observations, to be in about latitude 43° north, or at some point

* This has no practical value except as an approximate base from which was determined the measure of abnormal error for each hour in the twenty-four.

† See plate 11.

between Cape Mendocino and the mouth of Columbia river, within the accumulative influence of the return trade winds of the Pacific.

The mean of seven observations with air temperature of 58°, taken by Lieut. Michler at New Town, San Diego harbor, to which the same corrections for the various elements of error, as used in the above work, were applied, gave for the height of mean tide 30.018. From the above results we have the following table, uncorrected for gravity, and contrasted with a portion of Schouw's table for the North Atlantic ocean.

cific.		Atlantic.	
Latitude.		*Latitude.*	
° ′		°	
38. 00	30. 057	45	30. 011
37. 20	30. 040	40	30. 006
35. 10	30. 031	30	30 069
34. 27	30. 023	20	30. 004
32. 40	30. 018		

FROM FORT YUMA TO FORT FILLMORE.

To obtain the corrections for the temperature of the mercury above 100°, the formula given in the Smithsonian tables, prepared by Professor Guyot, was used. The correction for constant error was obtained by mutual comparisons of barometers 392 and 790, (Green's cis.,) and with the Smithsonian standard at Green's instrument depot, New York city. Frequent observations were taken to determine the horary correction between Fort Yuma and Fort Fillmore. The corrections are given in Table No. 3, and constructed in *Plate* 1, *figure* 4. A peculiarity was observed in this phenomenon, which will be adverted to in the sequel.

To determine the measure for abnormal oscillations of the barometer, a sufficient number of observations along the line of survey or in the contiguous regions could not be obtained with which to compare. The observations at San Diego, however, were compared with those of Lieut. Michler, at Fort Yuma, during the months of December, 1854, January, and part of February, and, with those of our own, in June, 1855, and gave very satisfactory results, and from this comparison a scale of corrections was obtained for that place. By reference to the diagrams it will be seen that the fluctuation of the atmosphere occurred very nearly simultaneously at those places, and, consequently, an accurate measure for the abnormal error was probably obtained. For the months of December, January, and part of February, the average amount of correction was found to be *minus* 0.180, and for the middle of the month of June *plus* 0.100. To the observations of Lieut. Michler the former correction was applied, and gave for the height of his astronomical station No. 1, opposite Fort Yuma, 35 feet above the surface of the river 310.8 feet, and for the level of the water 275.8 feet above mean tide at San Diego. At Camp 60, (Gila river,) about 7 miles above the junction of the Colorado and Gila rivers and about 20 feet above the water, 52 observations were taken, to which were applied the latter correction for abnormal error, and gave for the height of the Gila at that point 296.6 feet above mean tide at San Diego. Four observations at Ankrim's ferry, about one and a half miles below Lieut.

Michler's station, gave for the elevation of that place above the sea 260.7 feet. The height of Lieut. Michler's station above the water is estimated, and it is probably a few feet higher.*

These results are believed to be very nearly correct, yet there appears to be some effect upon the mercurial column, which is difficult to explain without a long and careful series of observations. May not this effect be due to the tension of aqueous vapor? The period at which the atmosphere on the Pacific coast and the lower region of the Colorado river is most heavily charged with moisture is during the winter months—the mean temperature of winter is not low; the tension of vapor is, therefore, comparatively great. Does it not, then, have the effect of increasing the pressure upon the cistern, causing the barometer to rise too high? The months of May and June being excessively hot and dry, there would be but little or no effect due to the tension of vapor, the pressure indicated being that of dry and highly rarefied air, would it not be too low? The observations of Lieut. Michler opposite Fort Yuma, above referred to, uncorrected for abnormal error, give as a mean 29.865, (58° mean air temperature.) Ours in June, for the same place, give 29.691, (90° mean air temperature.) The question is, which of these results is nearest the truth? If the tension of vapor has any effect, is its *increased* effect upon barometric pressure in winter in greater ratio than its absence entirely, or the decreased pressure due to rarefaction in summer? It appears to be in a sensibly greater ratio at Fort Yuma in winter than in summer.

After the normal corrections, as it were, are applied to any series of observations, does not the residuum include any effect of aqueous tension, if there be such? and if there is no effect due to the tension of vapor, is not the pressure during the winter months in the Colorado basin, &c., where the mean temperature is about 60°, and the atmosphere nearer its normal state, more nearly correct than in summer when the mean temperature is 90° and the reflection from the arid plain rarefies the air to so great an extent? These queries are thrown out by way of suggestion, as this question of the effect of aqueous vapor is still open to investigation and practice.

There are a complete set of observations with Mason's hygrometer, taken in connexion with the barometric observations to be found in the general table, and it is hoped that, in the hands of an experienced meteorologist, they may throw some weight on this subject.

To the observations at the various points between the Colorado and Rio Grande, the abnormal error was not applied; for, as above stated, suitable observations could not be obtained with which to compare. It appears, however, from the direction of the curve at San Diego and Fort Yuma, as late as June, and from the curve of the various camps, that this correction for the months of July and August, 1855, did not, probably, exceed *plus* 0.050.

For the correction of air temperature $\left(\frac{t + t' - 64^\circ}{900}\right)$ the mean monthly temperature, as nearly as could be ascertained, was taken for t' instead, as is usual, of taking the temperature

* The result of 80 observations of Lieut. Michler, in March and April of the same year, at the *initial* point, 27 miles below Fort Yuma, discussed and corrected in the above manner, give the height of the river at this point 156.8 feet above tide. The rapid current of the Colorado river, nearly six miles per hour during moderate freshets, can be accounted for by this slope of the plain through which it flows. There seems to be some reason in the supposition that this stream flows down in shutes from one plateau to another. This appears to be the general rule of all small streams of the Colorado and Gila basins and in the Great Basin where I have traveled—the communication from one *steppe* to another being through a shute or cañon caused by some great revolution of nature—a cracking due to an upheaving force, or, which is most probaple, to the shrinking of the earth's crust during the cooling process.

at the time of observation. Experience proves that this method gives more correct results. The mean temperature for June, by our own observations, confirmed by those taken for several years at Fort Yuma, is 90°. By a combination of all our observations on the Gila, at Pimas villages, and lower portion of San Pedro, for a part of June and of July, the mean temperature was found to be the same as at Fort Yuma, 90°. From the lower San Pedro to the Sauz it was found to be 86°, and hence to the Rio Grande 80°, corresponding with the mean temperature of the time in question with observations taken at Fort Fillmore for several years under the direction of the medical department of the United States army. All the observations from Fort Yuma to Fort Fillmore are referred directly to the sea level at San Diego, viz: 30.018, as deduced as before explained; this had previously been assumed at 30.050, and, in comparing identical points of a previous survey, this should be compensated for, and also an allowance made for different seasons.*

An interesting phenomenon occurred at Camp 76, San Pedro river, (July 21 and 22, 1855,) with reference to the diurnal oscillations of the barometer, which we do not remember to have seen mentioned elsewhere. Several days' hourly observations, from 7 a. m. to 7 p. m., (see *Plate* 1, *fig.* 6.,) and one set, July 21 and 22, for 36 consecutive hours, (see *Plate* 1, *fig.* 7,) gave for the maximum 7 a. m. and for the minimum 5 p. m.—*but one maximum and one minmum point in* 24 *hours.* The maximum temperature each day, respectively, was 99°.2 and 100° at 3 p. m., the minimum 57.°5 at 5 a. m.; maximum degree of dryness at 1 p. m. 30°.5, and at 3 p. m. 30°; minimum point 4° at 5 a. m. *Plate* 1, *fig.* 7, will illustrate more clearly these relations of pressure and dryness, and, when compared with *fig.* 8, being a similar series of 36 hours' observation, taken January 16 and 17, 1855, near San Luis Obispo, (Camp 17,) may serve to explain the phenomenon. In these diagrams the vertical scale is the same as in the other diagrams, and, to illustrate the relation of this difference between the wet and dry bulb thermometers to the pressure, the same divisions are made to represent each 1° of temperature, beginning from the base of the figure. From a glance at these diagrams it will be perceived that the respective maxima and minima points of pressure and dryness bear an intimate relation to each other. The explanation of this phenomena appears to be this: at San Luis Obispo, as the influence of the sun's presence begins materially to be felt at 10 a. m., the tension increases almost *pari pasu* with the decrease of pressure to their respective culminating points, and then the contrary effect is produced as the sun's influence is gradually withdrawn. The influence of radiation is then felt, producing a similar inverse movement until this cause ceases, and the opposite course is taken until the approaching sun again begins to exert its influence on the upper regions of the atmosphere, and a repetition of these movements for the next 24 hours takes place. In the San Pedro case, the effect of radiation is felt from the moment of the decline of the sun until his

* In the foregoing remarks I have omitted to state that the formula used for the computations of the heights was Loomis' Laplace modified, as given by him in his *Practical Astronomy*, with a table, &c. For the first division of our work the correction for air temperature was applied to the observed temperatures. Subsequent discussions of the observations in the Gila region led to a different application of this correction, as above stated, and too late to revise the immense number of observations in California. It is believed, however, that had this revision been made no material change would have been made in the profile, since all the important points were established in camps of long duration, where the mean temperature of the time of remaining was taken, and the most important points along the survey were determined, at hours of the day ranging very little from the daily mean.

return on the coming morning, which accounts for the absence of the night maximum and morning minimum almost universally observed.*

PHENOMENA OBSERVED.

There are some phenomena of general interest that were casually observed during our travel across the continent, which it may not be amiss to note down as a contribution to the great mass of facts which are daily accumulating, illustrative of the somewhat paradoxical laws of physical science. The prevailing wind upon the Colorado desert appears to be from the southeast, from the indication of the movable sands and gravel, between Sackett's wells and Alamo Mocho, arranging themselves in long elliptical hummocks, on the northwest side of each shrub and stone which intercepted their course; and to all appearance these hummocks are of a permanent character, and not subject to each shifting wind that chances to blow. The wind, during our march from Vallecito to the Colorado river, came from the southeast. For a week or more, however, at Camp 60, about 7 miles up the Gila, the wind blew a gentle breeze from the southwest, and continued during the daytime from that quarter along the Gila, as far as the Pimas villages. It is probable that this change of direction may be due to the influence of the rivers and the configuration of the country, causing a portion of the southeast wind from the Gulf of California to deflect up the basin of the Gila.

On the morning of the 9th of June, about 5 o'clock, at Fort Yuma, a slight earthquake was felt by some members of the party, but it was of short duration and seemed to excite but little attention.

On the 11th of June, at the mouth of the Gila, small cumulus and cirrus stratus clouds were observed, and a few drops of rain fell for a second or two; temperature, 107°. After several days' march up the Gila, cumulus clouds, with an occasional cirrus, appeared daily in the east, at a great height; their progress was from a few degrees south of east,† and on arriving at about the meridian of 113° 30′ disappeared entirely, doubtless vaporized by the ascending currents of heated air from the arid plains of the Colorado and lower Gila. These clouds were watched with interest daily, with fond hopes that they would precipitate rain, to relieve us from the oppressive heat of 115°, and we were forcibly struck with their uniform disappearance along a well defined north and south line.

Several days after the appearance of these clouds, and they increased daily, the temperature sensibly declined, and there appeared to be a general preparation of the elements for rain, and frequent showers were seen depending from the clouds, like long brush marks, but no water reached the earth.

The great height from which the rain falls is remarkable, the clouds floating at an elevation of about from 12,000 to 15,000 feet above the plains, far above the tops of the loftiest mountains. No ready means suggested themselves for measuring their height, and this may be too great or too small an estimate, but their *unusual* height was frequently remarked upon. This

* In Kaemtz's Meteorology, page 270, a reference is made to this phenomenon, as observed by M. Dove, after having applied a correction for the tension of vapor to Neuber's observations at Apenrade. In the above instance no correction of this sort has been made; a reference to the hygrometric observations in the general table will indicate the condition of the atmosphere in this respect.

† This is the usual direction of rain clouds from the Rio Grande across the plateau. To El Paso they come more from the outheast.

is easily accounted for by the excessive temperature of these plains, and the consequent effect of ascending currents and general rarefaction.

After several days of rain and a consequent decrease of temperature, these clouds descended and enveloped the summits of the mountains. During the period referred to the sky was never entirely overcast, and the rain came in terrific thunder showers, as many as eight or ten being observable in different parts of the sky, but moving parallel from a little south of east to the opposite point of the horizon.

We have said that a southwest wind prevailed all along the Gila as far as the Pimas villages. This breeze generally died away at sundown and a temporary lull prevailed until the moon rose, when almost immediately a comparatively cool and gentle breeze set in from the point of rising and continued more or less during the night. This phenomenon was observed for several days, from two days' march below the Maricopas wells to Tucson.

The excessive brilliancy of the skies was frequently remarked in these regions, even near the horizon. On the evening of the 3d of July, as a part of the train had fairly entered upon that long and dreaded *jornada* between the Gila and Tucson, we were riding in advance reflecting on the dreary march before us, with no little misgiving as to its issue: the head of Scorpio had passed the meridian, and the planet Jupiter, toward whose cheering light our pathway lead, was in the southeast; for some moments we had perceived a phantom-like presence on our left, which we were at a loss to determine or account for, when, on closer inspection, a scarcely appreciable shadow of ourself and mule was perceptible, following along the ground. Perceiving it to be constant, and proceeding from no passing meteor or terrestrial object, we took out a note-book, and holding a pencil before a blank leaf detected a well-defined shadow proceeding from the luminous portion of the galaxy near the southern horizon, and the brilliant stars of the beautiful constellations Scorpio and Sagittarius; no shadow was apparent from Jupiter, though shining with unwonted splendor.*

Numerous meteors were of almost nightly occurrence, both in California and across the continent, their general direction being southwesterly.

* Since penning the above paragraph I have discovered in my reading several allusions to this phenomenon of brilliancy, by travellers in eastern climes. In an Appendix to Burton's Pilgrimage to El Medinah and Meccah is an account of it, given by Banks, the translator of Giovanni Finati's Narrative, who was one of the three Christians who have succeeded in penetrating to that *sanctum sanctorum* of the Mohammedan. In Morris' Tour in the East the following passage occurs in a description of the passage of the desert between Cairo and Suez: "There was no moon in the sky, but the blue roof above us was fretted with multitudes of dazzling stars, *that cast a faint illumination upon the desert.*" There is a striking resemblance between the Arabian deserts, as described by intelligent travellers, and the Colorado and Sonora deserts, in geology, topography, vegetation, and to a remarkable degree in the customs of the respective populations; to fully present these resemblances would be to swell this paper beyond its legitimate limits.

TABLE No. 1.—*Diurnal oscillation from 7 a. m. to 5 p. m., 1854–'55.—California.*

CAMP 14.—SANTA MARGARITA.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
December 11	29.361	29.363	29.362	29.359	29.331	29.303	29.273	29.230	29.226	29.229	29.236
12	29.255	29.251	29.249	29.236	29.230	29.188	29.163	29.137	29.124	29.122	29.136
14	29.167	29.168	29.168	29.162	29.145	29.103	29.078	29.066	29.058	29.063	29.068
15	29.088	29.089	29.080	29.080	29.070	29.038	29.005	28.993	28.984	28.982	28.987
16	28.992	28.988	29.001	28.998	28.985	28.957	28.926	28.906	28.907	28.913	28.918
17	28.980	28.980	28.987	28.990	28.973	28.981	28.946	28.938	28.959	28.970	28.987
18	29.164	29.177	29.203	29.206	29.195	29.180	29.143	29.122	29.094	29.097	29.121
19	29.170	29.165	29.184	29.171	29.142	29.105	29.088	29.081	29.074	29.077	29.083
Mean	29.147	29.147	29.154 +	29.150	29.134	29.107	29.077	29.059	29.053 —	29.056	29.067

CAMP 14'.—HEAD OF SALINAS.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
December 22	28.614	28.617	28.623	28.628	28.623	28.598	28.569	28.570	28.571	28.574	28.585
23	28.690	28.696	28.704	28.688	28.681	28.652	28.631	28.627	28.646	28.650	28.656
24	28.738	28.727	28.734	28.725	*28.721	28.691	28.669	28.657	28.662	28.656	28.664
25	28.713	28.717	28.727	28.722	28.719	28.689	28.661	28.655	28.639	28.633	28.642
26	†28.678	28.675	28.689	28.689	28.673	28.656	28.644	28.640	28.646	28.650	28.665
27	28.785	28.790	28.800	28.805	28.809	28.796	28.767	28.764	28.770	28.782	28.784
29	28.731	28.743	28.728	28.719	28.688	28.663	28.641	28.624	28.619	28.623	28.641
Mean	28.707	28.708	28.715 +	28.711	28.702	28.678	28.654	28.648 —	28.650	28.652	28.662

CAMP 14".—NEAR CAMP 14.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
January 10	29.122	29.119	29.102	29.088	29.063	29.035	29.006	28.993	28.990	28.997	29.015
11	†29.007	29.004	29.002	28.996	28.971	28.948	28.906	28.979	28.875	28.840	28.850
12	†28.864	28.858	28.870	28.871	28.854	28.848	28.841	28.846	28.851	28.846	28.862
Mean	28.998 +	28.993	28.991	28.985	28.962	28.944	28.918	28.939	28.905	28.894 —	28.909

CAMP 17.—NEAR ARROYO GRANDE.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
January 16	29.809	29.814	29.809	29.829	29.827	29.795	29.773	29.752	29.736	29.743	29.748
17	29.793	29.806	29.818	29.833	29.830	29.796	29.783	29.770	29.768	29.764	29.763
18	†29.791	29.801	29.806	29.809	29.808	*29.778	29.768	29.761	†29.753	*29.752	29.758
19	†29.822	*29.827	29.830	29.848	29.843	29.826	29.811	29.794	29.801	29.793	†29.798
Mean	29.804	29.812	29.816	29.829 +	29.827	29.798	29.784	29.769	29.764	29.763 —	29.767

CAMP 21.—NEAR SANTA INEZ.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
January 28	29.431	29.440	29.464	29.455	29.434	29.405	29.361	29.355	29.346	29.345	†29.350
Mean	29.431	29.440	29.464 +	29.455	29.434	29.405	29.361	29.355	29.346	29.345 —	29.350

CAMP 25.—NEAR SANTA BARBARA.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
February 9	30.141	30.164	30.187	30.191	30.187	30.157	30.136	30.116	30.095	30.083	30.105
11	†30.008	30.004	30.008	30.013	30.025	29.995	29.967	29.952	29.952	29.952	29.950
13	29.975	29.948	29.974	29.982	29.985	29.960	29.936	29.929	29.926	29.909	29.909
Mean	30.041	30.039	30.056	30.062	30.066 +	30.037	30.013	29.999	29.991	29.981 —	29.988

TABLE No. 1—Continued.

CAMP 31.—SAN FRANCISQUITO.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
March 5	28.974	29.006	28.987	28.980	28.962	28.941	28.934	28.922	28.929	28.929	28.929
6	29.015	29.018	29.027	29.014	29.006	29.001	28.978	28.973	28.971	28.970	28.975
7	29.074	29.058	29.074	29.064	29.053	29.039	29.021	29.003	28.995	28.989	28.998
Mean	29.021	29.027	29.029 +	29.019	29.007	28.994	28.977	28.966	28.965	28.963 —	28.967

CAMP 41.—NEAR SAN BERNARDINO.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
April 10	*28.930	*28.932	28.935	28.938	28.933	28.932	28.901	28.889	*28.875	28.859	28.865
11	28.966	28.980	28.998	29.006	28.996	28.994	28.993	28.983	28.983	*28.984	28.986
12	29.079	29.075	29.089	29.090	29.086	29.075	29.071	29.049	29.055	29.057	29.064
14	29.127	29.127	29.123	29.119	29.113	29.106	29.080	29.073	29.059	29.053	29.043
Mean	29.025	29.028	29.036	29.038 +	29.032	29.027	29.011	28.998	28.993	28.988 —	28.989

CAMP 42.—JARUPA.

Date.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.
April 20	29.254	29.255	29.255	29.240	29.232	29.222	29.215	29.202	29.176	29.176	29.169
Mean	29.254	29.255 +	29.255	29.240	29.232	29.222	29.215	29.202	29.176	29.176	29.169 —
‡ General mean	29.182	29.184	29.194 +	29.192	29.182	29.160	29.137	29.128	29.121	29.119 —	29.127

NOTE.—Those observations marked with an * are interpolations, obtained by plotting the curve, and connecting it where the observations are wanting, &c. Those marked thus † are very slightly changed to correspond with the even hours.

Mean of extremes: 29.156.

Correction for 7 a. m.	—.026	Correction for 1 p. m.	+.019
8 a. m.	—.028	2 p. m.	+.028
9 a. m.	—.038	3 p. m.	+.035
10 a. m.	—.036	4 p. m.	+.037
11 a. m.	—.026	5 p. m.	+.029
12 m	—.004		

‡ For construction of this curve, see *Plate* 1, *fig.* 1.

TABLE NO. 2.—*Horary oscillation for 24 hours.—California.*

Place.	6 A. M.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.	6 P. M.	7 P. M.	8 P. M.	9 P. M.	10 P. M.	11 P. M.	12 M. N.	1 A. M.	2 A. M.	3 A. M.	4 A. M.	5 A. M.
Camp 14	29.354	29.361	29.363	29.362	29.359	29.331	29.298	29.268	29.256	29.255	29.259	29.292	29.294	29.319	29.307	29.333	29.325	29.360	29.346	29.346	29.355	29.332	29.294	29.348
Camp 14′	28.607	28.614	28.617	28.623	28.628	28.623	28.598	28.566	28.563	28.561	28.572	28.582	28.598	28.519	28.590	28.613	28.623	28.610	28.613	28.606	28.616	28.615	28.600	28.600
Camp 17	29.799	29.809	29.814	29.809	29.829	29.827	29.795	29.773	29.752	29.736	29.743	29.748	29.755	29.768	29.782	29.793	29.800	29.796	29.781	29.771	29.770	29.772	29.788	29.782
Camp 42	29.263	29.254	29.255	29.255	29.240	29.232	29.222	29.215	29.202	29.176	29.176	29.169	29.181	29.188	29.210	29.232	29.232	29.235	29.229	29.221	29.201	29.204	29.208	29.249
* Means..	29.251	29.259	29.262	29.262	29.264 +	29.253	29.228	29.205	29.193	29.182 —	29.187	29.198	29.207	29.198	29.222	29.243	29.245	29.250 +	29.242	29.236	29.235	29.230	29.222 —	29.245

Mean of extremes 29.230.

6 a. m................	— .021	6 p. m................	+ .023
7 a. m................	— .029	7 p. m................	+ .032
8 a. m................	— .032	8 p. m................	+ .008
9 a. m................	— .032	9 p. m................	— .013
10 a. m................	— .034	10 p. m................	— .015
11 a. m................	— .023	11 p. m................	— .020
12 m. n................	+ .002	12 m................	— .012
1 p. m................	+ .025	1 a. m................	— .006
2 p. m................	+ .037	2 a. m................	— .005
3 p. m................	+ .048	3 a. m................	.000
4 p. m................	+ .043	4 a. m................	+ .008
5 p. m................	+ .032	5 a. m................	— .015

* For construction of this curve see *Plate* I, *fig.* 2.

Table No. 3.—*Horary oscillations for Gila river, &c.—32d parallel.* 1855.

Place.	Time.	5 A. M.	6 A. M.	7 A. M.	8 A. M.	9 A. M.	10 A. M.	11 A. M.	12 M.	1 P. M.	2 P. M.	3 P. M.	4 P. M.	5 P. M.	6 P. M.	7 P. M.
Camp 60, near Fort Yuma.......	June 11............	29.581	29.588	29.590	29.593	29.609	29.605	29.598	29.583	29.559	29.538	29.517	29.508	29.494	29.495	29.532
Camp 60, near Fort Yuma.......	June 12............	29.617	29.638	29.650	29.680	29.688	29.693	29.687	29.678	29.666	29.640	29.621	29.607	29.598	29.606	29.614
Camp 68, Maricopa wells........	June 29............	*28.765	28.767	28.769	28.787	28.799	*28.799	28.774	28.757	28.743	28.721	28.709	28.687	28.682	28.687	28.694
Camp 80, Sugar Loaf..........	August 3...........	*26.405	26.411	26.411	26.406	†26.425	†26.421	26.418	26.400	26.380	26.347	26.325	26.317	26.304	26.324	*26.340
Means.................	....	‡28.592	28.601	28.605	28.616	28.629 +	28.627	28.619	28.604	28.587	28.561	28.543	28.529	28.519 —	28.528	28.545

Note.—Those observations marked * are interpolations, and those marked † are reduced to even hours.

‡ For construction of this curve see *Plate* I, *fig.* 4.

Mean of extremes 28.574.

5 a. m.................	— .018
6 a. m.....	— .027
7 a. m.................	— .031
8 a. m.................	— .042
9 a. m.................	— .055
10 a. m.................	— .053
11 a. m.....	— .045
12 m	— .030
1 p. m.................	— .013
2 p. m.................	+ .013
3 p. m	+ .031
4 p. m.................	+ .045
5 p. m.................	+ .055
6 p. m.................	+ .046
7 p. m.................	+ .029

Modified scale for camps 87, 88 & 89.

Mean of extremes 28.109.

6 a. m.................	— .022
7 a. m.................	— .026
8 a. m..........	— .039
9 a. m.................	— .052
10 a. m......	— .049
11 a. m.................	— .040
12 m	— .026
1 p. m.................	— .011
2 p. m...........	+ .013
3 p. m.................	+ .034
4 p. m.................	+ .044
5 p. m.......	+ .053

Fig 1

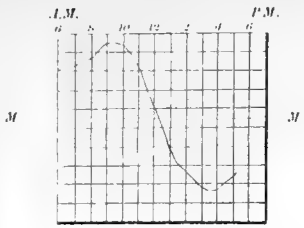


Fig. 4

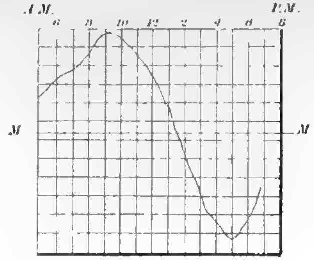


Fig. 7

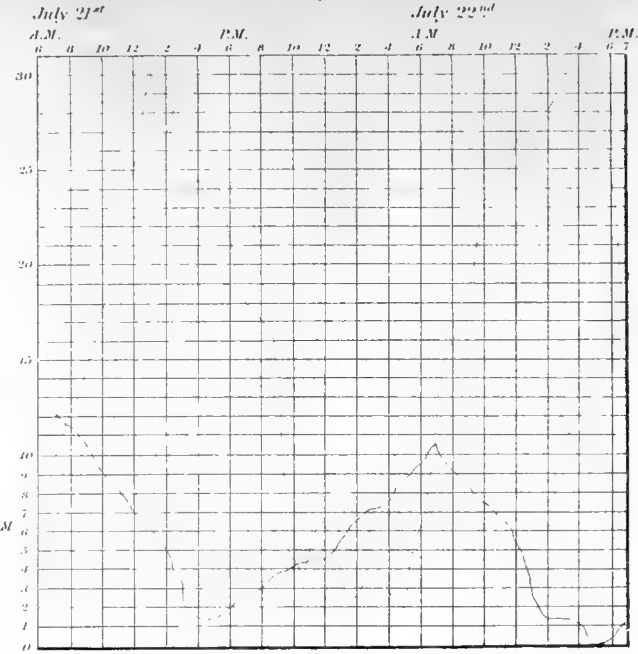


Fig 2

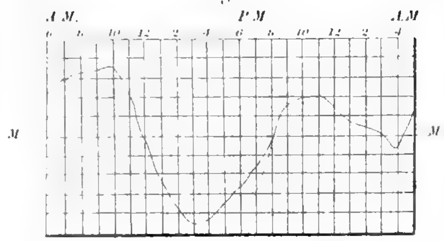


Fig 5

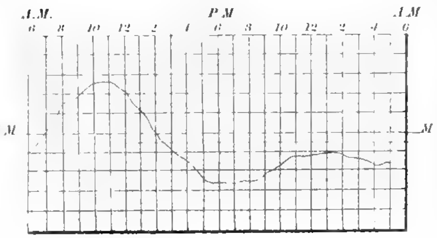


Fig. 8

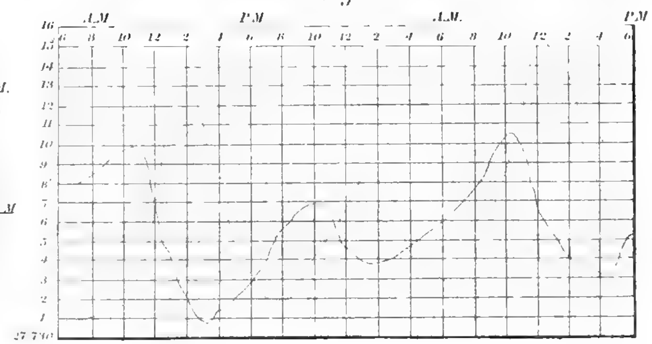


Fig. 3

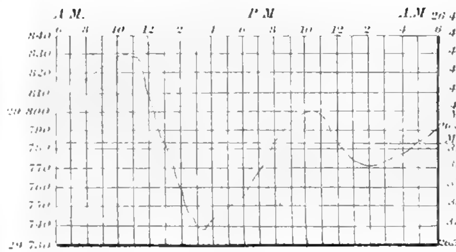
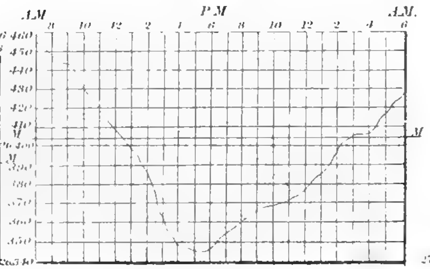
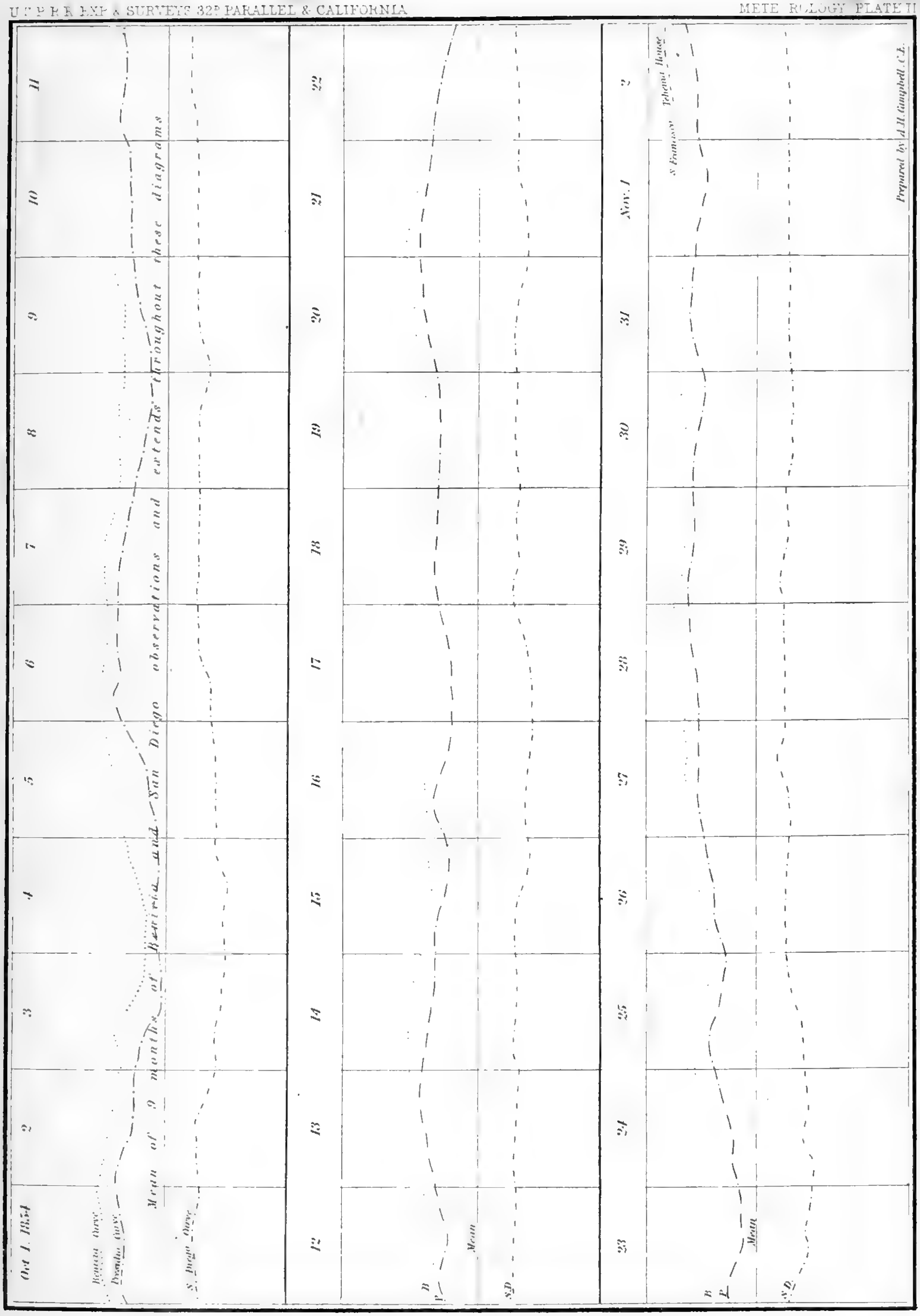


Fig. 6



Prepared by A.H. Campbell C.E.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Benicia Curve
Presidio Curve
S. Diego Curve
Mean of 9 months of Benicia and San Diego observations and extends throughout these diagrams
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Mean
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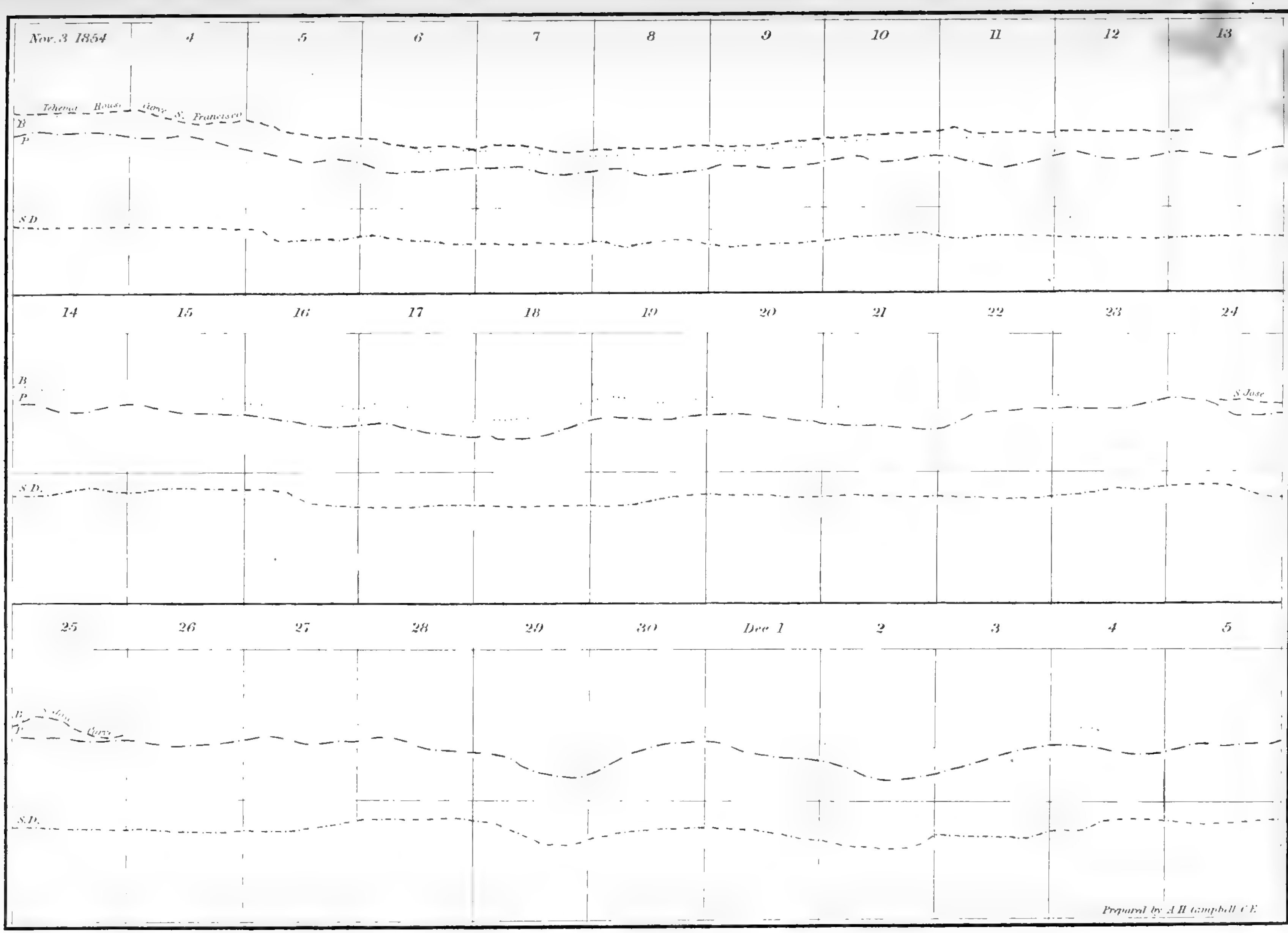
S. Francisco
Tehama House
Prepared by J. H. Campbell C.E.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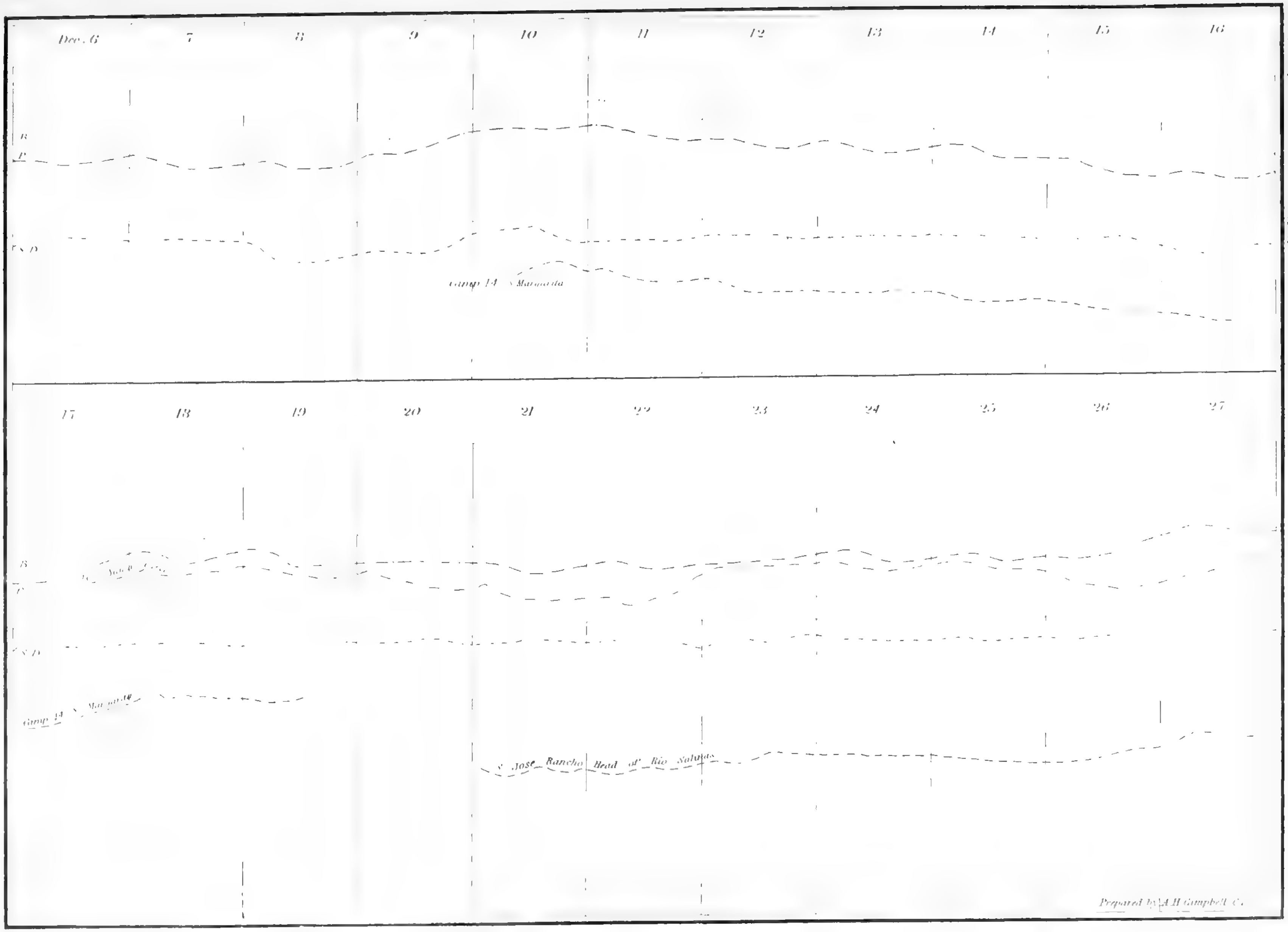
Prepared by A.H. Campbell C.E.



Dec. 6
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Camp 14 S. Margarita
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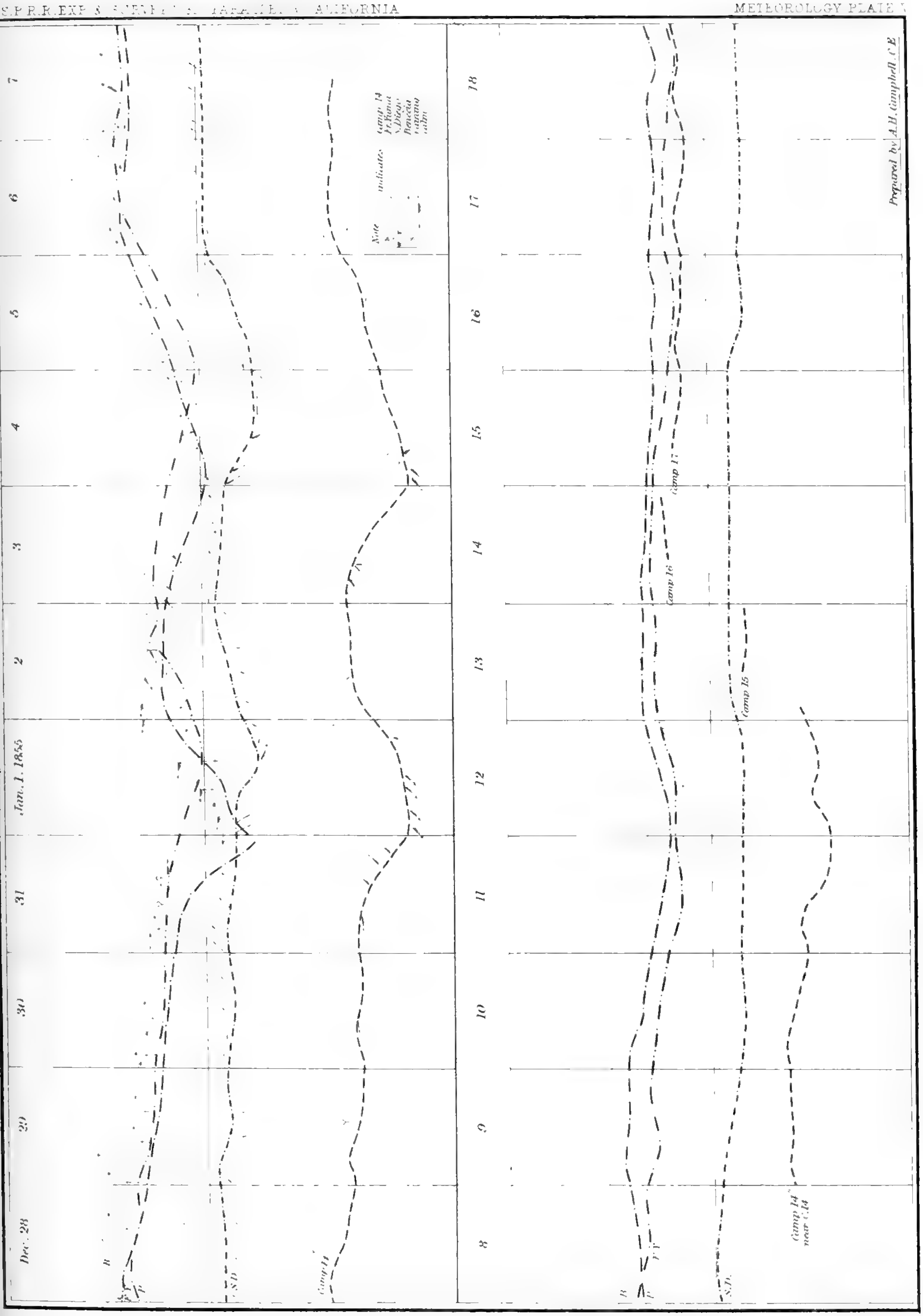
Camp 14 S. Margarita
S. Jose Rancho
Head of Rio Salinas
Prepared by A. H. Campbell C.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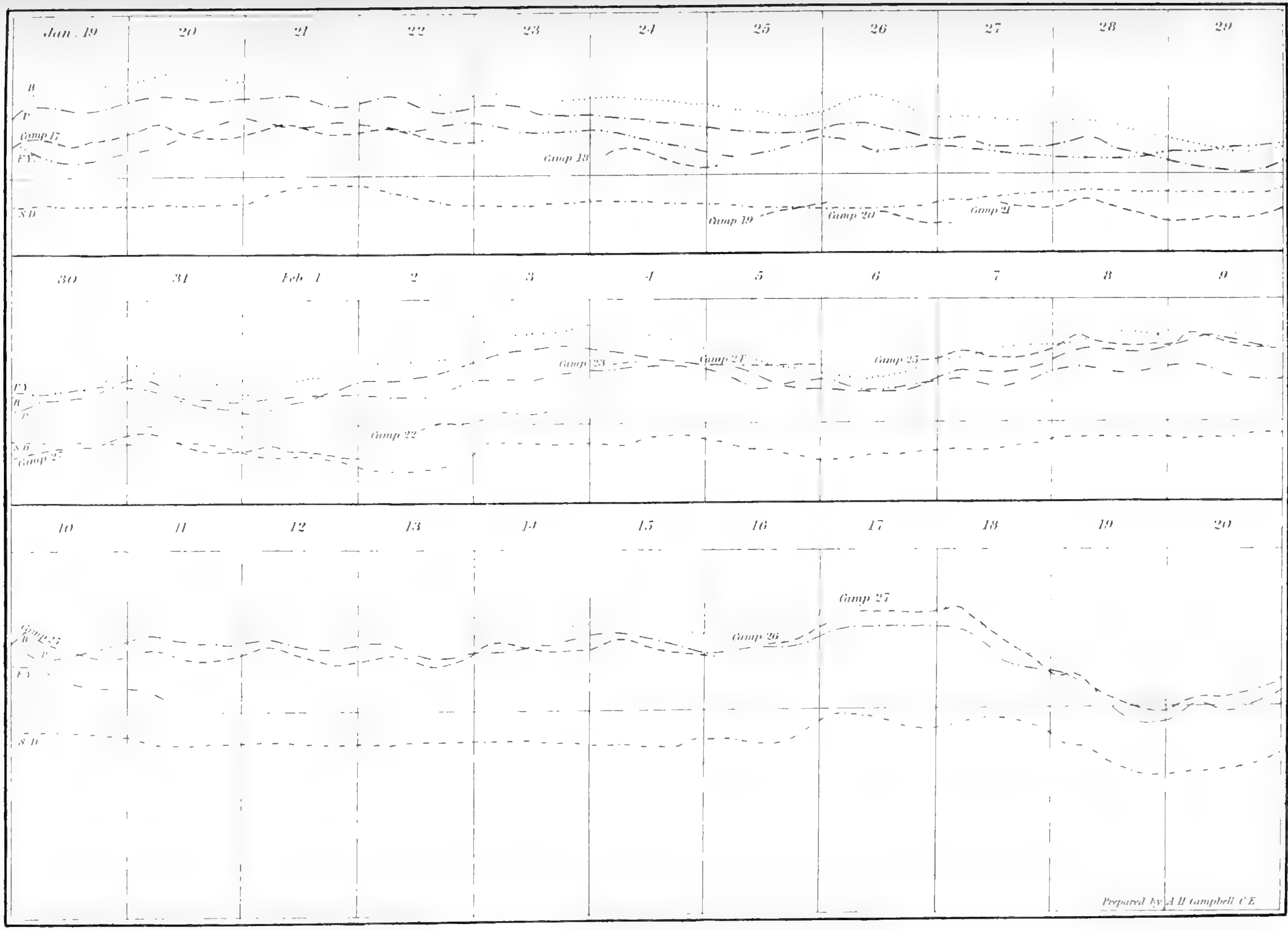
Camp 14 near C.14
Prepared by A.H. Campbell C.E.



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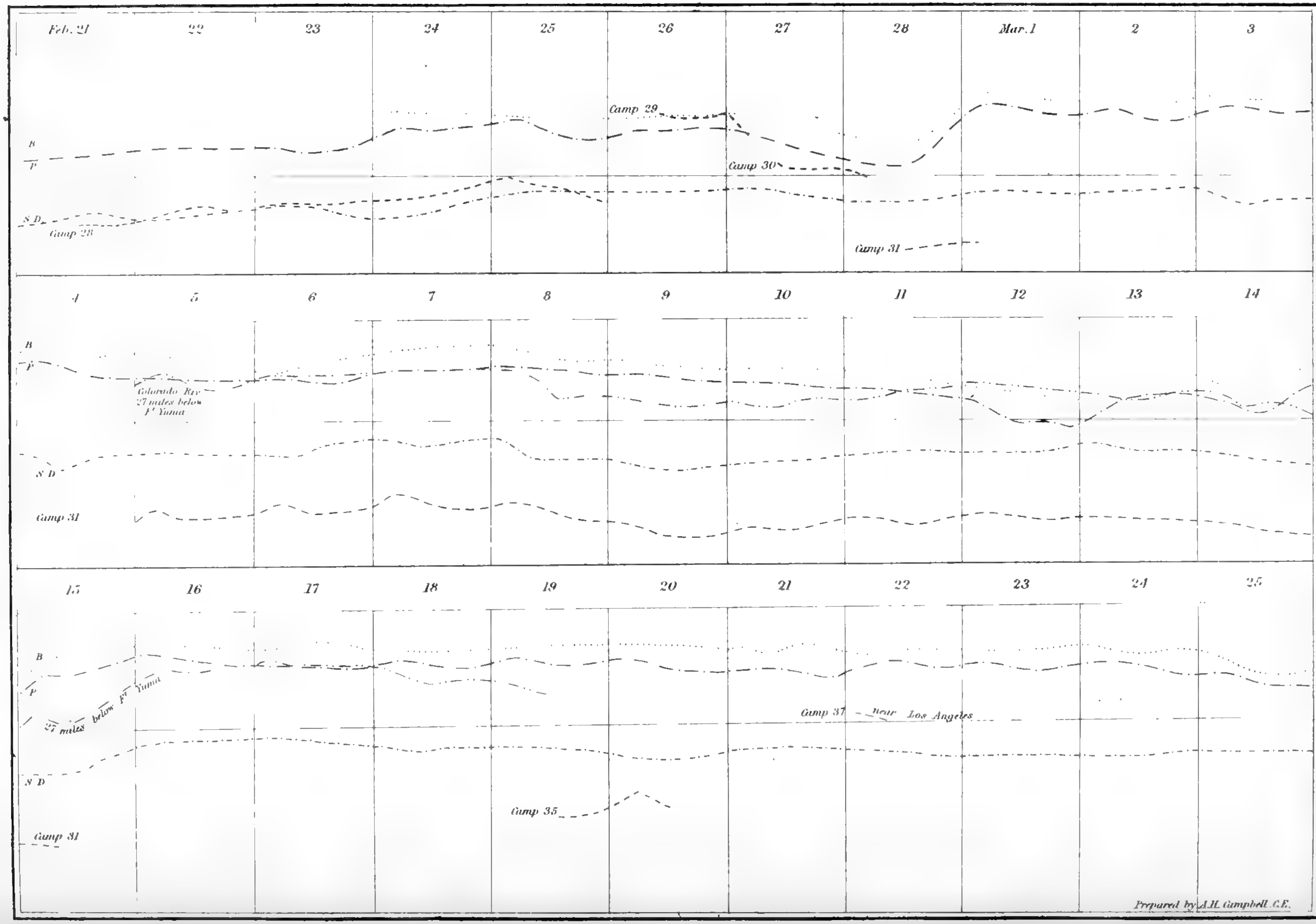
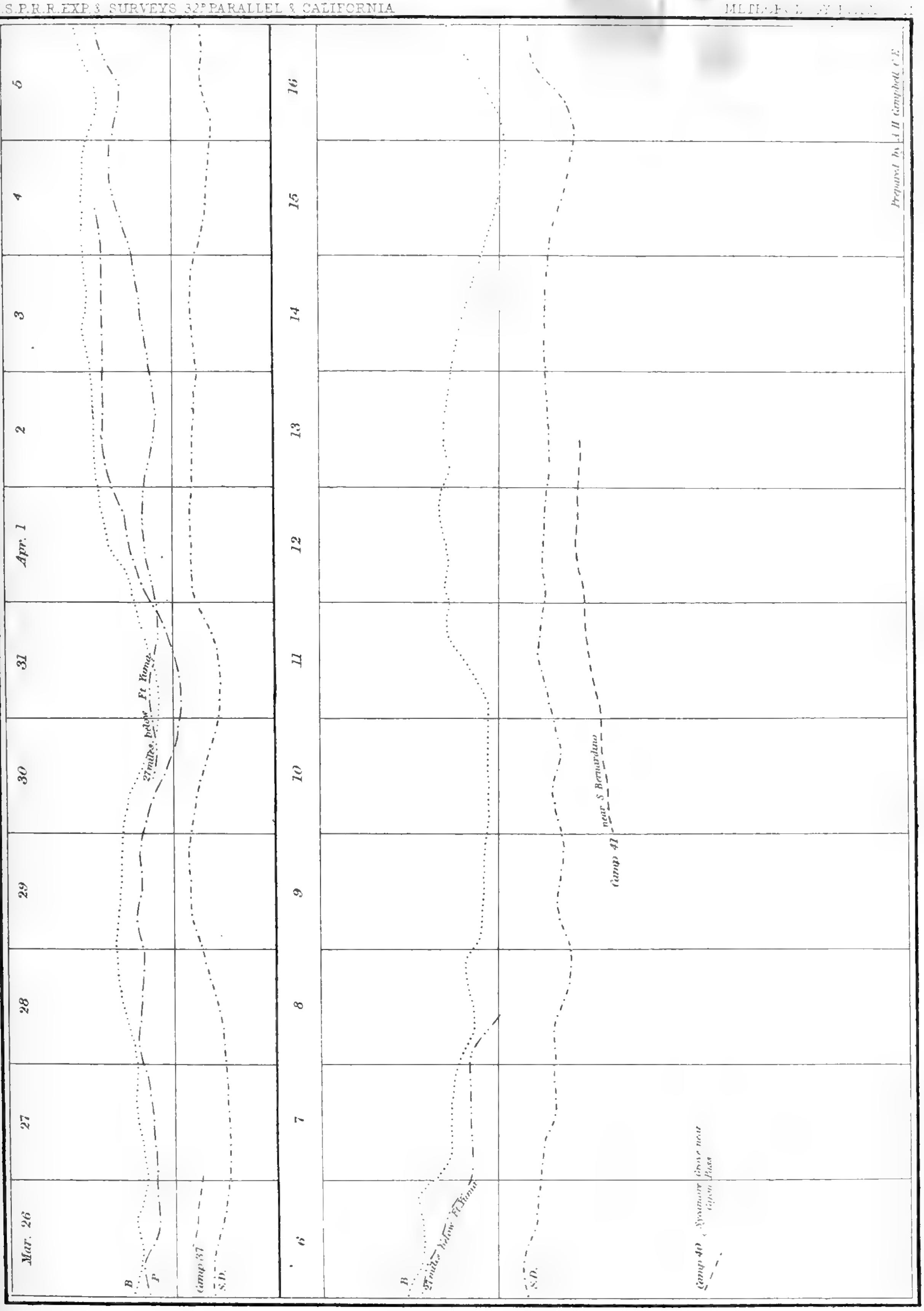
Prepared by A. H. Campbell C.E.



U S P R R EXP & SURVEYS 32° PARALLEL & CALIFORNIA

METEOROLOGY PLATE [illegible]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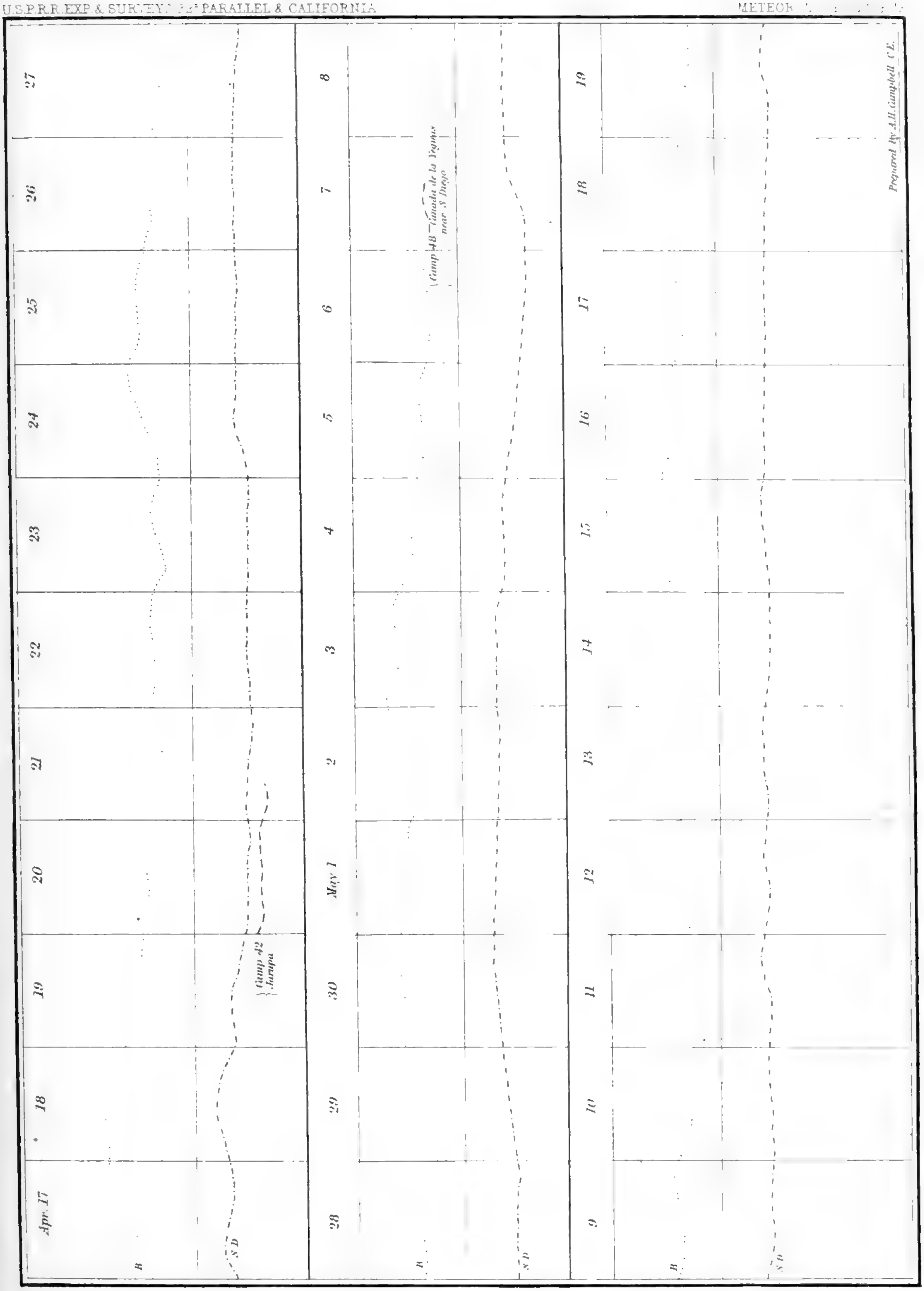
27 miles below Ft. Yuma
Camp 41 near S. Bernardino
Camp 40 Sycamore Grove near Cajon Pass
Prepared by A. H. Campbell C.E.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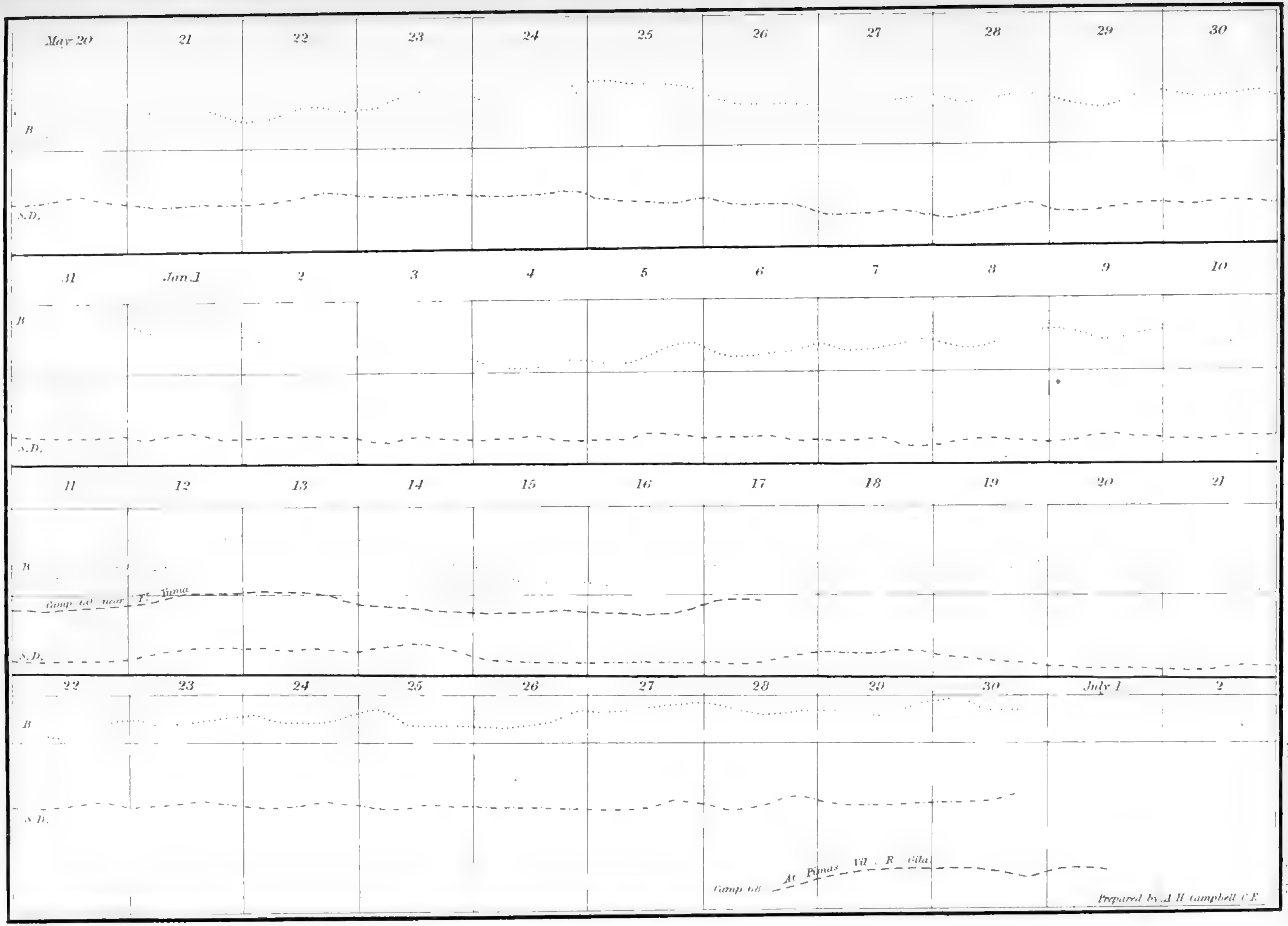
Camp 42 Jurupa
Camp 48 Cañada de la Vegnas near S Diego
Prepared by A.H. Campbell C.E.



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Camp 60 near Ft. Yuma
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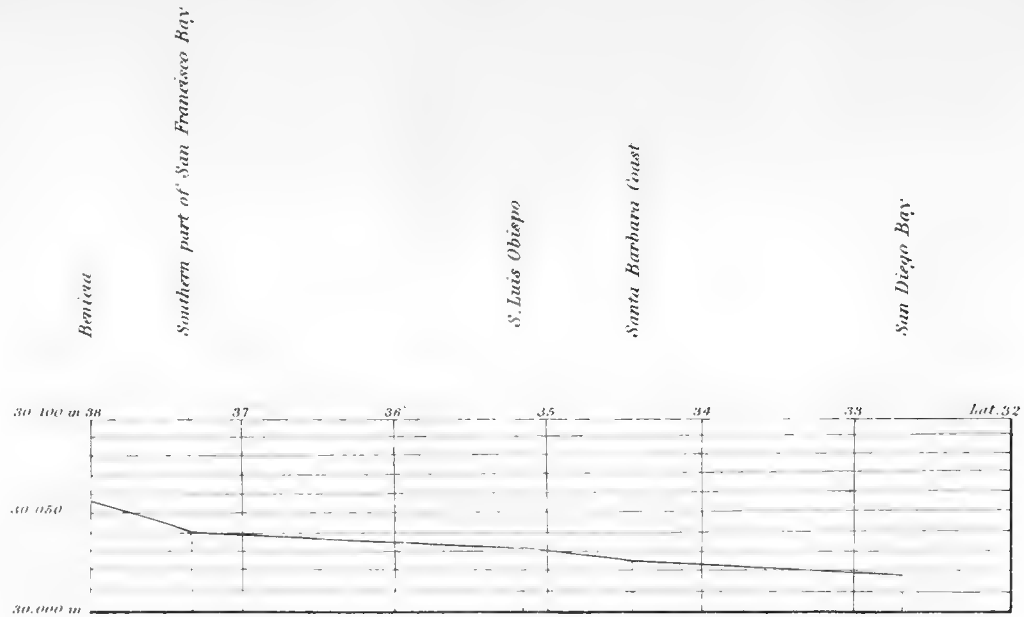
Camp 68 At Pimas Vil. R. Gila
Prepared by A. H. Campbell C.E.



BAROMETRIC PRESSURE AT LEVEL OF THE SEA.

Prepared by A.H. Campbell C.E.

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APPENDIX B.

REPORT UPON THE ROUTE FROM SAN DIEGO TO FORT YUMA, VIA SAN DIEGO RIVER, WARNER'S PASS, AND SAN FELIPE CANON.

BY CHARLES H. POOLE,
CHIEF ENGINEER.

SAN DIEGO, *California, October* 10, 1855.

DEAR SIR: I have the honor herewith to submit to you, in compliance with the request communicated to me at the time of your departure from California, the following report of the results obtained of a survey by me of the proposed route for a railway across the State of California, and between the port of San Diego and the mouth of the river Gila. This survey, as you are aware, was undertaken by the company organized at this place under the laws of the State of California for the purposes of insuring a careful and minute examination of passes in the Coast mountains believed to be practicable and adapted to the passage of a railroad.

The exploration was deemed more necessary and important, from the fact that the limited time allowed to Lieutenant Williamson for his examinations last year did not permit so close a survey of the country between the coast and the Colorado river as the very peculiar and difficult nature of the country seemed to require. It was believed essential that the acknowledged advantages of a terminus of the Pacific coast within 200 miles of the mouth of the Gila, at a port and harbor of unrivalled excellence, should not lightly be passed over in these preliminary examinations, nor suffered to be neglected for want of adequate information as to its practicability of access.

TOPOGRAPHY OF THE COUNTRY.

It will be proper to give a brief statement of the main features of the district proposed to be traversed by the railroad, in order to insure a correct understanding of the objects, details, and results of the survey.

The Pacific coast, from San Diego to San Pedro, a distance of 100 miles, has a general direction northwest, unbroken by any cove or inlet, presenting a continuous series of bluffs and narrow valleys, formed by the spurs and foot-hills of the mountains of the interior, which, as they approach the sea, gradually subside into rolling and sometimes abrupt ridges divided by water-courses tending to the ocean. About fifty miles from the sea, the Coast or Cordilleras range of mountains extend nearly parallel with the coast from their junction with, or rather their disjunction from, the Sierra Nevada, entirely across the district and through Lower California to Cape St. Lucas. The divide or watershed of these mountains is not a direct line of any given course, but is tortuous to the last degree, often nearly overlapping itself and forming numerous re-entering angles. The heights of the summits are seldom over 5,000 feet. Between the foot-hills of the range are numerous fertile valleys, narrow and bounded by the slopes of the spurs on either side. Small rivers take their rise in the gorges of the hills, and flowing seaward, lose their waters in the sandy beds of their course, discharging no water into the sea except during the season of rains, when the supply of the element is greater than the demand of the thirsty earth. The different water-courses leading down from the mountains on the west have a general direction oblique to the coast, and nearly at right angles to the range. The principal streams in the vicinity are the Sweetwater and San Diego rivers, discharging into San Diego bay, the Soledad, San Diegito, and San Luis Rey, emptying into the ocean within forty miles north of San Diego, and the San Mateo, Santa Anna, and San Gabriel, further north, and in the neighborhood of Los Angeles, and south of the roadstead of San Pedro. It is evident that the most practicable passage for railroad communication through the mountains must be found by following up one of these streams from the coast to the lowest and nearest summit, thence across it to some valley or water-course leading to the desert. The two largest streams of those enumerated are the San Diego and San Luis Rey rivers. Both have their sources near the middle of the dividing ridge; the former in a heavily timbered region, and the latter in the broad valleys of San José and Agua Caliente. Their courses are nearly parallel. The mouth of the San Luis is about 40 miles north of the port of San Diego, between which and the latter are a large number of natural obstacles to the construction of a road. The San Diego river falls into the bay of that name, coming from the mountains in nearly a straight course for a distance of about forty miles. This stream heads in the close vicinity of one of the most feasible passes yet known across the range, and its valley communicates with the summit by a gorge or cañon. On the eastern or desert slope of the mountains is a parallel series of valleys or ravines, the most extensive of which are those of Vallecito and San Felipe, which are conterminous, though embracing distinct water-courses. There is a valley north of and parallel with San Felipe, as yet without a name, which receives the drainage of that valley and the Cayote valley; further north is parallel with the other two. The latter is extremely difficult of access, and cannot easily be approached except from the desert. From the base of the mountains and the mouth of these valleys to the Colorado of the west lies the flat and sandy wilderness called the Colorado Desert. This is a belt of arid, level clay with a superficial covering of drifting sand, measuring 100 miles in width, extending north an indefinite distance, and terminated on the south by the shores of the Gulf of California.

PRELIMINARY EXPLORATIONS.

Under the direction of the officers of the railroad company, exploring parties were despatched to the interior to examine and report upon the different routes and passes supposed to be favorable to the proposed construction. Commencing at the southernmost of the routes suggested, that of Sweetwater valley, connecting with the pass of Jacumba, it was as carefully and diligently examined as the time and means of the company would allow. No pass of probable feasibility was found; that from Jacumba to the Desert being rough and precipitous, and there being encountered no other entering valleys on that side of the mountains of sufficient directness to admit of a choice in that direction. The peculiarly broken nature of the ground, however, it should be stated, presented many serious obstacles to a comprehensive examination of the district. It is possible that several of the numerous passages that extend their ramifications through these mountains may afford a practicable way for a road; but if so, they were unwittingly neglected or passed by as impracticable. It is often the case that narrow cañons lead up from between the foot-hills of this range, and finally open out into broad ravines which penetrate the mountains to a considerable distance.

The valley of the San Diego river was next examined, which, though more than forty miles in length, had scarcely been explored by white men beyond the Cajon Rancho, eighteen or twenty miles from its mouth. A rapid reconnoissance of this route showed that if its grades were not impracticable, it would fulfil all the necessary conditions of a favorable location for the road. Its source being in the vicinity of the valley of Santa Isabel, which connects with Warner's Pass, the best known passage for travel over which the present wagon road to Fort Yuma passes, and its connection with that valley by means of a tributary gorge or ravine being ascertained, it only remained to show whether the elevation at the summit of Santa Isabel could be overcome by any grade within the limits of practicability.

An inspection of the San Luis Rey route exhibited at once its inferiority to that of San Diego river, and until a careful survey of the latter should prove that the expectations formed of it were unfounded, it was not deemed advisable to undertake an elaborate survey of any of those further north.

Accordingly the requisite measures were taken to organize and equip a surveying party to measure and level accurately the proposed line, and examine incidentally its immediate vicinity, so that a change in its location might be effected without the necessity of a re-survey.

PRELIMINARY SURVEY OF THE LINE.

Although the survey of the interior, or mountain division of the line, was accomplished first in point of time, the results in this report will be given commencing at the initial point of the line, on San Diego bay, and reference will be made thereto in the accompanying tables of grade and distance.

MISSION VALLEY.

From the shore of the bay to the point where the line enters the Cajon gap, the route passes first over the marshy and sandy plain, dividing it from the plateau upon which the town of San Diego is built, and then follows, by a nearly straight line, the sandy bed of the river, through the Mission valley to the "Mission" of San Diego, (a military post, garrisoned by a detachment of the third artillery.) The line repeatedly intersects the sinuosities of that stream in its passage, but this circumstance will not compel the construction of a single foot of bridging, as an embankment of from three to four feet in height, well guarded with gravel and firm earth, will suffice to retain the waters of the river during the wet season upon either side of it. The valley is from half a mile to a mile in width, destitute of trees, and of loose sandy soil, covered with a thick growth of bushes. The side hills are composed of clay and gravel, about one hundred feet in height, sloping uniformly from the table land above. From the bay to the Mission the distance is a little over seven miles, the difference of level between the two points 64.46 feet, and the average grade 9.14 feet per mile. From the Mission the line deflects with the course of the river to the left, and a good location may be had on either side of the valley to the point of entrance at Cajon gap. By the left bank the distance is 2.65 miles, the rise 36.53 feet, giving a grade of 13.7 feet per mile. The ground is precisely similar in character to that below.

CAJON GAP.

At this point the nature of the ground changes, and the line is carried through a cañon, of which the sides are composed of fragmentary masses of rock, the mountains rising on either side to a considerable height. The width of the pass varies from sixty to two hundred feet, and its course is somewhat tortuous and irregular, though its general direction is straight. Throughout its whole extent, on the right bank of the river bed, is an ancient canal or aqueduct leading from the valley above to the gardens of the Mission below. The water way of this structure is lined with brick, and is raised several feet above the bank by a substructure of durable rock masonry, averaging five or six feet in breadth. From the fact that this extensive work was built by Indian artificers, under the direction of the superintending priests of the Mission, and that it is now nearly half the width required for a railroad track, it appears evident that no great difficulty would be experienced in constructing a road bed for a railway upon nearly the same line and with the same material.

The stream at the upper end of the gap is crossed by a solid dam of masonry laid in mortar, and is now in an excellent state of preservation. This dam formed a reservoir for the system of irrigation that was pursued in the entire Mission valley below. With trifling expense it could now be made available as a water-station for railway purposes. The distance to this point is 2.76 miles, and the difference of level 181.78 feet, giving a grade of 65.8 feet per mile.

CAJON VALLEY.

On leaving the Gap, the line passes into a long valley, bounded on each side by gently sloping hills, and filled in the middle with a wide belt of trees along the bed of the stream. These gradually inclined side hills offer an unsurpassed location for a road-bed, enabling the engineer to adopt any grade that circumstances may require, without a sacrifice of economy. The components of the soil are sand and a coarse gravel with pebbles, and at one or two points rock in a disintegrated form appears on the surface. It is also possible that hard red clay may be found in some of the excavations, as it frequently appears in the more elevated portions of the hills. The timber in the river "bottom" is chiefly willow and cotton-wood with occasionally some sycamore, which may be used economically for ties throughout all this portion of the work, renewable by a more durable material after the lapse of a few years. No bridges and but few culverts will be required for this section, which extends to the rancho of Cajon or "Santa Monica," a distance of 7.3 miles. The elevation for this distance is 129.67 feet, and the natural grade of the surface 17.75 feet per mile.

VALLEY OF CAPITAN GRANDE.

Beyond the rancho of Cajon the valley becomes more narrow, is bounded by loftier hills, and covered with a denser growth of trees and foliage, among which are found large specimens of the sycamore and many oaks. The sandy bed of the stream is, in some places, obstructed by having heavy rocks that have been loosened from the hill sides by rains and fallen into the channel. The hill slopes are, in general, well adapted to the proposed construction, being gravelly and not difficult of excavation. There are some obstacles, in the form of rocky spurs, that will require considerable labor in cutting through, but it is believed that in few instances will blasting be rendered necessary. Sufficient timber may be found in the valley for ties, which is chiefly oak of good quality. Lime is easily obtained from the neighborhood, and sand and rock being large components of the soil, the materials for the construction may be safely stated to be abundant. The distance to the Indian village of Capitan Grande is 12.5 miles, the altitude from last station 317.27 feet, and the inclination of the river bed 25.2 feet per mile. It will be necessary to raise the track considerably above the natural bed of the stream, for obvious reasons, and a feasible average grade may be adopted, ascending at the rate of about 51 feet per mile, arriving at a point on the side hill 323 feet above the level of the river, abreast of the Indian village, which is situated on its immediate border. This height and rate of ascent may be increased without disadvantage, as will be hereafter shown.

OAKWOOD CAÑON.

This is the name given to the gulch which heads in the valley of Santa Isabel, and whose waters are discharged into the San Diego river, just above the village, at Capitan Grande. Leaving the village and following the surveyed line, our course leads along a well timbered bottom with flat ridges of table land on both sides for three or four miles, then turning a little to the left, we find the valley becoming more narrow above the point where the pinery brook enters it, and is now enclosed by high regularly shaped hills covered closely with brush. In a couple of miles further the bed of the stream becomes so choked by the accumulation of rock and underbrush, that it is difficult to effect a passage through them. The slopes are generally clothed with turf and grass, studded with many out-cropping stones and fragments of rock, which may be easily displaced and rendered readily available for purposes of construction. Throughout the whole of this cañon the mountain slopes are lofty and regular, so that a grade line would cut the surface in a section of easy curves. In two or three places, however, cliffs or ledges of rock project from their sides for short distances, and these are the points which involve the chief difficulties of the route. A bridge or trestle work to cross the valley at these points seems to afford the most feasible method of passing these obstructions, though it is not certain they could not be so reduced by blasting as to admit safely the passage of trains. In the upper portion of the gulch there is a flourishing growth of heavy oak timber and no small quantity of sycamore.

From the Indian village to the head of the cañon the distance, by the measured line, is 14.30 miles, the difference of level 2,257.54 feet, and the average grade of the water-course 157.7 feet per mile. Commencing the grade of our road at the point where we left it on the hill above the Indian village, and assuming a cut of 85 feet to be necessary at the entrance of San Isabel valley, we have a difference of level between the two points of 1,849.54 feet, and by adding to the distance one-tenth for increased length in curvature, the resulting average grade will be 117.6 feet per mile for fifteen and three-quarter miles. But the grade can be reduced in a still greater degree by going back to the station at Cajon, and ascending at the moderate rate of 61.4 feet per mile to the Indian village; thence, from the higher point at the side hill thus attained, the grade to San Isabel will become 107.5 feet a mile for about sixteen miles. This average grade will, of course, be essentially modified to suit the various accidents of the ground, a more gradual inclination being given, where practicable, to those parts of the line abounding in curves, and the steep grades confined to the tangents or straight line portions. A careful examination of the side hills of this cañon demonstrated that, in general, no material increase in the cost of construction would ensue from placing the road at a considerable elevation above the line actually surveyed; indeed, the safety of the superstructure would seem to compel such a location, the district being subject to heavy freshets during the rainy season, and the bed of the stream indicates the occurrence of immense floods, whose volume is so great as to leave accumulations of drift-wood in the topmost branches of high trees on its banks. The additional expense of the few bridges or embankments that may be required in passing the outlets of gulches and ravines intersected by the line, will not much exceed the cost of protecting a lower track from the consequences of these torrents.

VALLEY OF SANTA ISABEL.

From the entrance of this valley to the rancho, or Old Mission of Santa Isabel, the line passes over the flat meadow or bottom land at a nearly level grade for 2.27 miles; round the valley on all sides are gently undulating hills, covered with oak trees, the soil being gravelly and apparently favorable for excavation. The valley is supplied with unfailing springs and streams of the purest water, whose contents may be collected by means of reservoirs to supply a water station in any desired quantity. Approaching the Old Mission it is proposed to elevate the track above the level of the valley, by deflecting the line to the right, and carrying it along the side hill, in order to gain a higher elevation with which to pass the adjacent summit. A point in the rear of the Mission, about 90 feet higher than the level of the valley, offering an eligible position for a station, it is assumed as the starting place for the grade over the summit. The ascent to this place from the entrance of the valley is at the rate of 64.72 feet per mile. This grade can be easily modified, so as to secure a level track for some distance on each side the station.

SUMMIT OF SANTA ISABEL.

Passing along the foot hills of this valley a rising ground, hemmed in by high hills, appears in front, over which now runs the main road to Fort Yuma. This road is intersected by the line at about a mile from the Mission, and the line is identical with it through the pass, and nearly to the foot of the hill in the valley of San José. At the summit no impediment to excavation is apparent on the surface, and it is believed that a cut of 80 or 100 feet in depth can be made without striking solid rock. Assuming a cut of 80 feet, the resulting grade of the line from the Santa Isabel station will be 100 feet per mile for 2.33 miles. Oak timber in great abundance is growing in the immediate vicinity of the line, and within six miles from San Isabel are vast forests of pine of superior quality, covering all the elevated lands east of this part of the route.

SAN JOSÉ AND WARNER'S RANCHO.

Leaving the summit to descend to the valley of San José, we find the grade of the natural surface to be about 175 feet per mile for upwards of 3 miles. This can be decreased by keeping to the right and following around the sides of the neighboring hills. This may tend rather to reduce than increase the distance, unless the curvatures should prove considerable. A grade of 92 feet for 3½ miles from the summit would reach a point 195.49 feet above the level of the bottom of the valley. By continuing along the hill sides, a feasible route is afforded to Warner's rancho, (a part of the same valley,) which involves, however, the construction of a bridge of considerable height at the crossing of San José creek, the head waters of San Luis Rey river. The distance is 4.35 miles, and the grade 26.21 feet per mile, to a point on the slope of the hill opposite Warner's house. This location, from the summit to Warner's, is not probably so favorable in point of economy of construction as a line following more nearly the course of the road as now travelled, that being over a comparatively smooth and equal surface, requiring no bridging or culverts of any magnitude. It may be better to adopt this, with its steep grade of 175 feet for a part of the distance, in preference to the other route; but it is a question which a minute survey only can determine. There is but little timber in this valley, though the hill sides within five or six miles afford a large amount of oak, and large pines are found scattered through all the gulches.

WARNER'S PASS.

This is the divide between the waters of the Pacific and those flowing into the Gulf of California. Its elevation above mean high tide is 3,629.54 feet.

From the rancho to the summit of this pass there is a gradual acclivity, traversed by a public road, whose average grade for the distance of 4.92 miles is 123.46 feet per mile. By commencing the grade line at the point opposite Warner's house, where we left it, which is 55.6 feet above the level of the wagon road, and carrying it to a proposed cut of 50 feet at the summit of the pass, the average grade is reduced to 102 feet per mile. A more economical construction of the road would be afforded by diminishing the rate of ascent over the first part of the line and proportionately increasing it near the summit. This portion of the route abounds in timber, and the water is plenty and excellent in quality. The ground is somewhat rolling in character, and the location may be so made as to equalize the excavations and embankments.

After passing the summit, the wagon road winds down the pass near the arroyo or water course flowing towards San Felipe, and enters the valley proper at the termination of the belt of trees known as Oak Grove. The natural grade of the surface to this point, a distance of nearly 2 miles, is 263 feet per mile. A side hill location must here be resorted to, and the left or north side of the valley appears most favorable for the purpose. A grade of 106 feet to the mile can be applied, which will reach an elevation of 249 feet above the bed of the stream at the watering place at Oak Grove.

Up to this point, throughout the whole route from the sea coast, the soil and climate are adapted to the production of almost every form of vegetation belonging to the temperate zone. But now the scene changes, and the face of the country begins to assume a tropical character, dry, sandy soil and rocky hill sides, thinly covered with low bushes, appearing on each side. The water in the streams is absorbed by their sandy beds, and little, if any, foliage is seen upon their banks.

VALLEY OF SAN FELIPE.

From Oak Grove to the Indian village at San Felipe the valley widens from a mile to two and a half miles, the mountain sides being rocky and inclined regularly towards the middle. About midway there is a swampy tract of about one hundred acres in extent, which is the only indication of water on this portion of the line. It disappears a few rods below the border of the marsh, and the sandy creek again becomes dry.

The slopes of this valley offer every facility for the location of the road, being broad inclined planes, composed of coarse gravel and sand, derived from the washing and wearing down of the mountain sides. Over the long, straight portions of this line a grade of 200 feet to a mile might with safety be adopted, though that of the whole line, from the station at Oak Grove to the village, a distance of 8.92 miles, is fixed at 106 feet, arriving on the slope behind the Indian huts at a point 22 feet above the level of the wagon road.

Half a mile before reaching the village water again appears in the form of springs. It is considered inferior in quality, and has a peculiar taste, due to the presence of alkaline or other salts. Vegetation here consists only of some varieties of cactus, sage, and a few samples of low mesquite and stunted cedar bushes. Far up the valley of "Volcan," which enters the valley nearly opposite this point, may be seen, however, dark forests of pine timber crowning the hill tops. These are ten miles off, but transportation to this point is not difficult.

From the Indian village two routes were surveyed to the open plane of the desert. The first was by way of the wagon road, as at present travelled, and the other through a cañon which conducts the waters of San Felipe into an adjoining valley leading directly to the desert.

The results obtained by the former do not vary materially from those obtained by Lieut. Williamson in his examination of the same ground in 1853, though they are not, of course, identical with them in every respect, owing to the different methods of observation pursued. An inspection of the tables appended to this report will serve to show, when compared with the data furnished by the survey of that officer, the slight difference between the measurements of altitudes by the barometer and those of the spirit level.

FROM SAN FELIPE TO THE COLORADO RIVER, BY WAY OF THE WAGON ROAD.

Reports of this route having been frequently made by officers in the service of the government, it will be only necessary to briefly allude to its characteristic features. The face of the country throughout this distance of 125 miles may be described as a desert, though the name is generally only applied to the level portion of the route. For forty miles before reaching the open expanse of the desert the road traverses sandy cañons and sterile basins, bounded on all sides by bare and rocky mountains, without enough of earth to cover their nakedness. Water is found only at distant points, and the absence of this element, combined with the intense heat, gives to the landscape a desolate and forbidding aspect.

From San Felipe the road commences a gentle ascent, and leaves the valley at a distance of 5.59 miles, at a grade of 36.8 feet per mile, passing a narrow ridge 50 feet in height, requiring a cut through rock of 450 feet in length. Crossing a small basin at a grade of 30.5 feet, we come to the entrance of a cañon at 2.46 miles. This cañon, which is extremely crooked, has a grade of 189.16 feet per mile for 1.42 miles, which, by resorting to the side hills, may be reduced to 100, making it necessary to cut and fill a series of rocky spurs and narrow ravines. From the foot of this cañon to the puerto or pass, beyond which there is no obstruction, the natural surface has a grade of 96.5 feet a mile, which would be increased to about 100 if the side hill location above be adopted. From the mouth of this pass, which is a mile in length, and has a fall of 195 feet, the valley of Vallecitas has a regular descent at the rate of about

60 feet per mile for 21.98 miles, to the watering place at Cariso creek; thence to Sackett's wells the grade is nearly horizontal, a distance of 15 miles, avoiding the ridges over which the wagon road now passes, and nearly following the course of the creek.

At Sackett's wells the supply of water is abundant, and is derived from holes sunk in an arroya or bed of a stream leading into the channel of Cariso creek. This point is fairly on the open plain of the desert, and should this route be selected for the road it will prove one of the most important and valuable water stations on the entire line.

From Sackett's to the Colorado river the desert appears to the unaided eye a perfect level, but it is shown to be undulating, and composed of several gentle slopes or swells of surface rising to a level terrace in the vicinity of Alamo Mocho.

The two "lagoons" on the desert being now dry, water is obtained from a well dug in the channel which connects them, at a point about half way between, and 14.5 miles from Sackett's.

This watering place is known by the name of "Indian Wells." The water is at a depth of about 30 feet, and is of tolerable quality.

From here to Alamo Mocho is a stretch of 20 miles without water, over a surface generally even and free of obstructions. From the Alamo wells to Cook's well is another space of 20 miles in a direct line, the soil being chiefly a coarse gravel, intermixed with sand. From Cook's well to the Colorado river at Pilot Knob the road lies along the valley or "bottom" of the river, a distance of 14 miles, mostly through a thick growth of mesquite, willow, and cotton-wood. From Pilot Knob to Fort Yuma, opposite the mouth of the Gila, is seven miles, making the total distance by this line from tide water at the bay of San Diego to the proposed crossing at the fort 200 miles and a half.

The character of the portion of the desert just described is now so well known that it is needless to enlarge upon it, and with the simple statement I am enabled to make from frequent examinations and intimate acquaintance with the ground, that *three-fourths of the distance is already graded and prepared by nature for the reception of the rails,* I take leave of the subject without further remark.

PROPOSED ROUTE BY WAY OF SAN FELIPE CAÑON.

A mere inspection of the route through the pass which drains the valley of San Felipe would not, probably, lead an observer to the conclusion that it is adapted to railroad purposes, and it was only after the difficulties of the line on the wagon road became apparent that attention was specially directed to it as a possible substitute. A careful survey of this pass, with the chain and level, demonstrated the following facts: Its length by the windings of the creek is 2.67 miles. The difference of level of its two extremities is 437.30 feet, and the average slope of the creek is, therefore, 162.5 feet to a mile. The level station, at the entrance of the cañon, is at least ten feet higher than the necessary elevation of the proposed road bed, and that at the outlet can be raised, say 150 feet, by following the side hill, so that the resulting grade will be reduced to the practicable limit of 103 feet per mile for the two and a half miles.

The side slopes of the pass present a ragged and rocky appearance, nearly identical with those of the Cajon Gap, near the mission of San Diego, and the two passes are nearly equal as to their length, breadth, and curves. They are so clearly similar that both must be accepted or rejected together.

The wide valley into which the creek enters offers superior advantages over the basins of Vallecitas and Cariso creek, and has a great resemblance to that of San Felipe, the mountain slopes spreading out at their base forming broad inclined planes highly favorable to the location of the road. The channel of the water course has an inclination of about 60 feet per mile, to a narrow pass or gorge formed by the projection of a rocky spur a distance of 17.4 miles. The elevation of the track at the mouth of the cañon, as proposed, will increase the rate of descent to about 80 feet per mile.

Immediately after passing the gorge the open plain of the desert appears to the view, bounded on the right by the mountains of the peninsular range leading into Lower California. On the left and north the spurs from the same range are seen overlapping *en echelon* as far as the eye can reach. By skirting the mountains on the right any desired elevation for the track can be adopted, and will ensure the avoidance of the patches of drift sand which are sometimes encountered on the lower plain.

From the gorge the proposed line runs along these foot hills to the base of a high mountain 12.20 miles distant therefrom; then descending gradually to the plain in nearly a southeast course, it passes over a broad level flat of blue clay for 10.8 miles, when it reaches the arroyo of Cariso creek, which is always dry at this point. Crossing this channel we traverse the wide plain with scarcely an obstacle for 20 miles, and come to the deep channel of New river. Here water can be obtained by digging, and by the sinking of artesian wells an exhaustless supply can doubtless be procured.

From New river to a point a few miles north of Cook's wells, where the lofty sand ridges from the north terminate, the route will have a nearly uniform and slightly ascending grade over alternate sections of hard clay, loose gravel, and beach sand with pebbles. About 18 miles, in a direct line, brings the line to the mouth of the Gila, by keeping to the north of Pilot Knob and traversing the table land or upper terrace bordered by the sand hills of Cook's wells. The entire distance from San Diego, by this route, is 189.10 miles.

It is now demonstrated beyond doubt that no route across the desert can be carried to the northward of the point near Cook's wells above indicated.

My surveys of the United States public lands during the present year, under the orders of the Surveyor General, show the existence of an extensive range of lofty sand hills or drifts rising from the plain to the average height of 350 feet, and from one to two miles in breadth Their direction is nearly northwest from Cook's wells, and they are terminated only by the desert range of mountains on the north, which are 50 miles distant. This singular obstacle, unlike the smaller detached sand hills of the neighborhood, seems to be entirely composed of drift sand, and is not, like other sand ridges, based upon a terrace or bank of earth. The ground on both sides of it is about at the same level, and is divided into two basins, which receive the drainage of several hundred square miles of territory. It was observed that the direction of the wind on the west side of the ridge was constantly from the northwest, while on the east side it blew from the north and northeast down the valley of the Colorado. Whether these winds are the cause of its formation is not a matter for present discussion; but the fact is plain that they offer a permanent obstacle to the construction of a railroad. It is evidently necessary to turn this barrier by passing to the south of it, where it subsides into the general level of that part of the desert.

The route from the foot of Warner's pass, at San Felipe, to the Gila, as above described, is believed to present facilities for construction greatly superior to that followed by the present wagon road. It is evident that some considerable amount of bridging or filling will be incurred at two or three points in this location, in order to pass the arroyos cut out of the hard clay of the desert by the rains of the wet season, but the cost cannot much exceed the outlay for a similar purpose on the more southern line. It is also true, that for the first five or six miles after leaving San Felipe the cost of construction must be considerably beyond the average, but for the rest of the route no obstacle presents itself throughout the entire distance to the Colorado river. By this line some twelve miles of distance are saved, and the grades are more favorable as well as more nearly conformable to the natural surface. An important consideration is the fact that this line will be built wholly within the territory of the United States, though very near and for some distance parallel to the boundary line of Mexico, while the proposed line adjacent to the wagon road will pass into Mexico 50 miles before reaching the Colorado river, and continue on foreign soil for about that distance before returning to our own territory.

Explorations recently made show that a more direct route to the desert from Warner's house exists over a collateral summit about five miles northeast of the pass. Its altitude is, however, over 100 feet greater, though it is approached by a longer line than the other, being about nine miles distant from the rancho. It descends on the other side nearly directly to the mouth of the cañon of San Felipe, joining the line surveyed at that point. This line is more favorable in regard to curvature and distance, though its grades must be steeper than the other. If its gradients were practicable it would probably cost less to build than any similar portion of the entire route.

The foregoing embraces most of the facts derived from the survey, the results of which, from the fact that the examination of the ground was as minute and thorough as was possible to make it with the instruments provided and the time allowed for the work, must be regarded as nearly accurate as are similar field operations for railroad purposes. The instruments used were a twelve-inch Y levelling instrument, a "railroad transit," with vertical circle, and one of Young's transits, to the use of the latter of which I am indebted to the kindness of Lieutenant Derby, of the Topographical corps. They were in excellent adjustment, and their work was repeatedly verified by the usual tests. Every distance was measured with a standard chain, and stations were established and marked at an average distance of 300 feet, and on rough ground at every 50 and 100 feet.

The distances across the desert are obtained from the measurements of the United States land survey, whose operations have now covered that part of the country and extended to the Colorado river. The heights between Carriso creek and the Colorado are deduced from the reports of Lieutenant Williamson and Major Emory.

THE ESTIMATE OF COST.

Although it is a matter of considerable difficulty to give a reliable estimate of the expense of the undertaking before the final location of the line is effected, yet, as a report of this nature can hardly be considered complete without this feature, an approximate calculation of the cost will be attempted. The expense of the material for the superstructure and equipment of the road when graded can be readily given, but that of the graduation, bridging, and masonry must necessarily be hypothetical in the absence of a knowledge of the ultimate and exact position of the road bed on every part of the line.

Assuming, for the purpose of this estimate, that the route is about equally divided into two classes of cheap and expensive work, though the cheaper is largely in excess, we have 10 miles at the western and 85 miles at the eastern end to be estimated at the lower rate.

The probable average cost of a single mile of this class at present prices, in California, will be for graduation, bridging, and masonry:

10,000 cubic yards earthwork, at 30 cents	$3,000
10 feet bridging, at $15	150
Culverts and drains	30
Cost of graduation, bridging, &c., for one mile	3,180

The probable cost of a single mile of the more expensive part will be for the same—

50,000 cubic yards earthwork, at 30 cents	$15,000
10,000 cubic yards rock excavation, at $3	30,000
500 cubic yards masonry, at $10	5,000
10 feet truss bridging, at $40	400
15 feet trestle bridging, at $20	300
300 feet drains and small culverts	300
Grubbing and clearing	200
Cost of graduation, bridging, and masonry, one mile	51,200

ESTIMATED COST OF SUPERSTRUCTURE FOR ONE MILE.

2,000 oak ties, 80 cents	$1,600
90 tons iron rails, (60 pounds to the yard,) chairs, and spikes, at $80	7,200
Transporting materials, track laying, &c	1,000
Cost of superstructure, one mile	9,800

ESTIMATED COST OF EQUIPMENT.

The cost of the equipment of the whole road complete will be—

FOR LOCOMOTIVES AND CARS.

10 locomotives and tenders	$8,000	$80,000	
24 passenger cars	2,500	60,000	
6 baggage cars	1,200	7,200	
20 cattle cars	600	12,000	
40 freight cars	800	32,000	
15 gravel cars	500	7,500	
10 hand cars	100	1,000	
Cost of locomotives and cars			$199,700

Brought forward		$199,700

FOR BUILDINGS AND FIXTURES.

Two freight and passenger depots at termini	$30,000	
Three engine houses..........$8,000	24,000	
Three turn tables. 3,000	9,000	
Six way stations 1,000	6,000	
One machine shop	20,000	
Five Artesian wells on deserts, 4,400	22,000	
Cost of buildings and fixtures		111,000
Total cost of equipment		310,700

Cost per mile of cheaper half—graduation, &c.	$3,180
Superstructure	9,800
Equipment per mile	1,635
Total cost of cheaper half of road per mile	14,615
Number of miles	95
Whole cost of cheaper half	1,388,425
Cost per mile of expensive half—for graduation	$51,200
For transportation add 25 per cent. to superstructure	12,250
Equipment	1,635
Total cost per mile of expensive half	65,085
Number of miles	95
Whole cost of expensive half	6,183,075
Whole cost of cheaper half	1,388,425
Whole cost of road in working order	7,571,500

The duty on railroad iron being 30 per cent., the cost of superstructure would be materially reduced by a remission by the government of that charge, making a saving of about $1,000 per mile, and reducing the cost of the road as estimated to $38,840 per mile.

The low rate at which the cheaper of these estimates is placed will not be a matter of surprise when we reflect that more than half the distance on the desert will be built without the necessity of graduation or preparing the ground in any way for the reception of the rails.

The estimate for the interior portion cannot be considered low, for many portions of the line will hardly exceed the cheaper part in cost. The distance on the desert, reckoned at 85 miles in the calculation, is actually over 100, and is generally of a character susceptible of economical construction. The item least likely to be in excess is that of transportation, which, at the present rates, would be the heaviest burden of expense the enterprise would have to sustain. For the interior division about 400 per cent. is added to this item in the estimate.

Accompanying this report is a table of grades, distances, and elevations of the route surveyed, together with a profile exhibiting the gradients adopted as the location of the line of the road. It is believed that future investigations will not tend to increase them, but will probably result in bringing to light lower and still more favorable locations and grades than have yet been discovered.

With high esteem, I have the honor to be, respectfully, your obedient servant,

CHARLES H. POOLE,

Chief Engineer San Diego and Gila Southern Pacific and Atlantic Railroad Company.

Lieut. JOHN G. PARKE.

Topographical Engineers, United States Army.

Table of grades, distances, and elevations of the proposed route for a railroad from San Diego to the Gila river.

Stations.	Distances in miles.		Grades per mile in feet.		Grades of natural surface.		Altitude in feet above.		Localities.	Remarks.
	Intermediate.	Total.	Ascending.	Descending.	Ascending.	Descending.	Previous stations.	Mean high tide.		
Bay of San Diego	....	....	....	....	....	....	....	....	....	....
Mission San Diego	7.048	7.04	9.14	....	9.14	....	64.46	64.46	Mission valley, valley of San Diego river.	Station at grade
Outlet Cajon gap	2.658	9.70	13.70	....	13.70	....	36.53	100.99	..do	..do
Head of gap	2.76	12.46	65.80	....	65.80	....	181.73	282.72	Cajon valley	..do
Cajon rancho	7.30	19.77	17.75	....	17.75	....	129.67	412.39	..do	..do
Capitan Grande, (Ind. vil.)	12.50	32.27	61.40	....	25.28	....	*122.23	729.66	Capitan Grande	Elevation 462.4 feet
Head of Oakwood cañon	14.30	46.57	107.50	....	154.70	....	2257.54	2985.20	..do	Cut 85 feet
Santa Isabel rancho	2.27	48.84	64.70	....	....	12.32	—27.98	2957.22	St. Isabel valley	Elevation 89.94 feet
Santa Isabel summit	2.33	51.17	100.00	....	172.95	....	402.94	3360.16	....	Cut 80 feet
San José	3.44	54.61	....	92.00	....	175.60	—591.97	2768.19	San José valley	Elevation 195.49 feet
Warner's rancho	4.35	58.96	26.20	....	58.37	....	253.93	3022.12	..do	Elevation 55.60 feet
Warner's pass	4.92	63.88	102.00	....	123.46	....	607.44	3629.56	..do	Cut 50 feet
Oak grove	1.90	65.78	....	106.00	....	263.73	—501.09	3128.47	San Felipe	Elevation 249.6 feet
San Felipe, (Indian village)	8.92	74.70	....	106.00	....	73 22	—673.17	2455.30	..do	Depression 22.6 feet
Entrance to cañon	2.25	76.95	....	33.40	....	33.48	—98.00	2357.30	..do	Depression 10 feet
Mouth of cañon	2.67	79.62	....	103.00	....	162.50	—437.30	1920.00	Desert valley	Elevation 150 feet
Gorge of valley	17.48	87.10	....	80.00	....	60.00	—444.00	1476.00	..do	Station at grade
Base of mountain	12.20	99.30	....	65.00	....	65.00	—796.00	680.00	Colorado desert	..do
Arroyo of Carriso creek	10.80	110.10	....	60.00	....	67.50	—630.00	50.00	..do	..do
Arroyo of New river	20.00	130.10	....	7.50	....	7.50	—150.00	—100.00	..do	..do
Point N. of Cook's well	41.00	171.10	1.46	....	1.46	....	600.00	500.00	..do	..do
Mouth of Gila, (Fort Yuma)	18.00	189.10	....	17.70	....	17.70	—320.00	180.00	..do	..do

*This appears to be an error—317.27? A. H. C.

APPENDIX C.

TRANSLATION OF AN ARCHIVE FROM TUCSON.

Señor Capitan Don Pedro Allande y Savedra:

Respected Capitan: In virtue of your order, dated the 20th of the current month, to the effect that I and two citizens of the most eminence, well known in the country and reliable, should appear in your presence to give you information concerning this locality as to watering places, lands for corn fields, pastures for horses and cattle, and minerals, and also as to points of ingress and egress of the inimical Apaches, and where they make their abodes, I, Don Manuel Barragua, and Antonio Romeo and Francisco Castro, (who are the two individuals who possess the requisites which you demanded,) most respectfully obey, and affirm that the town of Tubac is situated between two mountains, which are distant from each other six leagues.

In the valley there is much land fertile and suitable for corn fields. There is sufficient water for wheat growing, but scarcely enough each year for corn; but if that which is at Tumacacori be distributed, one week to the Indian laborers and another for Tubac, it will sufficiently benefit the said laborers, and there will be an abundance of water; in this manner was it disposed of by our former Capitan Don Juan Bapt. Auga, and recently this same disposition has been sanctioned by your honor.

There is much pasture, with an abundance of sustenance for horses and cattle, as well on the hills and in the dales as on the mountainless plains. In the same valley there is a great deal of cotton-wood and willow, and in the Santa Rita mountain there is an abundance of excellent pine, of easy access, six leagues distant.

Of provisions alone, there is raised every year by the inhabitants six hundred or more fanegas of wheat and corn—one-third part of the land not being occupied.

There are many mines of very rich metals to the west, in the vicinity of Aribac, at a distance of seven leagues; there are three, particularly, in the aforesaid vicinity, one of which yields, according to rule, (*de sopotable ley*) a silver mark from one arroba (25 pounds) of ore, the other yields six marks from a load (100 pounds) of ore, and the third yields a little less. Three leagues beyond this vicinity, in the valley of Bobocomari, there are fine gold *placers,* examined by Don José de Torro and this whole population. After three visits which these people made with Don José at great risks, and by remaining there over three days each trip, it was verified, by their having brought away and spent with two traders, who at this time have it, as much as $200 in gold.

In the Santa Rita mountain and its environs, which is distant from Tubac four leagues, there have been examined five silver mines—two have been tried with fire and three with quicksilver, with tolerable yield. All of this is notorious among this entire population, and they do not work them because there are Apaches in all these places; because they live and have their pastures there, and pass continually by this mountain itself to a place a little more than four leagues off, called Hot Springs (Agua Caliente.) Daily experiencing more violence from the enemy, because he is aware of the few troops that we possess, we have desired to break up our homes and sell our effects; and you being aware of it, we received the order, which you were pleased to send us, imposing heavy penalties upon us if we should remove or sell our goods, and have punctually obeyed it; and now, finally, the last month, the Apaches finished with the entire herd of horses and cattle, which we had guarded; and, at the same time, with boldness, destroyed the fields and carried away as much corn as they were able. Since the fort was removed to Tucson, these towns and missions have experienced some casualties; so much so, that they have been obliged to burn the town of Calabazas—a calamity it had never before experienced. Also, but a few days ago, the cavalcade which the Apaches brought from the west was grazing for three days in the vicinity, falling every day upon the fields to load with corn, and to run away with those whom they found there; and lastly, their not leaving the neighborhood, we momentarily expect that they may serve us and our families as they have served our property, there being nothing else left for them to do.

We trust in God that, by the numerous petitions of the poor people, this fort may be restored to its ancient site, and, if necessity requires it, there shall be more troops to protect the herds, by remaining at the several points of ingress and egress which the enemy have established throughout this entire region, and that they may be continually watching from the hills and the adjacent mountains.

We humbly beseech you, in the name of the whole community, that you will pity our misfortunes and listen to our petition, that you may remove the continual misfortunes that we have suffered, being in continual expectation of our total destruction.

We live in great confidence, from the knowledge that some of us have of you, that, by your exertion and by your conduct, and by that of the military commandant, we shall receive the benefit to which we are entitled, since no one is better known than Señor Savedra, and he knows that we exaggerate nothing, considering the many years we have been under his orders.

Your humble and obedient servant,

MANUEL BARRAGUA,

In the name of the entire community of Tubac.

FRANCISCO CASTRO.

ANTONIO ROMERO.

San Augustin de Tucson, *November* 24, 1777.

APPENDIX D.

DESCRIPTION OF MAPS AND PROFILES, WITH TABLE OF LATITUDES.

Map No. 1 comprises that portion of California lying west of the San Joaquin or Tulare valley, between the Bay of San Francisco and the roadstead of San Pedro, together with the basin of the Mojave river. The entire coast line, with the exception of that portion lying between Point San Luis and the mouth of the Santa Clara river, was obtained from the Coast Survey chart, 1853. The geographical positions of the Picacho de Gavilan, Point Concepcion, and Santa Barbara, were also obtained from Coast Survey determinations. The eastern limits of the Coast Range, and the positions of Tulare river and Buena Vista lakes, also a portion of the Mojave valley, Los Angeles and San Bernadino plains, Santa Ana river, and the eastern and western limits of the Sierra Nevada, were obtained from the surveys of the General Land Office. The lower portion of the Mojave valley and the south end of Soda lake were taken from the surveys of Capt. A. W. Whipple and Lieut. R. S. Williamson, U. S. Topographical Engineers.

Map No. 2 comprises the combined results of the surveys of 1854 and 1855, from the Pimas villages to the Rio Grande, at Fort Fillmore. The Rio Gila, from the Valle del Sauz, eastward, was obtained from the reconnaissance of Major W. H. Emory, U. S. T. Eng's, 1846. The remaining portion of the Gila, the positions of Fronteras, El Paso, Fort Fillmore, Sugar Loaf (Peloncillo) camp, Dos Cabezas spring, (Puerto del Dado), mouth of Quercus cañon, San Pedro springs, Tucson, Maricopa and Pimas villages, and mouth of the Salinas, (determined by Captain A. W. Whipple, Topographical Engineers,) and all the topography in the immediate vicinity of the recent boundary line between the United States and Mexico, were furnished from the office of the Mexican Boundary Commission. The northern extremities of all the mountains along this boundary line, from the 108° meridian to the San Luis range, (Sierra de los Animos,) and the position of Sierra Santa Rita, were determined by our own measurements, and on comparison were found to agree with the respective determinations of these points by the Boundary Commission, Major W. H. Emory, commissioner, 1855.

Sheet No. 3 comprises—1st. A profile of the route near the 32d parallel, from the Pimas villages to the Rio Grande, at Fort Fillmore. 2d. A profile of the route from the Bay of San Francisco to the plain of Los Angeles. 3d. A general profile, from the Red river, at Fulton, to San Diego, California ; and 3d *a*. A continuation of this route to San Francisco, *via* San Gorgonio pass and Los Angeles. And 4th. A detailed survey of Warner's pass. Map Nos. 3 and 3*a* comprise the profiles of Capt. John Pope, U. S. T. E., 1854 ; Lieut. John G. Parke, U. S. T. E., 1855, (32d parallel route) ; Charles H. Poole, esq., civil engineer ; Lieut. R. T. Williamson, U. S. T. E.; and Lieut. J. G. Parke, Topographical Engineers, 1855, (California coast route.) Profiles Nos. 3 and 3*a* are of the same scale, and are intended to illustrate the comparative lengths of the two routes, from Fort Yuma, Colorado river, to San Diego, and to San Francisco bays, respectively.

WASHINGTON, D. C., *June* 27, 1856.

DEAR SIR: I have the honor herewith to enclose the final determinations of latitude deduced from a careful examination and discussion of your series of astronomical observations.

The variety of your observations has afforded the means of well determining the chronometric and instrumental corrections, thus causing, in most instances, a close agreement in the latitudes deduced from stars far north and south. To facilitate the calculations, the most approved formulas and tables have been used.

Very respectfully, your obedient servant,

DANIEL G. MAJOR.

Lieut. JOHN G. PARKE, *Topographical Engineers.*

Table of Latitudes deduced from observations made by Lieutenant John G. Parke, Topographical Engineers.

Date.	Place.	Latitude. °	′	″	Object	Mean latitude. °	′	″
1854.								
November 24	San José	37	20	19. 4	Sun			
November 25	Do.			13. 3				
	Do.			16. 4				
	Do.	37	20	18. 4	Polaris	37	20	21. 0
	Do.			24. 2				
	Do.			34. 4				
November 26	Camp 1	37	9	2. 9	Polaris	37	8	59. 9
	Do.			0. 4				
	Do.		8	56. 4				
November 27	Camp 2	36	54	8. 0	Polaris	36	54	19. 5
	Do.			33. 0				
	Do.			17. 6				
November 29	Camp 4	36	45	2. 1	Polaris	36	45	8. 4
	Do.			14. 8				
December 1	Camp 5	36	38	43. 1	Sun	36	38	40. 0
	Do.			40. 0				
	Do.			36. 9				
December 3	Camp 7	36	23	16. 4	Polaris	36	23	16. 2
	Do.		23	16. 0				
December 4	Camp 8	36	10	12. 2	Polaris	36	10	22. 1
	Do.			32. 0				
December 8	Camp 12	35	39	30. 5	Polaris			
	Do.			44. 6				
	Do.			40. 6	Sun	35	39	33. 9
	Do.			33. 0				
	Do.			20. 8				
December 10	Camp 14	35	22	13. 4	Polaris*			
December 11	Do.			30. 4				
December 19	Do.							

* Probably a mistake of 1′ altitude.

TABLE OF LATITUDES—Continued.

Date.	Place.	Latitude.			Object.	Mean latitude.		
1854.		°	′	″		°	′	″
December 19	Camp 14	35	23	40.2	Sun			
	Do.			54.3				
	Do.			44.2				
	Do.			61.5				
	Do.			44.0	Polaris			
	Do.			16.6				
	Do.			4.7				
	Do.			21.4	Sun	35	23	32.2
	Do.			24.1				
	Do.			31.8				
December 21	Camp 14′	35	17	43.4	Polaris			
	Do.			46.6				
	Do.			61.7	Sun	35	17	51.9
	Do.			49.8				
	Do.			58.1				
1855.								
January 9 and 10	Camp 14″	35	22	07.7	Polaris			
	Do.			15.7				
	Do.			24.8				
	Do.			06.5	Sun			
	Do.		21	56.4				
	Do.			59.8				
	Do.			55.5	β Orionis	35	22	05.4
	Do.			54.6				
	Do.		22	08.0				
January 16, 18, and 19	Camp 17	35	10	23.7	Polaris			
	Do			07.7				
	Do.			32.7	Polaris			
	Do.			29.7				
	Do.			26.8				
	Do.	35	10	23.9	Sun			
	Do.			07.5				
	Do.			20.6				
	Do.			54.1	β Orionis			
	Do.			41.1				
	Do.			28.7				
	Do.			10.5	Sun	35	10	24.1
	Do.			12.8				
	Do.			17.9				
January 23 and 24	Camp 18	35	05	39.8	Polaris			
	Do.		06	13.8				
	Do.		06	05.5				
	Do.			07.8	Sun	35	06	04.4
	Do.			12.8				
	Do.			06.7				
January 25	Camp 19	34	51	29.8	Polaris			
	Do.			21.2				

TABLE OF LATITUDES—Continued.

Date.	Place.	Latitude.	Object.	Mean latitude.
1855.		° ′ ″		° ′ ″
January 26	Camp 20	34 44 43.5		
	Do.	52.5		34 44 48.8
	Do.	50.4		
January 27	Camp 21	34 33 51.0		
	Do.	34 01.4	Polaris	34 33 53.3
	Do.	33 47.5		
February 2 and 3	Camp 22	34 31 20.5	Polaris	
	Do.	13.0		
	Do.	34.1	β Orionis	
	Do.	13.8		
	Do.	14.7	Polaris	
	Do.	07.7		
	Do.	30 51.6	β Orionis	34 31 11.3
	Do.	54.7		
February 13 and 15	Camp 25	34 27 14.1		
	Do.	26 59.4	Polaris	
	Do.	27 16.8		
	Do.	27 13.6		
	Do.	15.3	Polaris	34 27 13.8
	Do.	23.7		
February 21	Camp 27′	34 25 36.7	Polaris	
	Do.	45.7		
February 25	Do.	34 25 40.1		
	Do.	40.8	Sun	
	Do.	42.7		
	Do.	34 25 45.3	β Orionis	34 25 41.9
March 15	Camp 31	34 28 13.5		
	Do.	27 50.3	Sun	34 28 02.9
	Do.	28 04.9		
March 19	Camp 35	34 08 14.5	Polaris	
	Do.	08 06.3		
	Do.	08 07.0	α Canis Majoris	34 08 10.4
	Do.	08 13.8		
July 21	Camp 76	31 55 06.9	Polaris	
	Do.	21.2		
	Do.	15.5		
	Do.	54 52.3	α Scorpionis	
	Do.	42.1		
July 24	Do.	31 54 54.0		
	Do.	54.0	Polaris	
	Do.	55 19.0		
	Do.	54 58.1	α Scorpionis	31 55 03.0
	Do.	55 06.5		
July 30	Camp 77	32 11 36.0	Polaris	32 11 37.5
	Do.	39.0		

APPENDIX E.

TABLE OF DISTANCES, AND BAROMETRIC AND METEOROLOGICAL OBSERVATIONS AND RESULTS.

BY ALBERT H. CAMPBELL, A. M.,
CIVIL ENGINEER TO THE EXPEDITION.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Upper and lower vernier.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
San José	Nov. 24	1.10 p. m.	0	392	....	30.155	66	66.3	30.054	29.928	....	....	63.5	59	4.5	N.W....	Cir. Strat	Clouds, and wind light.
Do	24	1.10 p. m.	0	1012	30.796 0.637	30.159	66.1	66.3	30.058	29.918	....	....	63.5	59	4.5	N.W....	Cir. Strat	Do. do.
Do	24	2 p. m.	0	1012	30.794 0.646	30.148	69	69.2	30.039	29.909	....	....	68	59.4	8.6	N.W....	Cir. Strat	Do. do.
Do.	24	2 p. m.	0	392	....	30.141	68.5	69.2	30.034	29.904	....	....	68	59.4	8.6	N.W....	Cir. Strat	Do. do.
Do	24	3 p. m.	0	1012	30.784 0.644	30.140	69.8	69.8	30.029	29.909	....	....	69	60.5	8.5	N.W....	Cir. Strat	Do. do.
Do	24	3 p. m.	0	392	....	30.129	69.5	69.8	30.019	29.899	....	....	69	60.5	8.5	N.W....	Cir. Strat	Do. do.
Do	24	4 p. m.	0	1012	30.782 0.648	30.134	68.2	68.7	30.028	29.912	....	....	68	60	8	N.W....	Cir. Strat	Do. do.
Do.	24	4 p. m.	0	392	....	30.125	68.1	68.7	30.019	29.903	....	....	68	60	8	N.W....	Cir. Strat	Do. do.
Do	24	4.25 p. m.	0	1012	30.760 0.648	30.112	62.5	63	30.021	29.913	....	....	62.5	57	5.5	N.W....	Cir. Strat	Clouds, 5; wind, 1; sunset.
Do	24	4.25 p. m.	0	392	....	30.120	62	63	30.030	29.922	....	....	62.5	57	5.5	N.W....	Cir. Strat	Do. do.
Do	24	5 p. m.	0	1012	30.752 0.626	30.126	61.5	63	30.038	29.941	....	....	61	55	6	N.W.5..	Cumulus, 1 ...	
Do	24	5 p. m.	0	392	....	30.121	60.5	63	30.033	29.936	....	....	61	55	6	N.W.5..	Cumulus, 1....	
Do	Nov. 25	7 a. m.	0	1012	30.773 0.628	30.145	38	39.5	30.199	30.037	....	....	39	38	1	N.W.5..	C. S. 3........	Su[illegible]e.
Do	25	7 a. m.	0	392	....	30.135	39	39.5	30.107	30.025	....	....	39	38	1	N.W.5..	C. S. 3........	
Do	25	8 a. m.	0	1012	30.800 0.608	30.192	48	47	30.140	30.050	....	....	45.5	45	0.5	N.W.5..	C. S. 3........	
Do	25	8 a. m.	0	392	....	30.179	49	47	30.124	30.034	....	....	45.5	45	0.5	N.W.5..	C. S. 3........	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Upper and lower vernier.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
San José	Nov. 25	9 a. m.	0	1012	30.808 0.614	30.194	53.5	52.3	30.127	30.039			51	49	2		C. S. 6	
Do.	25	9 a. m.	0	392		30.178	54	52.3	30.110	30.022			51	49	2		C. S. 6	
Do	25	10 a. m.	0	1012	30.832 0.590	30.242	63.5	62.5	30.148	30.052			61.5	56	5.5		C. S. 7	
Do	25	10 a. m.	0	392		30.200	64	62.5	30.105	30.009			61.5	56	5.5		C. S. 7	
Do	25	11 a. m.	0	1012	30.840 0.620	30.220	65.2	64.5	30.122	30.026			63	56	7		C. S. 7	
Do	25	11 a. m.	0	392		30.178	66.5	64.5	30.089	29.993			63	56	7		C. S. 7	
Do	25	12 m.	0	1012	30.822 0.648	30.174	70	69.8	30.063	29.973			69	56.5	12.5		C. S. 4	
Do	25	12 m.	0	392		30.169	70.5	69.8	30.057	29.967			69	56.5	12.5		C. S. 4	
Do	25	1 p. m.	0	1012	30.829 0.650	30.178	72	73	30.061	29.981			72.3	57	15.3	N.W. 1	C. S. 2	
Do	35	1 p. m.	0	392		30.160	73	73	30.041	29.961			73.3	57	15.3	N.W. 1	C. S. 2	
Do	25	2 p. m.	0	1012	30.836 0.656	30.180	75.5	75.1	30.054	29.984			75	60	15	N W. 1	C. S. 2	
Do	25	2 p. m.	0	392		30.155	76	75.1	30.028	29.958			75	60	15	N.W. 1	C. S. 2	
Do	25	3 p. m.	0	1012	30.822 0.646	30.176	71	71	30.062	30.012			71	56	15	N.W. 1	C. S. 2	
Do.	25	3 p. m.	0	392		30.149	71.3	71	30.034	29.980			71	56	15	N.W. 1	C. S. 2	
Do.	25	4 p. m.	0	1012	30.810 0.658	30.152	69.9	70.2	30.041	29.995			69.5	56.8	12.7	N.W. 5	C. S. 3	
Do.	25	4 p. m.	0	392		30.140	70.5	70.2	30.028	29.982			69.5	56.8	12.7	N.W. 5	C. S. 3	
Do.	25	4.30 p. m.	0	1012	30.800 0.644	30.156	66	67	30.055	30.012			65	55	10	N.W. 5	Cumulus, 3	Sundown.
Do.	25	4.30 p. m.	0	392		30.132	67.5	67	30.028	29.985			65	55	10	N.W. 5	Cumulus, 3	
Do.	25	5 p. m.	0	1012	30.782 0.650	30.132	60	61.1	30.047	30.010			61.1	53.8	7.3	N.W. 1	C. S. 3	
Do.	25	5 p. m.	0	392		30.122	60	61.1	30.037	30.000			61.1	53.8	7.3	N.W. 1	C. S. 3	
Do.	25	6 p. m.	0	1012	30.792 0.648	30.144	55	56	30.073r	30.038			55	48	7	N.W. 2	C. S. 2	
Do.	25	6 p. m.	0	392		30.210?	55	56	30.139r	30.015			55	48	7	N.W. 2	C. S. 2	

? Doubtful. Probable reading, .121, and so used in computations.

Do.	25	7 p. m.	0	1012	30.784	30.142	52.5	53.5	30.079r	30.044	....	....	52.9	48	4.9	N. 2	C. S. 3	
					0.642													
Do.	25	7 p. m.	0	392	....	30.210?	58	53.5	39.146r	30.022	....	....	52.9	48	4.9	N. 2	C. S. 3	Wind very light.
Do.	25	8 p. m.	0	1012	30.768	30.092	49	50	30.037r	30.001	....	....	49	45	4	N. 2	C. S. 3	Do.
					0.676													
Do.	25	8 p. m.	0	392	....	30.120?	49.5	50	30.064r	29 928	....	....	49	45	4	N. 2	C. S 3	Do.
Do.	25	9 p. m.	0	1012	30.759	30.126	48	49	30.074	30.034	....	....	48	44.5	3.5	N. 2	C. S. 1	Moonrise.
					0.624													
Do.	25	9 p. m.	0	392	....	30.200?	48.5	49	30.043	30.003	....	....	48	44.5	3.5	N. 2	C. S. 1	Do.
Do.	25	11 p. m.	0	1012	30.748	30.104	45	46	30.060	30.013	....	....	46	43	3	N. 2	C. S. 3	Wind light.
					0.644													
Do.	25	11 p. m.	0	392	....	30.100	45	46	30.056	30.009	....	....	46	43	3	N. 2	C. S. 3	
Do.	25	12 m.	0	1012	30.742	30.098	42	44	30.062	30.014	....	....	44	41.5	2.5	0	0	
					0.644													
Do.	25	12 m.	0	392	....	30.100	42	44	30.064	30.016	....	....	44	41.5	2.5	0	0	
Do.	26	1 a. m.	0	1012	30.724	30.056	40.7	41.5	30.023	29.973	....	....	41	39	2	0	0	
					0.668													
Do.	26	1 a. m.	0	392	....	30.100?	40.5	41.5	30.068	29.928	....	....	41	39	2	0	0	
Do.	26	2 a. m.	0	1012	30.722	30.061	39.5	41	30.032	29.965	....	....	41	38.5	2.5	0	0	
					0.661													
Do.	26	2 a. m.	0	392	....	30.080	39.5	41	30.051	30.004	....	....	41	38.5	2.5	0	0	
Do.	26	3 a. m.	0	1012	30.732	30.081	38.5	40.6	30.054	30.007	....	....	42	39	3	0	0	
					0.651													
Do.	26	3 a. m.	0	392	....	30.090	39	40.6	30.062	30.015	....	....	42	39	3	0	0	
Do.	26	4 a. m.	0	1012	30.725	30.075	36.8	38.5	30.053	30.010	....	....	38	36	2	0	0	
					0.650													
Do.	26	4 a. m.	0	392	....	30.065	37.2	38.5	30.042	29.999	....	....	38	36	2	0	0	
Do.	26	5 a. m.	0	1012	30.730	30.080	37.5	38.5	30.056	30.017	....	....	37.5	35.8	1.7	N	C. S. 3	
					0.650													
Do	26	5 a. m.	0	392	....	30.060	37.7	38.5	30.035	29.996	....	....	37.5	35.8	1.7	N	C. S. 3	
Do	26	6 a. m.	0	1012	30.770	30.116	37.8	38	30.091	30.051	....	....	38	36.5	1.5	N	C. S. 3	
					0.654													
Do	26	6 a. m.	0	392	....	30.093	38.3	38	30.066	30.026	....	....	38	36.5	1.5	N	C. S. 3	
Do	26	7 a. m.	0	1012	30.732	30.090	38.4	38	30.063	30.011	....	....	41	38	3	N	C. S. 3	
					0.642													
Do	26	7 a. m.	0	392	....	30.092	40	38	30.061	30.009	30.001	35.5	41	38	3	N	C. S. 3	
Station between 3 and 4	26	9 a. m.	3.25	1012	30.780	30.142	59	59	30.060	29.992	....	44.6	....	....	....	N.W. 5	C. S. 1	
					0.638													
Do. between 7 and 8	26	12 m.	11.25	1012	30.714	29.994	70.5	71	29.882	29.812	....	214.6	....	....	....	N.W. 1	C. S. 1	
					0.720													
Camp No. 1	26	3 p. m.	17.00	1012	30.632	29.874	76	76.7	29.747	29.707	....	....	....	....	....	0	C. S. 1	
					0.758													
Do	26	3 p. m.	17.00	392	....	29.846	77	76.7	29.716	29.676	....	....	....	....	....	0	C. S. 1	
Do	26	4 p. m.		1012	30.614	29.832	72	72.4	29.715	29.679	....	....	72	57	15	0	C. S. 1	
			17.00		0.782													
Do	26	4 p. m	17.00	392	....	29.825	72.5	72.4	29.707	29.671	....	....	72	57	15	0	C. S. 1	

? Doubtful. Probable readings, .121, .121, .020, and .010, and so used in computations.

APPENDIX E—Continued.

Stations.	Date.	Hour.	Distance from San José.	Number of barometer.	Upper and lower vernier.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 1	Nov. 26	4.30 p. m.	17.00	1012	30.600 0.776	29.824	69.5	70 5	29.714	29.681			70	56.7	13.3	0	C. S. 1	Sundown.
Do	26	4.30 p. m.	17.00	392		29.820	69.5	70.5	29.710	29.677			70	56.7	13.3	0	C. S. 1	
Do	26	5 p. m.	17.00	1012	30.600 0.780	29.820	67	68.4	29.717	29.692			68.9	56	11.1	0	C. S. 1	
Do	26	5 p. m.	17.00	392		29.819	67	68.4	29.716	29.691			68.9	56	11.1	0	C. S. 1	
Do	26	7.45 p. m.	17.00	1012	30.576 0.768	29.808	55.5	57	29.736	29.710								
Do	26	7.45 p. m.	17.00	392														
Do	27	7 a. m.	17.00	1012	30.674 0.734	29.940	42	43.5	29.904	29.842								
Do	27	7 a. m.	17.00	392		29.829	42.7	43.5	29.791	29.729	29.694	324.0						
Stations 3 and 4	27	9 a. m.	22.25	1012	30.666 0.736	29.950	63.5	62.5	29.837	29.759		262.2						
Δ between stations 11 and 12	27	12 m.	32.25	1012	30.760 0.696	30.064	77	77.5	29.934	29.844		186.0				N.W. 1	C. S. 1	
Camp No. 2, Pajaro river	27	3 p. m.	36.75	1012	30.776 0.758	30.018	80	83 5	29.980	29.920						E. 1	C. S. 1	
Do	27	3 p. m.	36.75	392		30.090	81	83.5	29.949	29.889								
Do	27	4 p. m.	36.75	1012	30 780 0.672	30.108	77	77.5	29.978	29.922								
Do	27	4 p. m.	36.75	392		30.081	77	77.5	29.951	29.895								
Do	27	4.40 p. m.	36.75	1012	30.748 0.676	30.072	69	70	29.963	29.913			70.2	56.5	13.7			Sundown.
Do	27	4.40 p. m.	36.75	392		30.070	69	70	29.961	29.911			70.2	56.5	13.7			
Camp No. 2.	27	5 p. m.	36.75	1012	30.748 0.682	30.066	67.5	68.9	29.962	29.915			68.5	55	13.5			
Do	27	5 p. m.	36.75	392		30.069	68	68.9	29.963	29.916			68.5	55	13.5			
Do	Nov. 28	6.25 a. m.	36.75	1012	30.728 0.636	30.092	40.2	40.6	30.061	29.965								
Do	28	6.25 a. m.	36.75	392		30.075	39.7	40.6	30.046	29.956								
Do	28	7 a. m.	36.75	1012	30.718 0.620	30.098	38	38.8	29.272	29.870								
Do	28	7 a. m.	36.75	392		30.056	38.8	38.8	30.029	29.927	29.915	116.5						

Station 4		28	7.45 a. m.	39.00	1012	30.730 0.648	30.082	50 4	45.1	30.023	29.909		119.5						
Station 7		28	9 a. m.	41.25	1012	30.740 0.654	30.086	60.5	58	30.000	29.882		146.4						
Camp No. 3, San Juan Bautista		28	10 a. m.	42.11	1012	30.736 0.672	30.064	63.5	63.5	29.970	29.844								
Do.		28	10 a. m.	42.11	392		30.039	64	63.5	29.944	29.818								
Do		28	11 a. m.	42.11	1012	30.736 0.668	30.068	69.7	69.8	29.958	29.832								
Do		28	11 a. m.	42.11	392		30.032	69.5	69.8	29.920	29.794								
Do		28	12 m	42 11	1012														
Do		28	12 m	42.11	392		30.029	76	75.5	29.902	29.782			74.5	58.5	16			Reading of barometer 1012 at Rancho de las Aromas.
Do		28	1 p. m.	42.11	392		30.020	75.5	75	29.895	29.785			74.5	58.5	16	N.W. 1	C. S. 3.	
Do		28	3 p. m.	42.11	392		30.000	75.5	73	29.880	29.800			72	58	14	N.W. 1	C. S. 5.	At 2.45 p. m. = 30.116—76° attached, 75° detached.
Do		28	4 p. m.	42.11	392		29.985	72	71.5	29.868	29.792			71	58	13	N.W. 1	C. S. 2.	At 3 p. m. = 30.128—74°.9 attached, 75° detached.
Do		28	4.30 p. m.	42.11	392		29 979	63.5	64	29.885	29.817			63.5	55	8.5	N.W. 1	C. S. 2.	
Do		28	5 p. m.	42.11	392		29.965	62	62.2	29.875	29.818			62	54.5	7.5	N.W. 1	C. S. 2.	
Do		28	5.55 p. m.	42.11	1012	30.676 0.693	29.983	59	59 8	29.901	29.845						N.W. 1	C. S. 2.	
Do	Nov.	29	6.35 a. m.	42.11	1012	30.648 0.708	29.940	53	50.9	29.882	29.846						N.W. 1	C. S. 3.	
Do		29	6.35 a. m.	42.11	392		29.930	50.8	50.9	29.871	29.835						N.W. 1	C. S. 3.	
Do		29	7 a. m.	42.11	1012	30.648 0.708	29.940	50	51	29.882	29.850						N.W. 1	C. S. 10.	
Do		29	7 a. m.	42.11	392		29.930	51	51	29.870							N.W. 1	C. S. 10.	
Do		29	8.10 a. m.	42.11	1012	30.640 752	29.868	63.9	57.2	29.793	29.753	29.835	211.1				S.E. 5	C. S. 10.	½ mile from trail, (same valley.)
Station 4		29	9 a. m.	42.11	1012	30.672 0.920	29.752	61.9	57.3	29.663	*29.625						S.E. 4	C. S. 9.	Divide.
Δ between stations 9 and 10		29	9.50 a. m.	47.71	1012	30.728 0.654	30.074	58.2	59	29.995	29.949		84.4				S.E. 4	C. S. 9.	Mist.
Station 13		29	10.40 a. m.	49.51	1012	30.588 0.804	29.874	60	59.5	29.699	29.663		351.3				S.E. 4	C. S. 8.	Mist.
Station 14		29	11 a. m.	50.04	1012	30.512 0.868	29.644	61	61	29.557	29.516		490.2				S.E. 4	C. S. 8.	
Station 17		29	11.30 a. m.	51.01	1012	30.460 0.872	29.588	60.9	62.5	29.501	†29.473						S.E. 4	C. S. 7.	
Δ between 17 and 18		29	0.10 p. m.	52.01	1012	30.598 0.796	29.802	64.5	62.4	29.706	29.686		330.9				S.E. 4	C. S. 7.	
Station 19		29	1 p. m.	53.87	1012	30.706 0.706	30.000	65	64	29.902	29.897		132.9				S.E. 4	Cirrus, 1	
Camp No. 4		29	3 p. m.	56.71	1012	30.722 0.658	30.064	57	57.8	29.988	30.018						N.W. 2	0	
Do.		29	3 p. m.	56.71	392		30.050	58	57.8	29.971	30.001						N.W. 2	0	
Do		29	4 p. m.	56.71	1012	30.714 0.670	30.044	55	55	29.973	30.012								

* Doubtful.

† Off line of survey.

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Upper and lower vernier.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 4	Nov. 29	4 p. m.	56.71	392		30.030	55	55	29.959	29.998								
Do	29	4.35 p. m.	56.71	1012	30.700 0.670	30.030	51	52	29.970	30.017			50.5	47	3.5			Sunset.
Do	29	4.35 p. m.	56.71	392		30.020	51.5	52	29.959	30.006			50.5	47	3.5			
Do	29	5 p. m.	56.71	1012	30.692 0.676	30.016	48	49	29.964	30.027			48	46	2			
Do	29	5 p. m.	56.71	392		30.019	48.5	49	29.960	30.029			48	46	2			
Do	29	6.35 p. m.	56.71	1012	30.672 0.692	29.980	42.8	44	29.942	30.017			42.5	42.5	0		C. S. 1	
Do	29	6.35 p. m.	56.71	392		29.982	42.5	44	29.945	30.020			42.5	42.5	0		C. S. 1	
Do	30	7 a. m.	56.71	1012	30.666 0.690	29.976	46	47.2	29.927	30.012			47	43	4		C. S. 9	Sunrise.
Do	30	7 a. m.	56.71	392		29.970	47.5	47.2	29.919	30.002	30.018	21.0	47	43	4		C. S. 9	
Station 5	30	9 a. m.	60.01	1012	30.676 0.700	29.976	50	49.5	29.918	29.990		44.0				N.E. 2	Cumulus, 9	Chilly.
Camp No. 5, Hill Rancho	30	0.20 p. m.	66.26	1012	30.740 0.640	30.100	62	63	30.020	30.060						N.E. 2	Cumulus, 9	
Do	30	0.20 p. m.	66.26	392		30.080	62.5	63	29.989	30.047						N.W. 2	Cum. & C. S. 8	
Do	30	1 p. m.	66.26	1012	30.732 0.718	30.014	63	62.5	29.921	29.961						N.W. 2	Cum. & C. S. 8	
Do	30	1 p. m.	66.26	392		30.020	62	62.5	29.930	29.988						N.W. 2	Cum. & C. S. 8	
Do	30	2 p. m.	66.26	1012	30.736 0.660	30.076	59	59.9	29.994	30.034			59.5	53	6.5	N.W. 3	C. & C. S. 9	
Do	30	2 p. m.	66.26	392		30.035	60	59.9	29.950	30.008			59.5	53	6.5	N.W. 3	C. & C. S. 9	
Do	30	3 p. m.	66.26	1012	30.726 0.654	30.070	56.7	57.5	29.997	30.037			57	52	5	N.W. 3	C. & C. S. 9	
Do	30	3 p. m.	66.26	392		30.035	57	57.5	29.959	30.017			57	52	5	N.W. 3	C. & C. S. 9	
Do	30	4 p. m.	66.26	1012	30.726 0.654	30.072	55	56	30.001	30.035			55	52	3	N.W. 3	C. & C. S. 9	
Do	30	4 p. m.	66.26	392		30.035	55	56	29.964	30.006			55	52	3	N.W. 3	C. & C. S. 9	
Camp No. 5	30	4.35 p. m.	66.26	1012	30.718 0.660	30.058	53.5	54.5	29.991	30.023			54	51	3	N.W. 3	Cum. & C. S. 9	
Do	30	4.35 p. m.	66.26	392		30.049	54	54.5	29.981	30.031			54	51	3	N.W. 3	Cum. & C. S. 9	
Do	30	5 p. m.	66.26	1012	30.720 0.646	30.074	53	54	30.008	30.041			52 5	50 5	2	N.W. 3	Cum. & C. S. 9	

Do.....................		30	5 p. m.....	66.26	393	....	30.059	53	54	29.99[illegible]	30.044	....	....	52.5	50.5	2	N.W.3..	Cum. & C. S. 9.	
Do.....................		30	6.45 p. m..	66.26	1012	30.718	30.076	53	53	30.010	30.025	....	....	53	50	[illegible]	N.W.3..	Cum. & C. S. 9.	
						0.642													
Do.....................		30	6.45 p. m..	66.26	392	....	30.079	52	53	30.016	30.049	....	....	53	50	3	N.W.3..	Cum. & C. S. 9.	
Do.....................		30	7 p. m.....	66.26	1012	30.718	30.064	53	53	29.998	30.008	....	....	53	50	3	N.W.3..	Cum. & C S. 9.	
						0.654													
Do.....................		30	7 p. m.....	66.26	393	....	30.089	52	53	30.026	30.054	....	....	53	50	3	N.W.3..	Cum. & C. S. 9.	
Do.....................		30	7.45 p. m..	66.26	1012	30.748	30.106	51.8	52.8	30.044	30.048	....	....	53.5	49	4.5	N.W.3..	C. S. 7.........	
						0.042													
Do.....................		30	7.45 p. m..	66.26	392	....	30.100	51	52.8	30.046	30.062	....	....	53.5	49	4.5	N.W.3..	C. S. 7.........	
Do.....................	Dec.	1	7 a. m.....	66.26	1012	30.750	30.110	42	43	30.074	30.022	....	....	43	41.5	1.5	N.W.3..	C. S. 7.........	
						0.640													
Do.....................		1	7 a. m.....	66.26	392	....	30.106	42	43	30.070	30.036	....	....	43	41.5	1.5	N.W.3..	C. S. 7.........	
Do.....................		1	8 a. m.....	66.26	1012	30.740	30.116	39.9	40.8	30.085	30.020	....	....	41	40	1	N.W.3..	C. S. 3.........	
						0.624													
Do.....................		1	8 a. m.....	66.26	392	....	30.110	39.9	40.8	30.079	30.032	....	....	41	40	1	N.W.3..	C. S. 3.........	
Do.....................		1	9 a. m.....	66.26	1012	30.758	30.128	46	47	30.081	30.013	....	....	46	45	1	N.W.3..	Cirr. 6.........	
						0.630													
Do.....................		1	9 a. m.....	66.26	392	....	30.119	46.5	47	30.071	30.021	....	....	46	45	1	N.W.3..	Cirr. 6.........	
Do.....................		1	10 a. m....	66.26	1012	30.810	30.180	59.5	60	30.097	30.021	....	....	59.4	53.5	5 9	E. 1.....	C. S. 6........	
						0 630													
Do.....................		1	10 a. m....	56.26	392	....	30.177	59.5	60	30.094	30.036	....	....	59.4	53.5	5.9	E 1.....	C. S. 6.........	
Do.....................		1	10 a. m....	66.26	977	....	30.142	59.5	60	30.059	30.023	....	....	59.4	53.5	5.9	E. 1.....	C. S. 6.........	
Do.....................		1	10 a. m....	66.26	978	....	30.143	59.5	60	30.060	30.024	....	....	59 4	53.5	5.9	E. 1.....	C. S. 6.........	
Do.....................		1	11 a. m....	66.26	1012	30.780	30.132	61	61	30.095	29.994	....	....	60.5	53	7.5	E. 1.....	C. S. 7.........	
						0.648													
Do.....................		1	11 a. m....	66.26	392	....	30.125	61.7	61	30.036	29.983	....	....	60.5	53	7.5	E. 1.....	C. S. 7.........	
Do.....................		1	11 a. m....	66.26	977	....	30 092	61	61	30.005	29.974	....	....	60.5	53	7.5	E. 1.....	C. S. 7.........	
Do.....................		1	11 a. m....	66.26	978	....	30.086	61	61	29.999	29.968	....	....	60.5	53	7.5	E. 1.....	C. S. 7.........	
Do.....................		1	12 m......	66.26	1012	30.780	30.132	65.5	65.5	30.033	29.973	....	....	65	55	10	E. 1.....	C. S. 6.........	
						0.648													
Do.....................		1	12 m......	66.26	392	....	30.120	65.4	65.5	30.021	29.979	....	....	65	55	10	E. 1	C. S. 6........	
Do.....................		1	12 m......	66.26	977	....	30.082	65.2	65.5	29.984	29.964	....	....	65	55	10	E. 1.....	C. S. 6.........	
Do.....................		1	12 m......	66.26	978	....	30.072	65 5	65.5	29.993	29.973	....	....	65	55	10	E. 1.....	C. S. 6	
Do.....................		1	1 p. m.....	66.26	1012	30.782	30.122	64.5	65	30.026	29.976	....	....	64.5	55	9.5	E. 1......	C. S. 6........	
						0.660													
Do.....................		1	1 p. m.....	66.26	392	....	30.100	65 5	65	30 001	29.969	....	....	64.5	55	9.5	E. 1......	C. S. 6........	
Do.....................		1	1 p. m.....	66.26	977	....	30.066	61.6	65	29.970	29.960	....	....	64.5	55	9.5	E. 1......	C. S. 6........	
Do.....................		1	1 p. m.....	66.26	978	....	30 060	65	65	29.962	29.952	....	....	64.5	55	9.5	E. 1......	C. S. 6........	
Do.....................		1	2 p. m.....	66.26	1012	30.770	30.124	64.5	65.2	30.028	29.993	....	....	64.6	55	9.6	E. 1......	C. S. & Cum. 9	Wind very light.
						0.646													
Do.....................		1	2 p. m.....	66.26	392	....	30.082	65.2	65.2	29.984	29.967	....	....	64.6	55	9.6	E. 1......	C. S. & Cum. 9	
Do.....................		1	2 p. m.....	66.26	977	....	30 042	64.8	65.2	29.945	29 960	....	....	64.6	55	9.6	E. 1......	C. S. & Cum. 9	
Do.....................		1	2 p. m.....	66.26	978	....	30.040	65.4	65.2	29.941	29.946	....	....	64.6	55	9.6	E. 1......	C. S. & Cum. 9	
Do.....................		1	3 p. m.....	66.26	1012	30.772	30.092	65	65.2	29.994	29.974	....	....	64.5	55	9.5	E. 1......	C. S. & Cum. 9	Gusty.
						0.680													
Do.....................		1	3 p. m.....	66.26	392	....	30.090	65.5	65.2	29.991	29.989	....	....	61.5	55	9.5	E. 1......	C. S. & Cum. 9	
Do.....................		1	3 p. m.....	66.26	977	....	30.050	64.5	65.2	29.954	29.974	....	....	64.5	55	9.5	E. 1......	C. S. & Cum. 9	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Upper and lower vernier.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 5	Dec. 1	3 p. m.	66.26	978	....	30.050	64.5	65.2	29.954	29.974	....	....	64.5	55	9.5	E. 1	C. S. & Cum. 9	
Do	1	4 p. m.	66.26	1012	30.758 0.670	30.088	62	62.5	29.998	29.987	....	....	62	54	8	E. 1	C. S. & Cum. 9	
Do	1	4 p. m.	66.26	392	....	30.080	62	62.5	29.990	29.997	....	....	62	54	8	E. 1	C. S. & Cum. 9	
Do	1	4 p. m.	66.26	977	....	30.038	62	62.5	29.948	29.977	....	....	62	54	8	E. 1	C. S. & Cum. 9	
Do	1	4 p. m.	66.26	978	....	30.030	62.2	62.5	29.940	29.969	....	....	62	54	8	E. 1	C. S. & Cum. 9	
Do	1	4.30 p. m.	66.26	1012	30.752 0.658	30.094	60.5	61	30.008	30.005	....	....	61	52.5	8.5	E. 1	C. S. & Cum. 9	Clear, sunset; moon in east.
Do	1	4.30 p. m.	66.26	392	....	30.060	60.7	61	29.974	29.989	....	....	61	52.5	8.5	E. 1	C. S. & Cum. 9	
Do	1	4.30 p. m.	66.26	977	....	30.022	61	61	29.935	29.992	....	....	61	52.5	8.5	E. 1	C. S. & Cum. 9	
Do	1	4.30 p. m.	66.26	978	....	30.018	61	61	29.931	29.968	....	....	61	52.5	8.5	E. 1	C. S. & Cum. 9	
Do	1	5 p. m.	66.26	1012	30.734 0.654	30.080	58.5	59.5	30.000d	30.008	....	....	59	53.5	5.5	E. 5	C. S. & Cum. 9	
Do	1	5 p. m.	66.26	392	....	30.040	58.3	59.5	29.960	29.986	....	....	59	53.5	5.5	E. 5	C. S. & Cum. 9	
Do	1	5 p. m.	66.26	977	....	30.020	58.5	59.5	29.940	29.988	....	....	59	53.5	5.5	E. 5	C. S. & Cum. 9	
Do	1	5 p. m.	66.26	378	....	30.018	58.5	59.5	29.938	29.986	....	....	59	53.5	5.5	E. 5	C. S. & Cum. 9	
Do	2	7 a. m.	66.26	1012	30.690 0.680	30.010	47	47.8	29.960	30.028	....	....	.....	.....	.....	E. 5	C. S. & Cum. 9	Sunrise.
Do	2	7 a. m.	66.26	392	....	30.000	47.5	47.8	29.949	30.035	30.014	24.0	.....	.....	.....	E. 5	C. S. & Cum. 9	
Δ between stations 1 and 2	2	9 a. m.	69.77	1012	30.700 0.700	30.000	56.5	54	29.925	30.007	....	30.3	.....	.....	.....	E. 1	C. S. 7	
Station 4	2	12 m.	77.02	1012	30.642 0.740	29.902	59.5	59.5	29.819	29.909	....	121.2	.....	.....	.....	S.E. 1	C. S. 9	
Camp No. 6	2	3 p. m.	83.82	1012	30.640 0.754	29.886	58	58.9	29.807	29.937	....	....	.....	.....	.....	S.E. 1	Nimbu9, 10	On right bank of river, (raining.)
Do	2	3 p. m.	83.82	392	....	29.862	59	58.9	29.780	29.925	....	....	.....	.....	.....	S.E. 1	Nimbus, 10	
Do	2	4 p. m.	83.82	1012	30.640 0.764	29.876	59.5	60	29.793	29.923	....	....	60	56.5	3.5	S.E. 5	Nimbus, 10	Raining.
Do	2	4 p. m.	83.82	392	....	29.855	59.5	60	29.772	29.917	....	....	60	56.5	3.5	S.E. 5	Nimbus, 10	Do.
Do	2	4.30 p. m.	83.82	1012	30.638 0.762	29.876	59	59.8	29.794	29.925	....	....	60	58	2	S.E. 5	Nimbus, 10	Raining, (sunset.)
Do	2	4.30 p. m.	83.82	392	....	29.855	59.5	59.8	29 772	29.918	....	....	60	58	2	S.E. 5	Nimbus, 10	Do. do.
Do	2	5 p. m.	83.82	1012	30.628 0.760	29.868	59	59	29.768	29.912	....	....	59.7	57	2.7	S.E. 5	Nimbus, 10	
Do	2	5 p. m.	83.82	392	....	29.849	58.5	59	29.768	29.909	....	....	59.7	57	2.7	S.E. 5	Nimbus, 10	

Do.	2	6 p. m.	83.82	1012	30.618	29.850	58.5	58.8	29.770	29.890	....	....	61	58	3	S.E. 5...	Nimbus, 10....	
					0.768													
Do.	2	6 p. m.	83.82	392	....	29.839	59.5	58.8	29.756	29.891	....	....	61	58	3	S.E. 5...	Nimbus, 10....	
Do.	3	6.40 a. m.	83.82	1012	30.646	29.898	54	54.5	29.830	29.860	....	....	54	53	1	S.E. 5...	Cum. 7........	Hard rain during night.
					0.748													
Do.	3	6.40 a. m.	83.82	392	....	29.900	54	54.5	29.832	29.877	....	....	54	53	1	S.E. 5...	Cum. 7........	Do. do.
Do.	3	7 a. m.	83.82	1012	30.650	29.918	53	53.7	29.852	29.880	....	....	53.5	53	0.5	S.E. 5...	Cum. 9........	
					0.732													
Do.	3	7 a. m.	83.82	392	....	29.910	53.5	53.7	29.843	29.886	....	....	53.5	53	0.5	S.E. 5...	Cum. 9........	
Do.	3	7.10 a. m.	83.82	1012	30.650	29.914	53	54	29.848	29.876	....	....	....	....	....	....	....	Rainbow.
					0.736													
Do.	3	7.10 a. m.	83.82	392	....	29.910	53.8	54	29.842	29.870	29.900	129.3	....	....	....	....	....	
Δ between stations 1 and 2	3	9 a. m.	86.32	1012	30.680	29.942	60.4	60	29.856	29.858	....	168.9	....	....	....	S.E. 1...	Cum. & Nim. 9.	
					0.738													
Δ between stations 6 and 7	3	12 m.	80.32	1012	30.696	29.954	70.2	69.9	29.843	29.823	....	203.4	....	....	....	S.E. 1...	Cir. & C. S. 4..	
					0.742													
Camp No. 7, near Soledad	3	3 p. m.	93.82	1012	30.650	29.890	67	67	29.787	29.777	....	....	67	60.7	6.3	S.E. 1...	Cumulus, 3....	
					0.760													
Do.	3	3 p. m.	93.82	392	....	29.882	68.5	67	29.774	29.777	....	....	67	60.7	6.3	S.E. 1...	Cumulus, 3 ...	
Do.	3	4 p. m.	93.82	1012	30.650	29.890	62.5	62.5	29.799	29.793	....	....	62	58.6	3.4	N.E. 1...	Cum. 2........	
					0.760													
Do.	3	4 p. m.	93.82	392	....	29.882	63	62.5	29.789	29.796	....	....	62	58.6	3.4	N.E. 1...	Cum. 2........	
Do.	3	4.30 p. m.	93.82	1012	30.648	29.900	59	60	29.818	29.815	....	....	60	57	3	N.E. 1...	Cum. 2........	
					0.748													
Do.	3	4.30 p. m.	93.82	392	....	29.855	59.5	60	29.802	29.812	....	....	60	57	3	N.E. 1...	Cum. 2........	
Do.	3	5 p. m.	93.82	1012	30.648	29.904	57.5	58	29.827	29.830	....	....	58	56	2	N.E. 1...	Cum. 1........	
					0.744													
Do.	3	5 p. m.	93.82	392	....	29.882	57.5	58	29.805	29.821	....	....	58	56	2	N.E. 1...	Cum. 1........	
Do.	3	6.50 p. m.	93.82	1012	30.668	29.930	54	55	29.862	29.867	....	....	54.5	53	1.5	N.E. 1...	Cum. 1........	
					0.738													
Do.	3	6.50 p. m.	93.82	392	....	29.922	54	55	29.854	29.872	....	....	54.5	53	1.5	N.E. 1...	Cum. 1...	
Camp No. 7	4	7 a. m.	93.82	1012	30.696	29.966	46.9	48	29.946	29.882	....	....	48	47.5	0.5	S.W. 1..	Cum. 10.......	Heavy and dense fog.
					0.700													
Do.	4	7 a. m.	93.82	392	....	29.989	47.5	48	29.938	29.885	29.827	197.9	48	47.5	0 5	S.W. 1..	Cum. 10.......	Do. do.
Δ between stations 2 and 3	4	9 a. m.	98.58	1012	30.700	30.052	51	50	29.992	29.904	....	121.9	....	....	....	....	....	
					0.648													
Δ between stations 6 and 7	4	12 m.	107.58	1012	30.640	29.890	63.5	63.5	29.796	29.696	....	311.9	....	....	....	S.E. 1...	Cumulus, 5....	Clearing up, (chilly.)
					0.750													
Δ between stations 8 and 9	4	3 p. m.	111.75	1012	30 620	29.826	69.9	70.5	29.715	29.635	....	382.6	....	....	....	S.E. 1...	Cumulus, 5....	On Mésa.
					0.794													
Camp No. 8, Salinas river	4	4.30 p. m.	113.25	1012	30.618	29.828	61	61.5	29.741	29.663	....	....	61.5	56	5.5	S.E. 1...	Cumulus, 5....	
					0.790													
Do.	4	4.30 p. m.	113.25	392	....	29.820	61.5	61.5	29.732	29.669	....	....	61.5	56	5.5	S.E 1...	Cumulus, 5....	
Do.	4	5 p. m.	113.25	1012	30 606	29.822	55	56.5	29.751	29.674	....	....	55.5	53	2.5	S.E. 1...	Cumulus, 5....	
					0.784													
Do.	4	5 p. m.	113.25	392	....	29.812	55.5	56.5	29.740	29.678	....	....	55.5	53	2.5	S.E. 1...	Cumulus, 5.. .	
Do.	4	8.15 p. m.	113.25	1012	30.612	29.844	47.5	48	29.793	29.711	....	....	49	48	1	S.E. 1...	Cumulus, 5....	Heavy dew falling.
					0.768													

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Upper and lower vernier.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		*Miles.*		*Inches.*	*Inches.*	°	°	*Inches.*	*Inches.*	*Inches.*	*Feet.*	°	°	°			
Camp No. 8, Salinas river	Dec. 4	8.15 p. m.	113.25	392		29.830	47.5	48	29.779	29.712			49	48	1	S.E. 1	Cumulus, 5	
Do.	5	7 a. m.	113.25	1012	30.642 0.736	29.906	45.5	46.5	29.861	29.759			46	45.5	0.5	S.E. 1		Sunrise; dense fog.
Do.	5	7 a. m.	113.25	392		29.872	46	46.5	29.825	29.738	29.700	310.0	46	45.5	0.5	S.E. 1		
Station 1	5	9 a. m.	116.00	1012	30.610 0.770	29.840	52	50	29.777	29.649		356.5				S.E. 1.—		
Station 6	5	12 m.	122.38	1012	29.878 1.336	28.542	47.5	47	28.491	28.351		1588.7				S.E. 1		Dense fog on top of mountain.
Station 8	5	3 p. m.	124.06	1012	30.174 1.098	29.076	55	54	29.005	28.905		1061.3				S.E. 1		
Camp No. 9, head of river San Antonio.	5	4.30 p. m.	127.26	1012	30.174 1.098	29.076	50.5	52	29.017	28.924						S,E. 1		
Do.	5	4.30 p. m.	127.26	392		29.069	50.5	52	29.010	28.937						S.E. 1		
Do.	5	5.15 p. m.	127.26	1012	30.168 1.082	29.086	51	50.8	29.026	28.940			52	50.5	1.5	S.E. 1		Foggy.
Do.	5	5.15 p. m.	127 26	392		29.059	50.5	50.8	29.000	28.931			52	50.5	1.5	S.E. 1		Do.
Do.	6	6.30 a. m.	127 26	1012	30.170 1.050	29.120	37.5	38	29.098	28.993			38	36	2	S.E. 1	C. S. 5	Fog disappeared about daylight.
Do.	6	6.30 a. m.	127.26	392		29.100	37.5	38	29.078	28.993			38	36	2	S.E. 1	C. S 5	
Do.	6	7 a. m.	127.26	1012	30.168 1.052	29.116	33	33.5	29.104	28.972						S.E. 1	C. S. 5	
Do.	6	7 a. m.	127.26	392		29 080	33.5	33.5	29.067	28.955	28.956	1002.0				S.E. 1	C. S. 5	
Station 6	6	9 a. m.	134.04	1012	30.328 0.948	29.380	49.5	49.5	29.326	29.168		806.3				S.E. 1	C. S. 5	Dense fog, and overcast.
Station 10	6	12 m.	137.59	1012	30.378 0.950	29.428	57.5	58	29.352	29.182		800.9				S E 1	C. S. 5	
Δ between stations 11 and 12	6	3 p. m.	140.78	1012	30.430 0.918	29.512	61	60	29.436	29.286		703.6				S.E. 1	C. S. 5	Overcast.
Camp No. 10, San Antonio riv.	6	4.30 p. m.	145.05	1012	30.434 0.920	29.514	53.5	53	29.448	29.315			52	51	1	S.E. 1	C. S. 5	Clear sunset.
Do.	6	4.30 p. m.	145.05	392		29.516	53.9	53	29.449	29.322			52	51	1	S.E. 1	C. S. 5	Do.
Do.	6	5 p. m.	145.05	1012	30.424 0.920	29.504	50	50.5	29.447	29.320			50	49	1	S.E. 1	Cir. 2	
Do.	6	5 p. m.	145.05	392		29.501	50	50.5	29.444	29.323			50	49	1	S.E. 1	Cir. 2	

Do	7	6.30 a. m.	145.05	1012	30.416 0.878	29.538	41	42	29.505	29.369			42	41	1	S.E. 1	Cir. 2	
Do	7	6.30 a. m.	145.05	392		29.526	41	42	29.493	29.363			42	41	1	S.E. 1	Cir. 2	Overcast; dense fog in night.
Do	7	7 a. m.	145.05	1012	30.410 0.886	29.521	38.5	40	29.490	29.356						S.E. 1	Cir. 2	
Do	7	7 a. m.	145.05	392		29.515	39.5	40	29.486	29.350	29.340	643.2				S.E. 1	Cir. 2	
Station 6	7	9 a. m.	149.35	1012	30.498 0.852	29.646	47.5	51.5	29.596	29.438		554.5				S.E. 1	Cir. 2	
Station 13	7	12 m	156.60	1012	30.470 0.882	29.588	53	54	29.523	29.373		616.8				S.E. 1	Cir. 2	
Station 17	7	3 p. m.	160.85	392		29.419	60	57	29.336	29.222		762.6				S.E. 1	Cir. 2	Barometer 1012 broken.
Camp No. 11, San Miguel	7	4.30 p. m.	163.44	392		29.527	52.5	54	29.464	29.351						S.E. 1	Cir. 2	On left bank of Salinas, near San
Do	7	5 p. m.	163.44	392		29.310	48.5	50	29.457	29.355			49.5	47	2.5	S.E. 1	Cir. 2	Miguel mission.
Do	8	6.45 a. m.	163.44	392		29.529	40	40	29.499	29.434			40	39	1	S.E. 1	Cir. 2	Overcast.
Do	8	7 a. m.	163.44	392		29.530	39.5	40	29.501	29.409	29.387	597.4	40	39	1	S.E. 1	Cir. 2	Overcast; light fog.
Camp No. 12, near Ojo Caliente	8	9 a. m.	168.62	392		29.538	44	49.8	29.481	29.366			40	39	1	S.E. 1	Cir. 2	Overcast.
Do	8	10 a. m.	168.62	392		29.540	50	48	29.478	29.365						N.W. 5	C. S. 1	
Do	8	12 m	168.62	392		29.507	55.5	55	29.436				55	48	7	N.W. 5	C. S. 1	
Do	8	12 m	168.62	977		29.462	55.5	55	29.391				55	48	7	N.W. 5	C. S. 1	
Do	8	12 m	168.62	978		29.458	55.5	55	29.387	29.319			55	48	7	N.W. 5	C. S. 1	
Do	8	1 p. m.	168.62	392		29.480	57	56.9	29.405				56	50	6	N.W. 5	C. S. 1	
Do	8	1 p. m.	168.62	977		29.436	57	56.9	29.361				56	50	6	N.W. 5	C. S. 1	
Do	8	1 p. m.	168.62	978		29.440	57	56.9	29.365	29.344			56	50	6	N.W. 5	C. S. 1	
Do	8	2 p. m.	168.62	392		29.468	57	56	29.393				55.5	49	6.5	N.W. 1	C. S. 1	
Do	8	2 p. m.	168.62	977		29.424	56.5	56	29.350				55.5	49	6.5	N.W. 1	C. S. 1	
Do	8	2 p. m.	168.62	978		29.426	57	56	29.351	29.341			55.5	49	6.5	N.W. 1	C. S. 1	
Do	8	3 p. m.	168.62	392		29.468	56.5	57	29.394				56	49	7	N.W. 1	C. S. 1	
Do	8	3 p. m.	168.62	977		29.424	56.5	57	29.350				56	49	7	N.W. 1	C. S. 1	
Do	8	3 p. m.	168.62	978		29.426	56.5	57	29.352	29.358			56	49	7	N.W. 1	C. S. 1	
Do	8	4 p. m.	168.62	392		29.460	51.5	51.7	29.399				51	47	4	N.W. 1	C. S. 1	
Do	8	4 p. m.	168.62	977		29.416	52	51.7	29.354				51	47	4	N.W. 1	C. S. 1	
Do	8	4 p. m.	168.62	978		29.410	50.5	51.7	29.349	29.362			51	47	4	N.W. 1	C. S. 1	
Do	8	4.15 p. m.	168.62	392		29.460	49	49.5	29.406				48.5	45.5	3	N.W. 1	C. S. 1	Sunset.
Do	8	4.15 p. m.	168.62	977		29.412	49.9	49.5	29.355				48.5	45.5	3	N.W. 1	C. S. 1	
Do	8	4.15 p. m.	168.62	978		29.410	50	49.5	29.353	29.427			48.5	45.5	3	N.W. 1	C. S. 1	
Do	8	5 p. m.	168.62	392		29.450	45	45.9	29.409				45	43	2	N.W. 1	C. S. 1	
Do	8	5 p. m.	168.62	977		29.406	45	45.9	29.363				45	43	2	N.W. 1	C. S. 1	
Do	8	5 p. m.	168.62	978		29.406	45.5	45.9	29.362	29.425			45	43	2	N.W. 1	C. S. 1	
Do	8	6 p. m.	168.62	392		29.464	44.5	46	26.422				46	43.5	2.5	N.W. 1	C. S. 1	
Do	8	6 p. m.	168.62	977		29.424	46	46	29.378				46	43.5	2.5	N.W. 1	C. S. 1	
Do	8	6 p. m.	168.62	978		29.426	46	46	29.380	29.432			46	43.5	2.5	N.W. 1	C. S. 1	
Do	9	6.45 a. m.	168.62	392		29.482	29	29.5	29.481				29	31	−2*d*	N.W. 1	C. S. 1	Overcast.
Do	9	6.45 a. m.	168.62	978		29.454	29	29.5	29.453	29.454			29	31	−2*d*	N.W. 1	C. S. 1	
Do	9	7 a. m.	168.62	392		29.482	29	29.5	29.481				28.9	30.5	−1.6	N.W. 1	C. S. 1	
Do	9	7 a. m.	168.62	978		29.454	29	29.5	29.453	29.373	29.363	622.4				N.W. 1	C. S. 1	
Δ between stations 3 and 4	9	9 a. m.	173.00	978		29.422	45.5	44	29.376	29.189		783.0				N.W. 1	C. S. 1	
Δ between stations 8 and 9	9	12 m	179.55	978		29.316	60.5	63	29.232	29.169		817.9				N.W. 1	C. S. 1	
Camp No. 13, Atascadero	9	3 p. m.	181.05	392		29.319	62	61.3	29.231							N.W. 1	C. S. 1	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 13, Atascadero	Dec. 9	3 p. m.	181.05	978	29.276	62	61.3	29.188	29.156						N.W. 1	C. S. 1	
Do	9	4 p. m.	181.05	392	29.319	58	57.9	29.241							N.W. 1	C. S. 1	
Do	9	4 p. m.	181.05	978	29.274	58	57.9	29 196	29.167						N.W. 1	C. S. 1	
Do	9	4.15 p. m.	181.05	392	29.316	53	53	29.251							N W. 1	C. S. 1	Sunset.
Do	9	4.15 p. m.	181.05	978	29.272	53	53	29.207	29.173						N.W. 1	C. S. 1	
Do	9	5 p. m.	181.05	392	29.320	47	48	29.271							N.W. 1	Overcast	
Do	9	5 p. m.	181.05	978	29.274	47.5	48	29.224	29.178						N.W. 1	Overcast	
Do	10	7 a. m.	181.05	392	29.460	26	26.5	29.467							N.W. 1	Overcast	Foggy; heavy frost.
Do	10	7 a. m.	181.05	978	29.432	26	26.5	29.439	29.199	29.168	807.3				N.W. 1	Overcast	
Δ between stations 4 and 5	10	9 a. m.	186.44	978	29.312	44	44.5	29.271	28.994		966.4				N.W. 1	Overcast	On a ridge; clear.
Camp No. 14, Santa Margarita	10	12 m.	189.61	392	29.380	57	61.5	29.305				52.5	47.3	5.2	N.W. 1	Overcast	Near rancho, de Santa Margarita.
Do	10	12 m.	189.61	978	29.342	56.5	61 5	29.268	29.024			52.5	47.3	5.2	N.W. 1	Overcast	
Do	10	0.30 p. m.	189.61	392	29.369	58	57.3	29.290				56.5	48.5	8	N.W. 1	Overcast	
Do	10	0.30 p. m.	189.61	978	29.330	57.5	57.3	29.253	29 021			56.5	48.5	8	N.W. 1	Overcast	
Do	10	1 p. m.	189.61	392	29.360	61.5	60.7	29.273				60.5	50 5	10	N.W. 1	Overcast	
Do	10	1 p. m.	189.61	978	29.326	61	60.7	29.240	29.017			60.5	50.5	10	N.W. 1	Overcast	
Do	10	2 p. m.	189.61	392	29.359	66	65	29.260							N.W. 1	Overcast	
Do	10	2 p. m.	189.61	978	29.326	65.5	65	29.228	29.014						N.W. 1	Overcast	
Do	10	3 p. m.	189.61	392	29.359	66	66	29.260				65.5	52	13.5	N.W. 1	Overcast	
Do	10	3 p. m.	189.61	978	29.326	66	66	29.227	29.028			65.5	52	13.5	N.W. 1	Overcast	
Do	10	4 p. m.	189.61	392	29.350	60	60	29 266				59	50	9	N.W. 1	Overcast	
Do	10	4 p. m.	189.61	978	29.312	60	60	29.228	29.026			59	50	9	N.W. 1	Overcast	
Do	10	4.30 p. m.	189.61	392	29.354	53	53.2	20.289				52.7	46	6.7	N.W. 1	Overcast	
Do	10	4.30 p. m.	189.61	978	29.314	53	53.2	29 219	29.044			52.7	46	6.7	N.W. 1	Overcast	
Do	10	5 p. m.	189.61	392	29.350	47	48.2	29.301				47.5	42	5 5	N.W. 1	Overcast	
Do	10	5 p. m.	189.61	978	29.310	47.5	48.2	29.250	29.051			47.5	42	5.5	N.W. 1	Overcast	
Do	10	6 p. m.	189.61	392	29.348	47.1	51	29.299				50.3	46	4.3	N.W. 1	Overcast	
Do	10	6 p. m.	189.61	978	29 324	51	51	29.265	29.055			50.3	46	4.3	N.W. 1	Overcast	
Do	10	7 p. m.	189.61	392	29.349	36	37	29.330				37	35	2	S.E. 1	0	Clear.
Do	10	7 p. m.	189.61	978	29.308	37.5	37	29.285	29.067			37	35	2	S.E. 1	0	
Do	10	8 p. m.	189.61	392	29 332	38.1	39.5	29.307				38	36	2	S.E. 1	0	
Do	10	8 p. m.	189.61	978	29.302	38.2	39.5	29.277				38	36	2	S.E. 1	0	
Do	10	8 p. m.	189.61	977	29.312	40	39.5	29.282	29.041			38	36	2	S.E. 1	0	
Do	10	9 p. m.	189.61	392	29.324	31.5		29.317				31.5	33	1.5	S.E. 1	0	Clear sky.
Do	10	9 p. m.	189.61	978	29.319	33.5		29.307				34.5	53	1.5	S.E. 1	0	Do

Do.	10	9 p. m.	189.61	977	29.334	33.8		29.320	29.056			34.5	33	1.5	S.E. 1	0	Clear sky.
Do.	10	10 p. m.	189.61	392	29.324	29.6	31	29.322				31.2	29.5	1.7	S.E. 1	0	
Do.	10	10 p. m.	189.61	978	29.276	31.5	31	29.269				31.2	29.5	1.7	S.E. 1	0	
Do.	10	10 p. m.	189.61	977	29.336	32	31	29.328	29.041			31.2	29.5	1.7	S.E. 1	0	
Do.	10	11 p. m.	189.61	392	29.375	29.5	30.5	29.374				29.9	28	1.9	0	0	Clear.
Do.	10	11 p. m.	189.61	978	29.337	31	30.5	29.331				29.9	28	1.9	0	0	Clear.
Do.	10	11 p. m.	189.61	977	29.328	32	30.5	29.320	29.086			29.9	28	1.9	0	0	Clear.
Do.	10	12 midnight	189.61	392	29.342	28.5	29	29.343				27.5	26.1	1.4	0	0	
Do.	10	12 midnight	189.61	978	29.326	29.7	29	29.323				27.5	26.1	1.4	0	0	
Do.	10	12 midnight	189.61	977	29.318	29.5	29	29.316	29.081			27.5	26.1	1.4	0	0	
Do.	11	1 a. m.	189.61	392	29.342	26.5	27.5	29.347				27	25	2	0	0	
Do.	11	1 a. m.	189.61	978	29.314	27	27.5	29.318				27	25	2	0	0	
Do.	11	1 a. m.	189.61	977	29,314	27	27.5	29.3.8	29.091			27	25	2	0	0	
Do.	11	2 a. m.	189.61	392	29.350	25	26.5	29.359				25 5	23.5	2	0	0	
Do.	11	2 a. m.	189.61	978	29.318	26	26.5	29.325				25 5	23 5	2	0	0	
Do.	11	2 a. m.	189.61	977	29.320	26	26.5	29.327	29.101			25.5	23.5	2	0	0	
Do.	11	3 a. m.	189.61	392	29 322	26.5	27	29.327				24.5	23	1.5	0	0	
Do.	11	3 a. m.	189.61	978	29.304	26.5	27	29.309				24.5	23	1.5	0	0	
Do.	11	3 a. m.	189.61	977	29.300	27	27	29.304	29.076			24.5	23	1.5	0	0	
Do.	11	4 a. m.	189 61	392	29.300	26	25.5	29.307				28	28		0	0	
Do.	11	4 a. m.	189.61	978	29.254	26	25.5	29.261				28	28		0	0	
Do.	11	4 a. m.	189.61	977	29.253	26.5	25.5	29.258	29.022			28	28		0	0	
Do.	11	5 a. m.	189.61	392	29.340	23	24.5	29.355				24	26	2	0	0	Bright and clear; heavy frost.
Do.	11	5 a. m.	189.61	978	29.304	23	24.5	29.319				24	26	2	0	0	Do. do.
Do.	11	5 a. m.	189.61	977	29.300	23	24.5	29.315	29.074			24	26	2	0	0	Do. do.
Do.	11	6 a. m.	189.61	392	29 377	22	23					23	22	1	0	0	Not used.
Do.	11	6 a. m.	189.61	978	29.382	22	23					23	22	1	0	0	Do.
Do.	11	6 a. m.	189.61	977	29.296	22	23					23	22	1	0	0	Do.
Do.	11	7 a. m.	189.61	392	29.350	22	23	29.367				22.5	21.5	1	0	0	Sunrise.
Do.	11	7 a. m.	189.61	978	29.316	22	23	29.333				22.5	21.5	1	0	0	
Do.	11	7 a. m.	189.61	977	29.312	22	23	29.329	29.065			22.5	21.5	1	0	0	
Do.	11	8 a. m.	189.61	392	29 359	31	29	29.372				30	28	2	0	0	
Do.	11	8 a. m.	189.61	978	29.334	29	29	29.333				30	28	2	0	0	
Do.	11	8 a. m.	189.61	977	29.330	29	29	29.329	29.065			30	28	2	0	0	
Do.	11	9 a. m.	189.61	392	29.399	38	36.5	29.374				35.5	32.5	3	0	0	
Do.	11	9 a. m.	189.61	978	29.382	36.5	36.5	29.330				35.5	32.5	3	0	0	
Do.	11	9 a. m.	189.61	977	29.348	36.5	36.5	29.326	29.064			35.5	32.5	3	0	0	
Do.	11	10 a. m.	189 61	392	29.410	46	45.5	29.364				43.2	41	2.2	0	0	
Do.	11	10 a. m.	189.61	978	29.376	45.5	45.5	29.332				43.2	41	2.2	0	0	
Do.	11	10 a. m.	189.61	977	29.370	45.5	45.5	29 326	29.069			43.2	41	2.2	0	0	
Do.	11	11 a. m.	189.61	392	29.399	50.5	49.2	29.341				47	42.5	5.5	0	0	
Do	11	11 a. m.	189.61	978	29.360	50	49.2	29.303				47	42.5	5.5	0	0	
Do.	11	11 a. m.	189.61	977	29.350	49.5	49 2	29.295	29.045			47	42 5	5.5	0	0	
Do.	11	12 m.	189.61	392	29.376	56.5	55.5	29.302				54	48	6	0	0	
Do.	11	12 m.	189.61	978	29.348	56	55.5	29.275				54	48	6	0	0	
Do.	11	12 m.	189.61	977	29.350	56	55.5	29.277	29.044			54	48	6	0	0	
Do.	11	1 p. m.	189.61	392	29.370	61	60	29.284				58.5	50	8.5	N.W. 5	0	
Do.	11	1 p. m.	189.61	978	29.330	60.7	60	29.244				58.5	50	8.5	N.W. 5	0	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 14	Dec. 11	1 p. m.	189.61	977	29.322	60.9	60	29.236	29.037			58.5	50	8.5	N.W. 5	0	
Do	11	2 p. m.	189.61	392	29.340	67	66.4	29.238				65	52	13	N.W. 5	0	
Do	11	2 p. m.	189.61	978	29.300	67	66.4	29.198				65	52	13	N.W. 5	0	
Do	11	2 p. m.	189.61	977	29.302	67	66.4	29.200	29.008			65	52	13	N.W. 5	0	
Do	11	3 p. m.	189.61	392	29.340	68	67.8	29.235				65	52.5	2.5	N.W. 5	0	
Do	11	3 p. m.	189.61	978	29.300	68.5	67.8	29.194				65	52.5	2.5	N.W. 5	0	
Do	11	3 p. m.	189.61	977	29.300	68	67.8	29.195	29.011			65	52.5	2.5	N.W. 5	0	
Do	11	4 p. m.	189.61	392	29.339	65	64.5	29.242				64.2	48.5	15.7	N.W. 5	0	
Do	11	4 p. m.	189.61	978	29.292	65	64.5	29.195				64.2	48.5	15.7	N.W. 5	0	
Do	11	4 p. m.	189.61	978	29.292	64.5	64.5	29.196	29.016			64.2	48.5	15.7	N.W. 5	0	
Do	11	4.25 p. m.	189.61	392	29.330	61.5	62	29.243				61.5	46.5	15	E. 5	0	
Do	11	4.25 p. m.	189.61	978	29.288	62	62	29.199				61.5	46.5	15	E. 5	0	
Do	11	4.25 p. m.	189.61	977	29.288	61.8	62	29.200	29.020			61.5	46.5	15	E. 5	0	
Do	11	5 p. m.	189.61	392	29.330	57.5	58.5	29.234				55.5	45	10.5	N. 5	0	
Do	11	5 p. m.	189.61	978	29.278	58.5	58.5	29.199				55.5	45	10.5	N. 5	0	
Do	11	5 p. m.	189.61	977	29.278	58	58.5	29.200	29.025			55.5	45	10.5	N. 5	0	
Do	12	7 a. m.	189.61	392	29.259	25.5	27	29.267				26	25	1	N. 5	0	
Do	12	7 a. m.	189.61	978	29.216	26	27	29.223				26	25	1	N. 5	0	
Do	12	7 a. m.	189.61	977	29.214	26	27	29.221	29.029			26	25	1	N. 5	0	
Do	12	8 a. m.	189.61	392	29.260	30.5	30.5	29.255				30	28.5	1.5	N. 5	0	
Do	12	8 a. m.	189.61	978	29.226	30	30.5	29.222				30	28.5	1.5	N. 5	0	
Do	12	8 a. m.	189.61	977	29.224	30	30.5	29.220	29.023			30	28.5	1.5	N. 5	0	
Do	12	9 a. m.	189.61	392	29.288	39.5	39	29.259				38.4	35.4	3	N. 5	0	
Do	12	9 a. m.	189.61	977	29.242	38.5	39	29.215	29.031			38.4	35.4	3	N. 5	0	
Do	12	10 a. m.	189.61	392	29.289	45	44	29.245				43	39.5	3.5	N. 5	0	
Do	12	10 a. m.	189.61	977	29.244	44	44	29.203	29.020			43	39.5	3.5	N. 5	0	
Do	12	11 a. m.	189.61	392	29.290	48.5	48	29.238				46.5	41.5	5	N. 5	0	
Do	12	11 a. m.	189.61	977	29.250	48	48	29.199	29.029			46.5	41.5	5	N. 5	0	
Do	12	12 m.	189.61	392	29.279	58	57.5	29.201				55	46.5	8.5	N. 5	0	
Do	12	12 m.	189.61	977	29.228	57.5	57.5	29.152	29.014			55	46.5	8.5	N. 5	0	
Do	12	1 p. m.	189.61	392	29.258	61	60.5	29.172				57	48.5	8.5	N. 5	0	
Do	12	1 p. m.	189.61	977	29.216	60.5	60.5	29.130	29.012			57	48.5	8.5	N. 5	0	
Do	12	2 p. m.	189.61	392	29.242	65	64	29.145				61	49.5	11.5	N. 5	0	
Do	12	2 p. m.	189.61	977	29.200	64.5	64	29.105	29.000			61	49.5	11.5	N. 5	0	
Do	12	3 p. m.	189.61	392	29.262	66	66	29.132				62	51	11	N. 5	C. S. 5	

Do	12	3 p. m.	189.61	977	29.190	65.5	66	29.092	28.999			62	51	11	N. 5	C. S. 5	
Do	12	4 p. m.	189.61	392	29.216	63.5	63.3	29.233				60.5	50	10.5	N. 5	C. S. 5	
Do	12	4 p. m.	189.61	977	29.180	63.5	63.3	29.087	29.004			60.5	50	10.5	N. 5	C. S. 5	
Do	12	Sunset	189.61	392	29.210	55.5	55.8	29.139				53.2	47.7	5.5	N. 5	C. S. 5	
Do	12	Sunset	189.61	977	29.168	55.5	55.8	29.097	29.012			53.2	47.7	5.5	N. 5	C. S. 5	
Do	12	5 p. m.	189.61	392	29.209	52	53	29.147				50.9	46	4.9	N. 5	C. S. 5	
Do	12	5 p. m.	189.61	977	29.162	52	53	29.100	29.010			50.9	46	4.9	N. 5	C. S. 5	
Do	13	7 a. m	189.61	392	29.191	25	26.2	29.200				26	24.5	1.5	N. 5	C. S. 5	
Do	13	7 a. m.	189.61	977	29.148	25.4	26.2	29.140	29.016			26	24.5	1.5	N. 5	C. S. 5	
Do	13	8 a. m.	189.61	392	29.200	30.5	30.5	29.195				30	28.3	1.7	N. 5	C. S. 5	
Do	13	8 a. m.	189.61	977	29.158	30	30.5	29.154	29.018			30	28.3	1.7	N. 5	C. S. 5	
Do	13	9 a. m.	189.61	392	29.198*d*	40	39.5	29.168	28.973			38.8	36	2.8	0	0	Doubtful observations.
Do	13	10 a. m.	189.61	392	29.199*d*	44	45	29.154	28.961			44	40	4	0	0	Do. do.
Do	13	11 a. m.	189.61	392	29.218	54.8	54	29.179	28.991			52	45	7	0	0	
Do	13	12 m	189.61	392	29.229	58	57.1	29.151	28.980			56	47.5	8.5	0	0	
Do	13	1 p. m.	189.61	392	29.230	61.5	60.6	29.143	28.995			58	49.5	8.5	0	0	
Do	13	2 p. m.	189.61	392	29.219	65.8	65	29.120	28.971			63.5	53.5	10	0	0	
Do	13	3 p. m.	189.61	392	29.100	66.8	66	28.990				62.9	52.4	10.5	0	0	
Do	13	3 p. m.	189.61	977	29.164	66	66	29.064	28.898			62.9	52.4	10.5	0	0	
Do	13	4 p. m.	189.61	392	29.199	63	62.9	29.107				61	53	8	0	0	
Do	13	4 p. m.	189.61	977	29.158	63	62.9	29.066	28.955			61	53	8	0	0	
Do	13	4.30 p. m.	189.61	392	29.190	55.5	55.2	29.119				53.5	48	5.5	0	0	
Do	13	4.30 p. m.	189.61	977	29.150	55.5	55.2	29.079	28.958			53.5	48	5.5	0	0	
Do	13	5 p. m.	189.61	392	29.180	50	51	29.123				49.9	46	3.9	0	0	
Do	13	5 p. m.	189.61	977	29.138	50.5	51	29.080	28.957			49.9	46	3.9	0	0	
Do	14	7 a. m.	189.61	392	29.170	28	29.5	29.171				28.2	28	0.2	0	0	
Do	14	7 a. m.	189.61	977	29.130	28.5	29.5	29.138	28.971			28.2	28	0.2	0	0	
Do	14	8 a. m.	189.61	392	29.185	33	33.3	29.173				32.5	31.8	0.7	0	0	
Do	14	8 a. m.	189.61	977	29.150	32.7	33.3	29.139	28.980			32.5	31.8	0.7	0	0	
Do	14	9 a. m.	189.61	392	29.210	41.5	41	29.176				40	38	2	0	0	
Do	14	9 a. m.	189.61	977	29.170	41	41	29.137	28.980			40	38	2	0	0	
Do	14	10 a. m.	189.61	392	29.218	47.5	47	29.168				45.5	42.5	3	0	0	
Do	14	10 a. m.	189.61	977	29.180	47	47	29.130	28.976			45.5	42.5	3	0	0	
Do	14	11 a. m.	189.61	392	29.220	54.5	53.5	29.152				52	47	5	0	0	
Do	14	11 a. m.	189.61	977	29.180	53.5	53.5	29.114	28.969			52	47	5	0	0	
Do	14	12 m.	189.61	392	29.200	60.5	60	29.115				58	50	8	0	0	
Do	14	12 m.	189.61	977	29.152	60	60	29.068	28.949			58	50	8	0	0	
Do	14	1 p. m.	189.61	392	29.181	64.5	64	29.086				60	51.7	8.3	0	0	
Do	14	1 p. m.	189.61	977	29.140	64	64	29.046	28.947			60	51.7	8.3	0	0	
Do	14	2 p. m.	189.61	392	29.179	67.5	67	29.076				64	53	11	N.W. 1	0	
Do	14	2 p. m.	189.61	977	29.134	67	67	29.032	28.950			64	53	11	N.W. 1	0	
Do	14	3 p. m.	189.61	392	29.170	68	68	29.065				65	53.5	11.5	N.W. 1	0	
Do	14	3 p. m.	189.61	977	29.132	67.7	68	29.028	28.953			65	53.5	11.5	N.W. 1	0	
Do	14	4 p. m.	189.61	392	29.170	65.4	64.7	29.072				62	54	8	N.W. 1	C. S. 1	
Do	14	4 p. m.	189.61	977	29.128	65	64.7	29.031	28.960			62	54	8	N.W. 1	C. S. 1	
Do	14	4.30 p. m.	189.61	392	29.158	57.5	57.8	29.082				55.8	50	5.8	N.W. 1	C. S. 1	
Do	14	4.30 p. m.	189.61	977	29.112	57.8	57.8	29.036	28.969			55.8	50	5.8	N.W. 1	C. S. 1	
Do	14	5 p. m.	189.61	392	29.142	53	53.8	29.077				51.8	47.5	4.3	N.W. 1	C. S. 1	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 14	Dec. 14	5 p. m.	189.61	977	29.100	53	53.8	29.035	28.967			51.8	47.5	4.3	N.W. 1.	C. S. 1	
Do.	15	7 a. m.	189.61	392	29.100	30	30.5	29.096				30	29	1	N.W. 1	C. S. 5	Sunrise.
Do.	15	7 a. m.	189.61	977	29.060	29.8	30.5	29.057	28.962			30	29	1	N.W. 1	C. S. 5	
Do.	15	8 a. m.	189.61	392	29.102	33	33.5	29.090				33	32	1	N.W. 1	C. S. 5	
Do.	15	8 a. m.	189.61	977	29.076	32.5	33.5	29.065	28.961			33	32	1	N.W.	C. S. 5	
Do.	15	9 a. m.	189.61	392	29.118	42	40.5	29.083				40	38	2	N.W. 1	C. S. 5	
Do.	15	9 a. m.	189.61	977	29.884	40	40.5	29.054	28.952			40	38	2	N.W. 1	C. S. 5	
Do.	15	10 a. m.	189.61	392	29.130	47	46.3	29.082				45	42	3	N.W. 1	C. S. 5	
Do.	15	10 a. m.	189.61	977	29.100	46	46.3	29.055	28.954			45	42	3	N.W. 1	C. S. 5	
Do.	15	11 a. m.	189.61	392	29.138	53	51.3	29 074				49.9	44.7	5.2	N.W. 1	C. S. 5	
Do.	15	11 a. m.	189.61	977	29.102	51.5	51.3	29.043	28.954			49.9	44.7	5.2	N.W. 1	C. S. 5	
Do.	15	12 m	189.61	392	29.129	59.9	58.9	29.048				56	48	8	N.W. 1	C. S. 5	
Do.	15	12 m	189.61	977	29.082	58.5	58.9	29.004	28.944			56	48	8	N.W. 1	C. S. 5	
Do.	15	1 p. m.	189.61	392	29.106	63.5	62.8	29.015				59.4	51	8.4	N.W. 1	C. S. 5	
Do.	15	1 p. m.	189.61	977	29.062	62.8	62.8	28.972	28.934			59.4	51	8.4	N.W. 1	C. S. 5	
Do.	15	2 p. m.	189.61	392	29.099	66	66	29.002				63	52	11	N.W. 1	C. S. 3	
Do.	15	2 p. m.	189.61	977	29.056	66	66	28.959	28.931			63	52	11	N.W. 1	C. S. 3	
Do.	15	3 p. m.	189.61	392	29.096	67.5	67.9	28.995				65	52.5	12.5	E. 1	C. S. 3	
Do.	15	3 p. m.	189.61	977	29.050	67.5	67.9	28.949	28.929			65	52.5	12.5	E. 1	C. S. 3	
Do.	15	4 p. m.	189.61	392	29.070	58	59	28.993				56	50	6	E. 1	C. S. 4	
Do.	15	4 p. m.	189.61	977	29.026	58	59	28.947	28.929			56	50	6	E. 1	C. S. 4	
Do.	15	4.25 p. m.	189.61	392	29.065	54.5	54.8	28.998				53	48	5	E. 1	C. S. 4	
Do.	15	4.25 p. m.	189.61	977	29.018	54.5	54.8	28.951	28.929			53	48	5	E. 1	C. S. 4	
Do.	15	5 p. m.	189.61	392	29.050	48.5	50	28.998				48.7	45	3.7	E. 1	C. S. 4	
Do.	15	5 p. m.	189.61	977	29.006	49	50	28.953	28.931			48.7	45	3.7	E. 1	C. S. 4	
Do.	16	7 a. m.	189.61	392	29.000	29	30.5	28.999				30	28.5	1.5	E. 1	C. S. 2	Sunrise.
Do.	16	7 a. m.	189.61	977	28.964	29.5	30.5	28.962	28.916			30	28.5	1.5	E. 1	C. S. 2	
Do.	16	8 a. m.	189.61	392	29.002	32	32.8	28.993				32	30.8	1.2	E. 1	C. S. 2	
Do.	16	8 a. m.	189.61	977	28.968	33.1	33.8	28.959	28.915			32	30.8	1.2	E. 1	C. S. 2	
Do.	16	9 a. m.	189.61	392	29.039	40	39.5	29.009				38.5	36.5	2	E. 1	C. S. 1	
Do.	16	9 a. m.	189.61	977	28.966	39	39.5	28.969	28.933			38.5	36.5	2	E. 1	C. S. 1	
Do.	16	10 a. m.	189.61	392	29.060	51	50	29.002				48.2	44	4.2	N. 1	C. S. 2	Slight breeze from north.
Do.	16	10 a. m.	189.61	977	29.026	50	50	28.970	28.932			48.2	44	4.2	N. 1	C. S. 2	
Do.	16	11 a. m.	189 61	392	29.060	55	54	28.991				50	46	4	N. 1	C. S. 2	
Do.	16	11 a. m.	189.61	977	29.020	54	54	28.954	28.934			50	46	4	N. 1	C. S. 2	

Do	16	12 m	189.61	392	29.050	61	60.9	28.966	....	....	....	58	49	9	N. 1	C. S. 2	
Do	16	12 m	189.61	977	29.008	61	60.9	28.924	28.933	....	....	58	49	9	N. 1	C. S. 2	
Do	16	1 p. m.	189.61	392	29.030	65.2	64.5	28.935	....	....	....	60	51	9	N. 1	C. S. 2	
Do	16	1 p. m.	189.61	977	28.988	65	64.5	28.893	28.925	....	....	60	51	9	N. 1	C. S. 2	
Do	16	2 p. m.	189.61	392	29.019	69.5	68.5	28.913	....	....	....	63	52	11	N. 1	C. S. 2	Slight breeze from north.
Do	16	2 p. m.	189.61	977	29.980	69	68.5	29.875	28.919	....	....	63	52	11	N. 1	C. S. 2	
Do	16	3 p. m.	189.61	392	29.014	67.5	68	28.913	....	....	....	66	53	13	N. 1	C. S. 2	
Do	16	3 p. m.	189.61	977	29.978	67	68	29.878	28.932	....	....	66	53	13	N. 1	C. S. 2	
Do	16	4 p. m.	189.61	392	29.000	58.5	59.1	28.922	....	....	....	57.5	49.8	7.7	N. 1	C. S. 4	
Do	16	4 p. m.	189.61	977	28.958	58.5	59.1	28.880	28.942	....	....	57.5	49.8	7.7	N. 1	C. S.	
Do	16	4.25 p. m.	189.61	392	28.990	54.5	56	28.923	....	....	....	55.5	47	8.5	N. 1	C. S. 3	Barometer has been falling all day.
Do	16	4.25 p. m.	189.61	977	28.950	55	56	28.881	28.942	....	....	55.5	47	8.5	N. 1	C. S. 3	
Do	16	5 p. m.	189.61	392	28.980	49	50	28.927	....	....	....	50	45	5	N. 1	C. S. 3	
Do	16	5 p. m.	189.61	977	28.938	48.5	50	28.886	28.944	....	....	50	45	5	N. 1	C. S. 3	
Do	17	7.10 a. m.	189.61	392	28.982	27.7	28.5	28.984	....	....	....	28	26	2	N. 1	C. S. 3	
Do	17	7.10 a. m.	189.61	977	28.950	27.7	28.5	28.952	28.932	....	....	28	26	2	N. 1	C. S. 3	
Do	17	8 a. m.	189.61	392	29.000	33.8	34	28.987	....	....	....	33.5	31.5	2	N. 1	C. S. 3	
Do	17	8 a. m.	189.61	977	28.962	33.5	34	28.949	28.927	....	....	33.5	31.5	2	N. 1	C. S. 3	
Do	17	9 a. m.	189.61	392	29.022	40.5	40.8	28.991	....	....	....	40	37	3	N. 1	C. S. 1	
Do	17	9 a. m.	189.61	977	28.990	40	40.8	28.960	28.919	....	....	40	37	3	N. 1	C. S. 1	
Do	17	10 a. m.	189.61	392	29.050	49.5	49	28.996	....	....	....	48	43	5	N. 1	C. S. 1	
Do	17	10 a. m.	189.61	977	29.012	49	49	28.959	28.924	....	....	48	43	5	N. 1	C. S. 1	
Do	17	11 a. m.	189.61	392	29.050	56	55.5	28.979	....	....	....	54.5	47.5	7	N. 1	C. S. 1	
Do	17	11 a. m.	189.61	977	29.012	55	55.5	28.943	28.927	....	....	54.5	47.5	7	N. 1	C. S. 1	
Do	17	12 m	189.61	392	29.070	59	58	28.991	....	....	....	57	51	6	0	C. S. 0	
Do	17	12 m	189.61	977	29.022	57.5	58	28.947	28.927	....	....	57	51	6	0	C. S. 0	
Do	17	1 p. m.	189.61	392	29.040	62	61.3	28.953	....	....	....	60.4	52.5	7.9	0	C. S. 0	
Do	17	1 p. m.	189.61	977	29.000	61.5	61.3	28.914	28.915	....	....	60.4	52.5	7.9	0	C. S. 0	
Do	17	2 p. m.	189.61	392	29.038	64	63	28.946	....	....	....	61.4	53	8.4	N.W. 1	C. S. 0	
Do	17	2 p. m.	189.61	977	28.998	63.5	63	28.907	28.911	....	....	61.4	53	8.4	N.W. 1	C. S. 0	
Do	17	3 p. m.	189.61	392	29.050	60	59.5	28.968	....	....	....	58.5	52	6.5	N.W. 1	C. S. 0	
Do	17	3 p. m.	189.61	977	29.006	59.5	59.5	28.925	28.934	....	....	58.5	52	6.5	N.W. 1	C. S. 0	
Do	17	4 p. m.	189.61	392	29.051	55.5	55.5	28.981	....	....	....	55	50.5	4.5	W. 1	C. S. 0	
Do	17	4 p. m.	189.61	977	29.006	55.5	55.5	28.936	28.947	....	....	55	50.5	4.5	W. 1	C. S. 0	
Do	17	4.25 p. m.	189.61	392	29.049	51.5	52	28.990	....	....	....	51	48	3	W. 5	C. S. 0	
Do	17	4.25 p. m.	189.61	977	29.004	51.3	52	28.945	28.947	....	....	51	48	3	W. 5	C. S. 0	
Do	17	5 p. m.	189.61	392	29.051	49.8	50.2	28.996	....	....	....	50	48.3	1.7	W. 1	C. S. 1	Many clouds rising in the west.
Do	17	5 p. m.	189.61	977	29.008	49.5	50.2	28.954	28.951	....	....	50	48.3	1.7	W. 1	C. S. 1	
Do	18	7.10 a. m.	189.61	392	29.200	39.7	40.5	29.171	....	....	....	40.5	40	0.5	W. 1	Overcast.	A strong appearance of rain; thick fog.
Do	18	7.10 a. m.	189.61	977	29.162	39.7	40.5	29.133	28.988	....	....	40.5	40	0.5	W. 1	Overcast.	
Do	18	8 a. m.	189.61	392	29.210	40	40.5	29.180	....	....	....	40.5	40	0.5	W. 1	Overcast.	
Do	18	8 a. m.	189.61	977	29.180	40	40.5	29.150	28.999	....	....	40.5	40	0.5	W. 1	Overcast.	
Do	18	9 a. m.	189.61	392	29.239	40	40.1	29.209	....	....	....	40.5	40	0.5	W. 1	Overcast.	
Do	18	9 a. m.	189.61	977	29.202	39.8	40.1	29.173	29.005	....	....	40.5	40	0.5	W. 1	Overcast.	
Do	18	10 a. m.	189.61	392	29.249	43	42.7	29.211	....	....	....	42.2	41.8	0.4	W. 1	Overcast.	
Do	18	10 a. m.	189.61	977	29.212	42	42.7	29.177	29.010	....	....	42.2	41.8	0.4	W. 1	Overcast.	
Do	18	11 a. m.	189.61	392	29.239	43.5	42	29.200	....	....	....	42.2	41	1.2	W. 1	Overcast.	
Do	18	11 a. m.	189.61	977	29.202	42	42	29.167	29.009	....	....	42.2	41	1.2	W. 1	Overcast.	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 14	Dec. 18	12 m.	189.61	392	29.235	47	45.3	29.187				45.2	43.8	1.4	W. 1	Clear	
Do	18	12 m.	189.61	977	29.194	45.5	45.3	29.150	29.016			45.2	43.8	1.4	W. 1	Clear	
Do	18	1 p. m.	189.61	392	29.319	55	53.2	29.250				51.2	48	3.2	W. 1	Clear	
Do	18	1 p. m.	189.61	977	29.178	54.5	53.2	29.111	29.002			51.2	48	3.2	W. 1	Clear	
Do	18	2 p. m.	189.61	392	29.210	60.5	59.3	29.127				57	51.5	5.5	W. 1	Clear	
Do	18	2 p. m.	189.61	977	29.172	59.5	59.3	29.092	29.000			57	51.5	5.5	W. 1	Clear	
Do	18	3 p. m.	189.61	392	29.192	65	64.3	29.097				62.5	49	13.5	W. 1	Clear	
Do	18	3 p. m.	189.61	977	29.166	64.5	64.3	29.073	28.979			62.5	49	13.5	W. 1	Clear	
Do	18	4 p. m.	189.61	392	29.192	63	62	29.103				62.3	46.5	15.8	W. 1	Clear	
Do	18	4 p. m.	189.61	977	29.166	64.5	62	29.068	28.984			62.3	46.5	15.8	W. 1	Clear	
Do	18	4.25 p. m.	189.61	392	29.191	59	59.2	29.112				59.2	45.5	13.7	W. 1	Clear	
Do	18	4.25 p. m.	189.61	977	29.168	59.2	59.2	29.089	28.995			59.2	45.5	13.7	W. 1	Clear	
Do	18	5 p. m.	189.61	392	29.191	55	55.1	29.122				55.5	44.5	13.7	W. 1	Clear	
Do	18	5 p. m.	189.61	977	29.166	55	55.1	29.097	29.000			55.5	44.5	13.7	W. 1	Clear	
Do	18	5.50 p. m.	189.61	392	29.180	47.5	50	29.131				48	45	3	W. 1	Clear	
Do	18	5.50 p. m.	189.64	977	29.156	47.5	50	29.107				48	45	3	W. 1	Clear	
Do	18	5.50 p. m.	189.61	978	29.158	49	50	29.105	29.006			48	45	3	W. 1	Clear	
Do	18	6.15 p. m.	189.61	392	29.175	43.5	45	29.139				43.9	40	3.9	W. 1	Clear	
Do	18	6.15 p. m.	189.61	977	29.150	44	45	29.110				43.9	40	3.9	W. 1	Clear	
Do	18	6.15 p. m.	189.61	978	29.154	44	45	29.114	29.005			43.9	40	3.9	W. 1	Clear	
Do	19	7 a. m.	189.61	392	29.165	25	26.4	29.174				27	26	1	W. 1	Clear	
Do	19	7 a. m.	189.61	977	29.130	25.5	26.4	29.138				27	26	1	W. 1	Clear	
Do	19	7 a. m.	189.61	978	29.134	25	26.4	29.143	28.994			27	26	1	W. 1	Clear	
Do	19	8 a. m.	189.61	392	29.170	29.7	29.9	29.167				30	28.5	1.5	W. 1	Clear	
Do	19	8 a. m.	189.61	977	29.136	29	29.9	29.135				30	28.5	1.5	W. 1	Clear	
Do	19	8 a. m.	189.61	978	29.138	29	29.9	29.137	28.987			30	28.5	1.5	W. 1	Clear	
Do	19	9 a. m.	189.61	392	29.219	37.5	37.3	29.196				36	33.4	2.6	W. 1	Clear	
Do	19	9 a. m.	189.61	977	29.172	37	37.3	29.150				36	33.4	2.6	W. 1	Clear	
Do	19	9 a. m.	189.61	978	29.172	37	37.3	29.150	28.996			36	33.4	2.6	W. 1	Clear	
Do	19	10 a. m.	189.61	392	29.222	45	44.5	29.179				43	38	5	W. 1	C. S. 5	Slight breeze from the northwest.
Do	19	10 a. m.	189.61	977	29.180	44.5	44.5	29.138				43	38	5	W. 1	C. S. 5	
Do	19	10 a. m.	189.61	978	29.184	44.5	44.5	29.142	28.985			43	38	5	W. 1	C. S. 5	
Do	19	11 a. m.	189.61	392	29.210	54	53	29.144				51	45	6	W. 1	C. S. 5	
Do	19	11 a. m.	189.61	977	29.176	53	53	29.112				51	45	6	W. 1	C. S. 5	
Do	19	11 a. m.	189.61	978	29.178	53	53	29.114	28.966			51	45	6	W. 1	C. S. 5	

Do		19	12 m	189.61	392	29.193	61.2	61	29.109				57	48	9	W. 1	C. S. 5	
Do		19	12 m	189.61	977	29.158	60.5	61	29.075				57	48	9	W. 1	C. S. 5	
Do		19	12 m	189.61	978	29.160	60.7	61	29.077	28.951			57	48	9	W. 1	C. S. 5	
Do		19	1 p. m	189.61	392	29.190	65.5	65.2	29.094				61.5	48	13.5	W.N.W. 1	C. S. 5	
Do		19	1 p. m	189.61	977	29.150	65.4	65.2	29.054				61.5	48	13.5	W.N.W. 1	C. S. 5	
Do		19	1 p. m	189.61	978	29.156	65.6	65.2	29.060	28.957			61.5	48	13.5	W.N.W. 1	C. S. 5	
Do		19	2 p. m	189.61	392	29.183	67	66.5	29.083				63.8	48.5	15.3	W.N.W. 1	C. S. 5	
Do		19	2 p. m	189.61	977	29.149	66.5	66.5	29.051				63.8	48.5	15.3	W.N.W. 1	C. S. 5	
Do		19	2 p. m	189.61	978	29.154	66.7	66.5	29.055	28.959			63.8	48.5	15.3	W.N.W. 1	C. S. 5	
Do		19	3 p. m	189.61	392	29.179	66.9	66.5	29.079				63.5	48	15.5	W.N.W. 1	C. S. 5	
Do		19	3 p. m	188.61	977	29.140	66.2	66.5	29.042				63.5	48	15.5	W.N.W. 1	C. S. 5	
Do		19	3 p. m	189.61	978	29.146	66.9	66.5	29.046	28.959			63.5	48	15.5	W.N.W. 1	C. S. 5	
Do		19	4 p. m	189.61	392	29.170	63.5	63.9	29.080				62.2	47	15.2	W.N.W. 1	C. S. 1	
Do		19	4 p. m	189.61	977	29.136	63.5	63.9	29.046				62.2	47	15.2	W.N.W. 1	C. S. 1	
Do		19	4 p. m	189.61	978	29.050	64	63.9	29.050	28.964			62.2	47	15.2	W.N.W. 1	C. S. 1	
Do		19	4.25 p. m	189.61	392	29.169	60	61	29.087				60	46	14	W.N.W. 1	C. S. 1	
Do		19	4.25 p. m	189.61	977	29.132	60.2	61	29.050				60	46	14	W.N.W. 1	C. S. 1	
Do		19	4.25 p. m	189.61	978	29.140	61	61	29.056	28.966			60	46	14	W.N.W. 1	C. S. 1	
Do		19	5 p. m	189.61	392	29.142	49	50	29.089				49	43	6	W.N.W. 1	C. S. 1	
Do		19	5 p. m	189.61	977	29.104	49.5	50	29.050				49	43	6	W.N.W. 1	C. S. 1	
Do		19	5 p. m	189.61	978	29.108	50	50	29.052	28.962			49	43	6	W.N.W. 1	C. S. 1	
Do		19	6.30 p. m	189.61	392	29.139	39.5	40.5	29.111				40.5	37	3.5	W.N.W. 1	C. S. 1	
Do		19	6.30 p. m	189.61	977	29.100	40	40.5	29.070				40.5	37	3.5	W.N.W. 1	C. S. 1	
Do		19	6.30 p. m	189.61	978	29.106	40	40.5	29.076	28.978			40.5	37	3.5	W.N.W. 1	C. S. 1	
Do		20	7 a. m	189.61	392	29.120	23.5	25	29.133				24.5	23	1.5	W.N.W. 1	C. S. 2	At 7.45 p. m., Dec. 20, a meteor was seen starting about 15° above the horizon, in the N.E., and passed over the heavens in a S.W. direction, extending to the horizon.
Do		20	7 a. m	189.61	977	29.080	24	25	29.092				24.5	23	1.5	W.N.W. 1	C. S. 2	
Do		20	7 a. m	189.61	978	29.090	24	25	29.102	28.948			24.5	23	1.5	W.N.W. 1	C. S. 2	
Do		20	8 a. m	189.61	392	29.120	25.5	26.2	29.128				26	25.5	0.5	W.N.W. 1	C. S. 2	
Do		20	8 a. m	189.61	977	29.084	25.4	26.2	29.092				26	25.5	0.5	W.N.W. 1	C. S. 2	
Do		20	8 a. m	189.61	978	29.096	25	26.2	29.105	28.949	28.986	978.0	26	25.5	0.5	W.N.W. 1	C. S. 2	
From Camp 14, (San Luis pass,) station 6	Dec.	13	9 a. m		977	29.150	41	41.5	29.101	28.960		991.9						
Station 37		13	10 a. m		977	28.800	50	51	28.831	28.589		1358.8						
43 ft. below summit, station 41		13	10.30 a. m	194.23	977	28.688?	52	52	28.719?	28.472?								
Do		13	11 a. m	194.23	977	28.670	55	56.1	28.701	28.456								
Do		3	11.30 a. m	194.23	977	28.668	57.5	58.9	28.691	28.441								Observations taken in San Luis Pass.
Do		13	12 m	194.23	977	28.654	59	60	28.685	28.442								
Do		13	0.30 p. m	194.23	977	28.650	61.2	62	28.681	28.440								
Do		13	1 p. m	194.23	977	28.650	63	64	28.681	28.446	28.445	1556.5						
Camp No. 14', San José rancho	Dec.	21	7.05 a. m		392	28.640	23.5	23.6	28.627	28.527								
Do		21	8.45 a. m		392	28.662	34.5	35	28.644									
Do		21	8.45 a. m		977	28.629	28	35	28.669	28.531								
Do		21	10 a. m		392	28.694	48	46.7	28.644									
Do		21	10 a. m		977	28.658	46	46.7	28.613	28.504								

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 14′, San José rancho.	Dec. 21	1 p. m.		392	28.662	63	61.5	28.574				60	48	12			Barometers in the sun since 10.30 a. m.
Do.	21	1 p. m.		977	28.622	63	61.5	28.534	28.485			60	48	12			Attached thermometer broken.
Do.	21	2 p. m.		392	28.660	64	63.9	28.570				61.5	49	12.5	W.N.W. 1	C. S. 2	
Do.	21	2 p. m.		977	28.622	64	63.9	28.532	28.491			61.5	49	12.5	W.N.W. 1	C. S. 2	
Do.	21	3 p. m.		392	28.659	64	63.8	28.569				62.1	48	14.1	W.N.W. 1	C. S. 2	
Do.	21	3 p. m.		977	28.620	64	63.8	28.530	28.496			62.1	48	14.1	W.N.W. 1	C. S. 2	
Do.	21	4 p. m.		392	28.652	58	57	28.577				57.5	44	13.5	E. 1	Cirrus 2	
Do.	21	4 p. m.		977	28.618	58	57	28.543	28.509			57.5	44	13.5	E. 1	Cirrus 2	
Do.	21	5 p. m.		392	28.640	48	48	28.590				47.5	40	7.5	E. 1	C. S. 2	
Do.	21	5 p. m.		977	28.600	48	48	28.550	28.511			47.5	40	7.5	E. 1	C. S. 2	
Do.	21	6 p. m.		392	28.642	43	43.2	28.605				43	38	5	E. 1	C. S. 2	
Do.	21	6 p. m.		977	28.604	43	43.2	28.567	28.529			43	38	5	E. 1	C. S. 2	
Do.	21	7 p. m.		392	28.630	39.5	40	28.587				40	37	3	E. 1	C. S. 2	
Do.	21	7 p. m.		977	28.580	39.5	40	28.537	28.491			40	37	3	E. 1	C. S. 2	
Do.	21	8 p. m.		392	28.601	30	32.5	28.597				31	26	5	E. 1	C. S. 2	
Do.	21	8 p. m.		977	28.564	30	32.5	28.560	28.494			31	26	5	E. 1	C. S. 2	
Do.	21	9 p. m.		392	28.620	28	29.5	28.621				28	24.5	3.5	E. 1	C. S. 2	
Do.	21	9 p. m.		977	28.580	28	29.5	28.581	28.506			28	24.5	3.5	E. 1	C. S. 2	
Do.	21	10 p. m.		392	28.630	27.5	29	28.632				28	24.5	3.5	E. 1	C. S. 2	
Do.	21	10 p. m.		977	28.588	27.5	29	28.590	28.509			28	24.5	3.5	E. 1	C. S. 2	
Do.	21	11 p. m.		392	22.610	25	26.5	28.619				25	23	2	E. 1	C. S. 2	
Do.	21	11 p. m.		977	28.568	25	26.5	28.577				25	23	2	E. 1	C. S. 2	
Do.	21	12 p. m.		392	28.609	23.5	25	28.622				24.5	27	7.5			
Do.	21	12 p. m.		977	28.568	23.5	25	28.581	28.528			24.5	27	7.5			
Do.	22	1 a. m.		392	28.600	22.5	24.5	28.616				24.5	24	0.5			
Do.	22	1 a. m.		977	28.556	22.5	24.5	28.572	28.531			24.5	24	0.5			
Do.	22	2 a. m.		392	28.609	22.5	24.4	28.625				24	22.5	1.5			
Do.	22	2 a. m.		977	28.568	22.5	24.4	28.584	28.542			24	22.5	1.5			
Do.	22	3 a. m.		392	28.610	22	23	28.627				22	20.5	1.5	S. 1		
Do.	22	3 a. m.		977	28.562	22	23	28.579	28.539			22	20.5	1.5	S. 1		
Do.	22	4 a. m.		392	28.600	23	24	28.614				23	21.5	1.5	S. 1		
Do.	22	4 a. m.		977	28.548	23	24	28.562	28.508			23	21.5	1.5	S. 1		
Do.	22	5 a. m.		392	28.602	25	26	28.611				25	23	2	S. 1		
Do.	22	5 a. m.		977	28.556	25	26	28.565	28.506			25	23	2	S. 1		
Do.	22	6 a. m.		392	28.610	25	25.5	28.619				24	23	1	S. 1		

Do	22	6 a. m		977	28.562	25	25.5	28.571	28.534			24	23	1	S. 1		
Do	22	7 a. m		392	28.626	28.5	30	28.626				29.5	27	2.5	N.E. 1		
Do	22	7 a. m		977	28.578	28.5	30	28.578	28.508			29.5	27	2.5	N.E. 1		
Do	22	8 a. m		392	28.669	47	48	28.622				45.6	36	9.6	E. 1		
Do	22	8 a. m		977	28.636	47	48	28.589	28.509			45.6	36	9.6	E. 1		
Do	22	9 a. m		392	28.700	55	54.2	28.632				54	42	12	E. 1		
Do	22	9 a. m		977	28.658	55	54.2	28.590	28.525			54	42	12	E. 1		
Do	22	10 a. m		392	28.710	58.5	58	28.634				58	44	14	E. 2		
Do	22	10 a. m		977	28.674	58.5	58	28.598	28.522			58	44	14	E. 2		
Do	22	11 a. m		392	28.710	60.5	60	28.629				60.5	46	14.5	E. 2		¶Wind increasing.
Do	22	11 a. m		977	28.674	60.5	60	28.593	28.522			60.5	46	14.5	E. 2		
Do	22	12 m		392	28.700	63.5	62.8	28.611				62.5	47.2	15.3	E. 2		
Do	22	12 m		977	28.650	63.5	62.8	28.561	28.514			62.5	47.2	15.3	E. 2		
Do	22	1 p. m		392	28.680	69.5	63.8	28.576				63.2	48	15.2	E. 1	C. S. 1	
Do	22	1 p. m		977	28.642	69.5	63.8	28.538	28.508			63.2	48	15.2	E. 1	C. S. 1	
Do	22	2 p. m		392	28.672	65	64.5	28.579				64	48.5	15.5	E. 2	C. S. 1	
Do	22	2 p. m		977	28.630	65	64.5	28.537	28.513			64	48.5	15.5	E. 2	C. S. 1	
Do	22	3 p. m		392	28.670	64.5	64	28.579				64	50	14	E. 1	C. S. 2	
Do	22	3 p. m		977	28.630	64.5	64	28.539	28.516			64	50	14	E. 1	C. S. 2	
Do	22	4 p. m		392	28.669	61.8	61.5	28.583				61	49	12	E. 1	C. S. 2	
Do	22	4 p. m		977	28.628	61.8	61.5	28.542	28.521			61	49	12	E. 1	C. S. 2	
Do	22	4.35 p. m		392	28.664	58	58	28.589				58	47.6	11.6	E. 1	C. S. 5	
Do	22	4.35 p. m		977	28.620	58	58	28.545	28.525			58	47.6	11.6	E. 1	C. S. 5	
Do	22	5 p. m		392	28.669	57	57.5	28.596				57.5	47	10.5	E. 1	C. S. 2	
Do	22	5 p. m		977	28.624	57	57.5	28.551	28.514			57.5	47	10.5	E. 1	C. S. 2	
Do	23	7 a. m		392	28.700	30	31.2	28.696				31.9	32	0.1	E. 1	C. S. 2	
Do	23	7 a. m		977	28.664	30	31.2	28.660	28.554			31.9	32	0.1	E. 1	C. S. 2	
Do	23	8 a. m		392	28.720	36.5	36.5	28.700				36	35	1	E. 1	C. S. 2	
Do	23	8 a. m		977	28.688	36.5	36.5	28.668	28.558			36	35	1	E. 1	C. S. 2	
Do	23	9 a. m		392	28.750	45.5	45	28.707				45	41.5	3.5	E. 1	C. S. 2	
Do	23	9 a. m		977	28.720	45.5	45	28.677	28.546			45	41.5	3.5	E. 1	C. S. 2	
Do	23	10 a. m		392	28.760	55	56	28.692				53	44	9	E. 1	C. S. 2	
Do	23	10 a. m		977	28.728	55	56	28.660	28.532			53	44	9	E. 1	C. S. 2	
Do	23	11 a. m		392	28.769	61	62	28.686				59	49.5	19.5	E. 1	C. S. 2	
Do	23	11 a. m		977	28.734	61	62	28.651	28.535			59	49.5	19.5	E. 1	C. S. 2	
Do	23	12 m		392	28.760	68.5	68.4	28.658				64	52.5	11.5	E. 1	C. S. 2	
Do	23	12 m		977	28.724	68.5	68.4	28.622	28.528			64	52.5	11.5	E. 1	C. S. 2	
Do	23	1 p. m		392	28.745	72	71.3	28.634				70	53	17	E. 1	C. S. 2	
Do	23	1 p. m		977	28.714	72	71.3	28.603	28.530			70	53	17	E. 1	C. S. 2	
Do	23	2 p. m		392	28.745	72.5	72.5	28.633				70	55	15	E. 1	C. S. 2	
Do	23	2 p. m		977	28.708	72.5	72.5	28.596	28.535			70	55	15	E. 1	C. S. 2	
Do	23	3 p. m		392	28.757	70.5	71.5	28.650				68.3	55	13.3	E. 1	C. S. 2	
Do	23	3 p. m		977	28.712	70.5	71.5	28.605	28.561			68.3	55	13.3	E 1	C. S. 2	
Do	23	4.10 p. m		392	28.740	62.5	64	28.654				60	58	2	E. 1	C. S. S.	
Do	23	4.10 p. m		977	28.708	62	64	28.622	28.566			60	58	2	E. 1	C. S. 2	
Do	23	4.35 p. m		392	28.740	58.5	59.5	28.664				57.5	51	6.5	E. 1	C. S. 2	
Do	23	4.35 p. m		977	28.704	58.5	59.5	28.628	28.576			57.5	51	6.5	E. 1	C. S. 2	
Do	23	5 p. m		392	28.730	55	55.5	28.662				54	47.5	6.5	E. 1	C. S. 2	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 14′	Dec. 23	5 p. m.		977	28.694	55	55.5	28.626	28.575			54	47.5	6.5	E. 1	C. S. 2	
Do	24	7 a. m.		392	28.744	28.7	29	28.744				29	29		E. 1	C. S. 2	
Do	24	7 a. m.		977	28.708	28.7	29	28.708	28.572			29	29		E. 1	C. S. 2	
Do	24	8 a. m.		392	28.750	34.5	34.9	28.735				34.5	33	1.5	E. 1	C. S. 2	
Do	24	8 a. m.		977	28.710	34.5	34.9	28.695	28.559			34.5	33	1.5	E. 1	C. S. 2	
Do	24	9.30 a. m.		392	28.790	49	48.2	28.738				47	42	5	E. 1	C. S. 2	
Do	24	9.30 a. m.		977	28.758	49	48.2	28.706	28.547			47	42	5	E. 1	C. S. 2	
Do	24	10 a. m.		392	28.800	55	54	28.732				51.3	45	6.3	E. 1	C. S. 2	
Do	24	10 a. m.		977	28.762	55	54	28.694	28.539			51.3	45	6.3	E. 1	C. S. 2	
Do	24	12 m.		392	28.799	67.5	66.4	28.700				62	51	11	E. 1	C. S. 2	
Do	24	12 m.		977	28.758	67.5	66.4	28.659	28.547			62	51	11	E. 1	C. S. 2	
Do	24	1 p. m.		392	28.780	71.5	69.8	28.670				67	53	14	E. 1	C. S. 2	
Do	24	1 p. m.		977	28.736	71.5	69.8	28.626	28.548			67	53	14	E. 1	C. S. 2	
Do	24	2 p. m.		392	28.780	73	72	28.667				71	54.5	16.5	E. 1	C. S. 2	
Do	24	2 p. m.		977	28.736	73	72	28.623	28.545			71	54.5	16.5	E. 1	C. S. 2	
Do	24	3 p. m.		392	28.780	71	70.8	28.672				68.5	53.5	15.0	E. 1	Cirrus 2	
Do	24	3 p. m.		977	28.736	71	70.8	28.628	28.557			68.5	53.5	15.0	E. 1	Cirrus 2	
Do	24	4 p. m.		392	28.760	67	67	28.662				64	53.5	10.5	E. 1	Cirrus 2	
Do	24	4 p. m.		977	28.724	67	67	28.626	28.553			64	53.5	10.5	E. 1	Cirrus 2	
Do	24	4.35 p. m.		392	28.745	59.5	60	28.666				58	50	8	E. 1	Cirrus 1	
Do	24	4.35 p. m.		977	28.706	59.5	60	28.627	28.551			58	50	8	E. 1	Cirrus 1	
Do	24	5 p. m.		392	28.740	55	55.5	28.672				55	48	7	E. 1	Cirrus 1	
Do	24	5 p. m.		977	28.700	55	55.5	28.632	28.553			55	48	7	E. 1	Cirrus 1	
Do	25	7 a. m.		392	28.720	29	29.8	28.719				30.5	30.2	0.3	E. 1	C. S. 1	
Do	25	7 a. m.		977	28.684	29	29.8	28.683	28.587			30.5	30.2	0.3	E. 1	C. S. 1	
Do	25	8 a. m.		392	28.740	34.5	34.5	28.725				34	33.4	0.6	E. 1	C. S. 1	
Do	25	8 a. m.		977	28.700	34.5	34.5	28.685	28.589			34	33.4	0.6	E. 1	C. S. 1	
Do	25	9 a. m.		392	28.765	41	40.5	28.733				40.5	38	2.5	E. 1	C. S. 1	
Do	25	9 a. m.		977	28.728	41	40.5	28.696	28.589			40.5	38	2.5	E. 1	C. S. 1	
Do	25	10 a. m.		392	28.790	52	50	28.727				50	44.5	5.5	E. 1	C. S. 1	
Do	25	10 a. m.		977	28.756	52	50	28.693	28.586			50	44.5	5.5	E. 1	C. S. 1	
Do	25	11 a. m.		392	28.800	59	59.3	28.722				57	49.2	7.8	E. 1	Cirrus 2	
Do	25	11 a. m.		977	28.768	59	59.3	28.690	28.588			57	49.2	7.8	E. 1	Cirrus 2	
Do	25	12 m		392	28.782	63.5	63.8	28.693				62	52	10	N. W.	Cirrus 2	Slight breeze from N.W.
Do	25	12 m		977	28.750	63.5	63.8	28.661	28.575			62	52	10	N. W.	Cirrus 2	

Do.	25	1 p. m.		392	28.765	66	66	28 669				64	52.5	11.5	N.W.	Cirrus, 2	
Do.	25	1 p. m.		977	28.726	66	66	28.630	28.570			64	52.5	11.5	N.W.	Cirrus, 2	
Do.	25	2 p. m.		392	28.760	67.1	67	28.662				66	53.2	12.8	N.W.	Cirrus, 2	
Do.	25	2 p. m.		977	28.722	67.1	67	28.624	28.568			66	53.2	12.8	N.W.	Cirrus, 2	
Do.	25	3 p. m.		392	28.742	65.5	66	28.648				65	52.5	12.5	N W. 5.	C. C. S. 1	
Do.	25	3 p. m.		977	28.700	65.5	66	28.606	28.554			65	52.5	12.5	N.W. 5.	C. C. S. 1	
Do.	25	4 p. m.		392	28.730	63.5	63.5	28.641				62.8	52 3	10.5	N.W. 5.	C. C. S. 1	
Do.	25	4 p. m.		977	28.690	63 5	63.5	28.601	28.550			62.8	52.3	10.5	N.W. 5.	C. C. S. 1	
Do.	25	4.35 p. m.		392	28.729	60	60.5	28.649				58	51	7	N.W. 5.	C. C. S. 1	
Do.	25	4.35 p. m.		977	28.688	60	60.5	28.608	28.554			58	51	7	N.W. 5.	C. C. S. 1	
Do.	25	5 p. m.		392	28.720	55	55.6	28.652				54	48.5	5.5	N.W. 5.	C. C. S. 1	
Do.	25	5 p. m.		977	28.676	55	55.6	28.608	28.551			54	48.5	5 5	N.W. 5.	C. C. S. 1	
Do.	26	7.25 a. m.		392	28.700	34	34	28.686				34	33.9	0.1	N.W. 5.	C. C. S. 1	Overcast. A dense fog.
Do.	26	7.25 a. m.		977	28.656	34	34	28.642	28.519			34	33.9	0.1	N.W. 5.	C. C. S. 1	Do. do.
Do.	26	8 a. m.		392	28 700	35	35	28 683				35	34	1	N.W. 5.	C. C. S. 1	Do. do.
Do.	26	8 a. m.		977	28.660	35	35	28.643	28.517			35	34	1	N.W. 5.	C. C. S. 1	Do. do.
Do.	26	9 a. m.		392	28.732	42	42.2	28.698				42	40.2	1.8	N.W. 5.	C. C. S. 1	Do. do.
Do.	26	9 a. m.		977	28.690	42	42.2	28.656	28.521			42	40.2	1.8		Overcast	A dense f og.
Do.	26	10 a. m.		392	28.740	47	46.9	28.693				46.5	43.5	3		Overcast; C. S.	Fog disappeared.
Do.	26	10 a. m.		977	28.708	47	46.9	28.661	28.523			46.5	43.5	3		Overcast; C. S.	
Do.	26	11 a. m.		392	28.730	49	48.2	28.678				47.5	45	2.5	N.W. 5.	Overcast; C. S.	
Do.	26	11 a. m.		977	28.696	49	48.2	28.644	28.517			47.5	45	2.5	N.W. 5.	Overcast; C. S.	
Do.	26	12 m.		392	28 720	50	49.5	28.664				48.5	46	2.5	N.W. 5.	Overcast; C. S.	
Do.	26	12 m.		977	28.680	50	49.5	28.644	28.522			48 5	46	2.5	N.W. 5	Overcast; C. S.	
Do.	26	1 p. m.		392	28.710	50	49.8	28.654				49	46	3	N.W 5.	Overcast; C. S	
Do.	26	1 p. m.		977	28.666	50	49.8	28.610	28.533			49	46	3	N.W. 5.	Overcast; C. S.	
Do.	26	2 p. m.		392	28.709	50	50	28 653				49	46	3	N.W. 5.	Overcast; C. S.	
Do.	26	2 p. m.		977	28.660	50	50	28.604	28.533			49	46	3	N.W. 5.	Overcast; C. S.	
Do.	26	3 p. m.		392	28.711	50	50.2	28.655				49.6	46	3.6	N.W. 5.	Overcast; cum.	
Do.	26	3 p. m.		977	28.670	50	50.2	28 614				49.6	46	3.6	N.W. 5.	Overcast; cum.	
Do.	26	3 p. m.		978	28 676	50	50.2	28.620	28.541			49.6	46	3.6	N.W. 5.	Overcast; cum.	
Do.	26	4 p. m.		392	28.711	50.5	50.5	28.655				49.8	45.6	4.2	N.W. 5.	C. S. C. cir. 9.	
Do.	26	4 p. m.		977	28.676	50.5	50.5	28.620				49 8	45 6	4.2	N W. 5.	C. S. C. cir. 9.	
Do.	26	4 p. m.		978	28.682	50.5	50.5	28.626	28.547			49.8	45.6	4.2	N.W. 5.	C. S. C. cir. 9.	
Do.	26	4.15 p. m.		392	28.720	49	49	28 668				48 8	45	3.8	E. 5	C. S. C. cir. 8.	
Do.	26	4.15 p. m.		977	28 686	49	49	28.634				48.8	45	3.8	E. 5	C. S. C. cir. 8.	
Do.	26	4 15 p. m.		978	28.690	49	49	28.638	28.562			48.8	45	3.8	E. 5	C. S. C. cir. 8.	
Do.	26	5 p. m.		392	28.719	47	47.5	28.672				47	44	3	E. 5	. S. C. cir. 7.	
Do.	26	5 p. m.		977	28.682	47	47.5	28.635				47	44	3	E. 5	C. S. C cir. 7.	
Do.	26	5 p. m.		978	28.690	47	47.5	28.643	28.554			47	44	3	E. 5	C. S. C. cir. 7.	
Do.	27	7 a. m.		392	28.820	41	41.2	28.7e7				41 4	40	1.4	E. 1	Cum. 1	Wind sprung up about midnight.
Do.	27	7 a. m.		977	28.792	41	41 2	28.759				41.4	40	1.4	E. 1	Cum. 1	
Do.	27	7 a. m.		978	28.800	41.2	41.2	28.767	28 579			41.4	40	1.4	E. 1	Cum. 1	
Do.	27	8 a. m.		392	28.855	43.7	44.5	28.796				44	40	4	S.E. 2	Cum. 1	
Do.	27	8 a. m.		977	28.800	43.7	44.5	28 761				44	40	4	S.E. 2	Cum. 1	
Do.	27	8 a. m.		978	28.808	44	44.5	28.768	28.577			44	40	4	S E. 2	Cum. 1	
Do.	27	9 a. m.		392	28.852	47	46.8	28.804				46.5	41	5.5	S.E. 2	Cum. 1	
Do.	27	9 a. m.		977	28.820	47	46.8	28.772				46.5	41	5.5	S.E. 2	Cum. 1	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		*Miles.*		*Inches.*	°	°	*Inches.*	*Inches.*	*Inches.*	*Feet.*	°	°	°			
Camp No. 14′	Dec. 27	9 a. m.		978	28.828	47	46.8	28.780	28.572			46.5	41	5.5	S.E. 2	Cum. 1	
Do.	27	10 a. m.		392	28.862	49.5	49	28.808				48.5	42.1	6.4	S.E. 2	Cum. 1	
Do.	27	10 a. m.		977	28.832	49.5	49	28.778				48.5	42.1	6.4	S.E. 2	Cum. 1	
Do.	27	10 a. m.		978	28.840	49.5	49	28.786	28.579			48.5	42.1	6.4	S.E. 2	Cum. 1	
Do.	27	11 a. m.		392	28.869	50.5	50.5	28.813				49.8	42.1	7.7	N.E. 4	Cum. 1	
Do.	27	11 a. m.		977	28.838	50.5	50.5	28.782				49.8	42.1	7.7	N.E. 4	Cum. 1	
Do.	27	11 a. m.		978	28.840	50.5	50.5	28.784	28.583			49.8	42.1	7.7	N.E. 4	Cum. 1	
Do.	27	12 m.		392	28.860	52	51.8	28.800				51	43.5	7.5	E. 4	Cum. 1	
Do.	27	12 m.		977	28.828	52	51.8	28.768				51	43.5	7.5	E. 4	Cum. 1	
Do.	27	12 m.		978	28.834	52	51.8	28.774	28.592			51	43.5	7.5	E. 4	Cum. 1	
Do.	27	1 p. m.		392	28.829	52	51.8	28.769				51	43	8	E. 5	Cum. 1	
Do.	27	1 p. m.		977	28.800	52	51.8	28.740				51	43	8	E. 5	Cum. 1	
Do.	27	1 p. m.		978	28.808	51.8	51.8	28.748	28.586			51	43	8	E. 5	Cum. 1	
Do.	27	2 p. m.		392	28.829	52	51.8	28.769				51	43.5	7.5	E. 5	Cum. 1	
Do.	27	2 p. m.		977	28.800	52	51.8	28.740				51	43.5	7.5	E. 5	Cum. 1	
Do.	27	2 p. m.		978	28.808	51.8	51.8	28.748	28.579			51	43.5	7.5	E. 5	Cum. 1	
Do.	27	3 p. m.		392	28.830	50.9	50.8	28.774				50	43	7	E. 45	Cum. 1	
Do.	27	3 p. m.		977	28.808	50.9	50.8	28.742				50	43	7	E. 45	Cum. 1	
Do.	27	3 p. m.		978	28.810	50.9	50.8	28.754	28.585			50	43	7	E. 45	Cum. 1	
Do.	27	4 p. m.		392	28.840	50	49.2	28.785				48.2	42	6.2	E. 2	Cum. 1	
Do.	27	4 p. m.		977	28.810	50	49.2	28.755				48.2	42	6.2	E. 2	Cum. 1	
Do.	27	4 p. m.		978	28.818	50	49.2	28.763	28.599			48.2	42	6.2	E. 2	Cum. 1	
Do.	27	5 p. m.		392	28.823	45	46	28.786				45	40	5	E. 2	Cum. 1	
Do.	27	5 p. m.		977	28.800	45	46	28.758				45	40	5	E. 2	Cum. 1	
Do.	27	5 p. m.		978	28.806	45	46	28.754	28.593			45	40	5	E. 2	Cum. 1	
Do.	28	7 a. m.		392	28.836	23	24.6	28.850				24.5	26	8.5	E. 2	Cum. 1	
Do.	28	7 a. m.		977	28.806	23	24.6	28.820				24.5	26	8.5	E. 2	Cum. 1	
Do.	28	7 a. m.		978	28.810	22.5	24.6	28.823	28.566			24.5	26	8.5	E. 2	Cum. 1	
Do.	28	8 a. m.		392	28.860	30	30	28.856				30	29	11	E. 2	Cum. 1	
Do.	28	8 a. m.		977	28.832	30	30	28.828				30	29	11	E. 2	Cum. 1	
Do.	28	8 a. m.		978	28.830	28.3	30	28.830	28.586			30	29	11	E. 2	Cum. 1	
Do.	28	9 a. m.		392	28.875	34	34	28.861				34	31	3	E. 2	Cum. 1	
Do.	28	9 a. m.		977	28.846	34	34	28.832				34	31	3	E. 2	Cum. 1	
Do.	28	9 a. m.		978	28.850	33	34	28.838	29.579			34	31	3	E. 2	Cum. 1	
Do.	28	10 a. m.		392	28.890	42.9	42.3	28.854				41	36.5	4.5	E. 2	Cum. 1	

Do	28	10 a. m		977	28.870	42.9	42.3	28.834				41	38.5	4.5	E. 2	Cum. 1
Do	28	10 a. m		978	28.868	42.5	42.3	28.833	28.580			41	36.5	4.5	E. 2	Cum. 1
Do	28	2 p. m		392	28.840	63.2	63	28.752				61	49	22	E. 2	Cum. 1
Do	28	2 p. m		977	28.804	63.2	63	28.716				61	49	22	E. 2	Cum. 1
Do	28	2 p. m		978	28.816	64.2	63	28.726	28.547			61	49	22	E. 2	Cum. 1
Do	28	3 p. m		392	28.829	61.2	62	28.744				59.5	49	10.5	E. 2	Cum. 1
Do	28	3 p. m		977	28.792	61.2	62	28.707				59.5	49	10.5	E. 2	Cum. 1
Do	28	3 p. m		978	28.800	64	62	28.708	28.543			59.5	49	10.5	E. 2	Cum. 1
Do	28	4 p. m		392	28.828	59	60	28.749				57	48	9	E. 2	Cum. 1
Do	28	4 p. m		977	28.792			28.713				57	48	9	E. 2	Cum. 1
Do	28	4 p. m		978	28.800	61.5		28.715	28.551			57	48	9	E. 2	Cum. 1
Do	28	4.25 p. m		392	28.810	50	51.5	28.754				49.9	44.5	5.4	E. 2	Cum. 1
Do	28	4.25 p. m		977	28.772	50	51.5	28.716				49.9	44.5	5.4	E. 2	Cum. 1
Do	28	4.25 p. m		978	28.784	52	51.5	28.723	28.552			49.9	44.5	5.4	E. 2	Cum. 1
Do	28	5 p. m		392	28.801	46.5	47	28.755				46	42	4	E. 2	Cum. 1
Do	28	5 p. m		977	28.760	46.5	47	28.714				46	42	4	E. 2	C. S. 3
Do	28	5 p. m		978	28.774	46.5	47	28.728	28.549			46	42	4	E. 2	C. S. 3
Do	29	7 a. m		392	28.720	19	20	28.744				20	21	1	E. 2	C. S. 4
Do	29	7 a. m		977	28.670	19	20	28.694				20	21	1	E. 2	C. S. 3
Do	29	7 a. m		978	28.688	17	20	28.718	28.505			20	21	1	E. 2	C. S. 3
Do	29	8 a. m		392	28.740	24.5	24.5	28.751				23.5	24	1.5	E. 2	C. S. 3
Do	29	8 a. m		977	28.700	24.5	24.5	28.711				23.5	24	1.5	E. 2	C. S. 4
Do	29	8 a. m		978	28.718	22.8	24.5	28.733	28.525			23.5	24	1.5	E. 2	C. S. 4
Do	29	9 a. m		392	28.750	34	33.8	28.736				32.6	30	2.6	E. 2	C. S. 4
Do	29	9 a. m		977	28.710	34	33.8	28.696				32.6	30	2.6	E. 2	C. S. 4
Do	29	9 a. m		978	28.720	33.5	33.8	28.707	28.510			32.6	30	2.6	E. 2	C. S. 4
Do	29	10 a. m		392	28.763	43.7	43.5	28.724				42	34	8	E. 2	C. S. 4
Do	29	10 a. m		977	28.730	43.7	43.5	28.691				42	34	8	E. 2	C. S. 4
Do	29	10 a. m		978	28.740	41.5	43.5	28.697	28.513			42	34	8	E. 2	C. S. 4
Do	29	11 a. m		392	28.759	53.5	53.1	28.694				48.4	39	9.4	E. 2	C. C. S. 8
Do	29	11 a. m		977	28.724	53.5	53.1	28.659				48.4	39	9.4	E. 2	C. C. S. 8
Do	29	11 a. m		978	28.734	55	53.1	28.665	28.492			48.4	39	9.4	E. 2	C. C. S. 8
Do	29	12 m		392	28.755	62	61.2	28.668				57.7	43.2	14.5	E. 2	C. C. S. 7
Do	29	12 m		977	28.720	62	61.2	28.633				57.7	43.2	14.5	E. 2	C. C. S. 7
Do	29	12 m		978	28.726	64.5	61.2	25.636	28.499			57.7	43.2	14.5	E. 2	C. C. S. 7
Do	29	1 p. m		392	28.750	67.5	67	28.649				64	47.2	16.8	E. 2	C. C. S. 6
Do	29	1 p. m		977	28.710	67.5	67	28.609				64	47.2	16.8	E. 2	C. C. S. 6
Do	29	1 p. m		978	28.712	63.5	67	28.608	28.505			64	47.2	16.8	E. 2	C. C. S. 6
Do	29	2 p. m		392	28.739	69	68.9	28.635				66	47	19	E. 2	C. C. S. 6
Do	29	2 p. m		977	28.694	69	68.9	28.590				66	47	19	E. 2	C. C. S. 6
Do	29	2 p. m		978	28.700	70	68.9	28.594	28.502			66	47	19	E. 2	C. C. S. 6
Do	29	3 p. m		392	28.730	67	67.8	28.630				65	46.5	18.5	E. 2	C. C. S. 3
Do	29	3 p. m		977	28.784	67	67.8	28.684				65	46.5	18.5	E. 2	C. C. S. 3
Do	29	3 p. m		978	28.790	69	67.8	28.685	28.564			65	46.5	18.5	E. 2	C. C. S. 3
Do	29	4 p. m		392	28.720	62	63	28.633				60	47	13	E. 2	C. C. S. 3
Do	29	4 p. m		977	28.777	62	63	28.690				60	47	13	E. 2	C. C. S. 3
Do	29	4 p. m		978	28.692	63.5	63	28.602	28.565			60	47	13	E. 2	C. C. S. 3
Do	29	4.35 p. m		392	28.705	51.5	52.5	28.646				50	42	8	E. 2	C. C. S. 3

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 14′	Dec. 29	4.35 p. m.		977	28.656	51.5	52.5	28.597				50	42	8	E. 2	C. C. S. 3	
Do.	29	4.35 p. m.		978	28.670	52	52.5	28.609	28.597			50	42	8	E. 2	C. C. S. 3	
Do.	29	5 p. m.		392	28.700	46.5	47.4	28.654				46	40	6	E. 2	C. C. S. 3	
Do.	29	5 p. m.		977	28.650	46.5	47.4	28.604				46	40	6	E. 2	C. C. S. 3	
Do.	29	5 p. m.		978	28.660	46.5	47.4	28.614	28.541			46	40	6	E. 2	C. C. S. 3	
Do.	30	7 a. m.		392	28.639	25.5	27.1	28.646				27	26	1	E. 2	C. C. S. 7	
Do.	30	7 a. m.		977	28.590	25.5	27.1	28.597				27	26	1	E. 2	C. C. S. 7	
Do.	30	7 a. m.		978	28.604	26.5	27.1	28.607	28.539			27	26	1	E. 2	C. C. S. 7	
Do.	30	8 a. m.		392	28.640	28.5	29.8	28.640				29	27.5	1.5	E. 2	C. C. S. 3	
Do.	30	8 a. m.		977	28.600	28.5	29.8	28.600				29	27.5	1.5	E. 2	C. C. S. 3	
Do.	30	8 a. m.		978	28.610	28	29.8	28.611	28.539			29	27.5	1.5	E. 2	C. C. S. 3	
Do.	30	9 a. m.		392	28.659	38	37.8	28.634				36.5	31	5.5	E. 2	C. C. S. 5	
Do.	30	9 a. m.		977	28.624	38	37.8	28.599	28.530			36.5	31	5.5	E. 2	C. C. S. 5	
Do.	30	12 m.		392	28.682	64	64.6	28.592				61	45.5	15.5	W. 5	C. C. S. 5	
Do.	30	12 m.		977	28.646	64	64.6	28.556	28.522			61	45.5	15.5	W. 5	C. C. S. 5	
Do.	30	1 p. m.		392	28.680	64	64.5	28.590				62	45.5	16.5	W. 5	C. C. S. 5	
Do.	30	1 p. m.		977	28.646	64	64.5	28.556	28.544			62	45.5	16.5	W. 5	C. C. S. 5	
Do.	30	2 p. m.		392	28.680	62.5	63	28.596				60	47	13	W. 5	C. C. S. 5	
Do.	30	2 p. m.		977	28.646	62.5	63	28.562	28.559			60	47	13	W. 5	C. C. S. 5	
Do.	30	3 p. m.		392	28.670	60	60.5	28.590				58.2	47	11.2	W. 5	Cirrus, 1	
Do.	30	3 p. m.		977	28.638	60	60.5	28.558	28.561			58.2	47	11.2	W. 5	Cirrus, 1.	
Do.	30	4 p. m.		392	28.660	54	54.2	28.595				52.2	44.5	7.7	W. 5	Cirrus, 7.	
Do.	30	4 p. m.		977	28.620	54	54.2	28.555	28.554			52.2	44.5	7.7	W. 5	Cirrus, 7	
Do.	30	4.35 p. m.		392	28.649	50	51	28.594				49	43.5	5.5	W. 5	Cirrus, 5	
Do.	30	4.35 p. m.		977	28.610	50	51	28.555				49	43.5	5.5	W. 5	Cirrus, 5	
Do.	30	4.35 p. m.		392	28.640	47.5	48	28.592	28.548			46.5	42.5	4	W. 5	C. C. S. 3	
Do.	30	5 p. m.		977	28.600	47.5	48	28.552	28.533			46.5	42.5	4	W. 5	C. & C. S. 3	
Do.	31	7 a. m.		392	28.673	41.5	42	28.640				41.5	39.5	2	W. 5	C. S. & cum. 9	
Do.	31	7 a. m.		977	28.636	41.5	42	28.603	28.537			41.5	39.5	2	W. 5	C. S. & cum. 9	
Do.	31	8 a. m.		392	28.669	43	43.5	28.632				42.6	40.9	1.7	W. 5	C. S. & cum. 8	
Do.	31	8 a. m.		977	28.630	43	43.5	28.593	28.536			42.6	40.9	1.7	W. 5	C. S. & cum. 8	
Do.	31	1 p. m.		392	28.639	58.5	57.5	28.563				57.5	52.4	5.1	W. 5	Overcast, cum. and C. S.	Great appearance of rain.
Do.	31	1 p. m.		977	28.600	58.5	57.5	28.524	28.554			57.5	52.4	5.1	W. 5	do.	

Do.		31	2 p. m.		392	28.640	58	57.3	28.565				56.5	52	4.5	W. 1	Overcast, cum. and nimbus.	Slight sprinkling at 1h. 25m. Not used.
Do.		31	2 p. m.		977	28.639	58	57.3	28.564	28.584			56.5	52	4.5	W. 1	......do......	
Do.		31	3 p. m.		392	28.642	54.5	54.2	28.576				53.8	51	2.8	W. 1	Overcast	Commenced raining at 2h. 15m.; raining.
Do.		31	3 p. m.		977	28.606	54.5	54.2	28.540	28.625			53.8	51	2.8	W. 1	Overcast	
Do.		31	4 p. m.		392	28.610	53.2	53.2	28.547				53	51	2	W. 1	Overcast	Sudden gust; raining slightly.
Do.		31	4 p. m.		977	28.576	53.2	53.2	28.513	28.609			53	51	2	W. 1	Overcast	Raining slightly.
Do.		31	4.35 p. m.		392	28.609	52.5	52.9	28.545				52.5	51	1.5	W. 1	Overcast	Do.
Do.		31	4.35 p. m.		977	28.576	52.5	52.9	28.512	28.616			52.5	51	1.5	W. 1	Overcast	Do.
	1855.																	
Do.	Jan.	1	9 a. m.		392	28.300	53	53.5	28.237				53	53		S.W. 7	Overcast	Raining; rained hard all night; towards morning there was a great deal of lightning; the wind veered from N.E. to S.W., with a force 9.
Do.		1	9 a. m.		977	28.260	53	53.5	28.208	28.426			53	53		S.W. 7	Overcast	
Do.		1	12 m.		392	28.330	50	49.5	28.275				49	48	1	S.W. 7	Overcast	Stopped raining at 11h. 30m. a. m., but commenced again at 12h. 20m. p. m.
Do.		1	12 m.		977	28.292	50	49.5	28.238	28.514			49	48	1	S.W. 7	Overcast	
Do.		1	1 p. m.		392	28.330	53.5	51	28.266				49.5	48.5	1	S.W. 5	Overcast	Raining.
Do.		1	1 p. m.		977	28.292	53.5	51	28.228	28.418			49.5	48.5	1	S.W. 5	Overcast	Do.
Do.		1	2 p. m.		392	28.335	50.5	50	28.279				49	48	1	S.W. 3	Overcast	Do.
Do.		1	2 p. m.		977	28.300	50.5	50	28.244	28.471			49	48	1	S.W. 3	Overcast	Do.
Do.		1	3 p. m.		392	28.330	49	49	28.278				48	47	1	S.W. 1	Overcast	Do.
Do.		1	3 p. m.		977	28.294	49	49	28.242	28.517			48	47	1	S.W. 1	Overcast	Do.
Do.		1	4 p. m.		392	28.330	45.5	47	28.287				46.5	45.3	1.2	S.W. 1	Overcast	Do. Stopped raining at 4h. 15m. p. m.
Do.		1	4 p. m.		977	28.300	45.5	47	28.257	28.526			46.5	45.3	1.2	S.W. 1	Overcast	
Do.		1	4.35 p. m.		392	28.330	45	47	28.288				46	44	2	S.W. 1	Nimbus 9	
Do.		1	4.35 p. m.		977	28.300	45	47	28.258	28.513			46	44	2	S.W. 1	Nimbus 9	
Do.		1	5 p. m.		392	28.340	44.5	45	28.299				45	43	2	S.W. 1	Cum. & nim. 5	
Do.		1	5 p. m.		977	28.308	44.5	45	28.267	28.514			45	43	2	S.W. 1	Cum. & nim. 5	
Do.		2	7.15 a. m.		392	28.580	33	34	28.568				33	32.5	0.5	S.W. 1	Cum. & nim. 5	Commenced raining at 6h. 30m. p. m. Frequent showers during the night.
Do.		2	7.15 a. m.		977	28.546	33	34	28.534	28.517			33	32.5	0.5	S.W. 1	Cum. & nim. 5	
Do.		2	8 a. m.		392	28.590	35	35.5	28.573				34.5	34.5		S.W. 1	Cum. & nim. 5	
Do.		2	8 a. m.		977	28.560	35	35.5	28.543	28.512			34.5	34.5		S.W. 1	Cum. & nim. 5	
Do.		2	9 a. m.		392	28.630	39.5	39.5	28.602				39	38	1	S.W. 1	Cum. 1	
Do.		2	9 a. m.		977	28.600	39.5	39.5	28.572	28.521			39	38	1	S.W. 1	Cum. 1	
Do.		2	10 a. m.		392	28.670	42.3	42.1	28.636				41.3	39.5	1.8	S.W. 1	C. & C. C. S. 4	
Do.		2	10 a. m.		977	28.650	42.3	42.1	28.616	28.563			41.3	39.5	1.8	S.W. 1	C. & C. C. S. 4	
Do.		2	11 a. m.		392	28.680	44	43.5	28.640				43	40	3	S.W. 1	C. & C. C. S. 4	
Do.		2	11 a. m.		977	28.658	44	43.5	28.618	28.570			43	40	3	S.W. 1	C. & C. C. S. 4	
Do.		2	12 m.		392	28.676	46	45.4	28.631				45	41.2	3.8	S.W. 1	C. & C. C. S. 2	
Do.		2	12 m.		977	28.646	46	45.4	28.601	28.574			45	41.2	3.8	S.W. 1	C. & C. C. S. 2	
Do.		2	1 p. m.		392	28.669	48	47.6	28.619				47	43	4	S.W. 1	C. & C. C. S. 2	
Do.		2	1 p. m.		977	28.638	48	47.6	28.588	28.584			47	43	4	S.W. 1	C. & C. C. S. 2	
Do.		2	2 p. m.		392	28.670	48.3	46.9	28.620				47	42	5	S.W. 1	C. & C. C. S. 2	
Do.		2	2 p. m.		977	28.640	48.3	46.9	28.590	28.590			47	42	5	S.W. 1	C. & C. C. S. 2	
Do.		2	3 p. m.		392	28.670	48.5	47.9	28.619				47	41.5	5.5	N.W. 1	C. & C. C. S. 3	Slight breeze from the northwest.
Do.		2	3 p. m.		977	28.640	48.5	47.9	28.589	28.591			47	41.5	5.5	N.W. 1	C. & C. C. S. 3	
Do.		2	4 p. m.		392	28.680	46.5	46.5	28.634				45.5	40	5.5	N.W. 1	C. & C. C. S. 1	
Do.		2	4 p. m.		977	28.650	46.5	46.5	28.604	28.608			45.5	40	5.5	N.W. 1	C. & C. C. S. 1	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		*Miles.*		*Inches.*	°	°	*Inches.*	*Inches.*	*Inches.*	*Feet.*	°	°	°			
Camp No. 14'	Jan. 2	4.37 p. m.		392	28 679	41.5	42	28 646				41	38	3	N.W. 1	C. S. .05	
Do	2	4.37 p. m.		977	28.650	41 5	42	28.617	28.616			41	38	3	N.W. 1	C. S. .05	
Do	2	5 p. m.		392	28.665	39	40	28.638				39	37	2	N.W. 1	C. S. .05	Clear.
Do	2	5 p. m.		977	28.640	39	40	28 613	28.606			39	37	2	N.W. 1	C. S. .05	
Do	3	8 a. m.		392	28 739	40.5	40.6	28.709				39.5	37	2.5	N.W. 1	Cum. & C. S. 9	
Do	3	8 a. m.		977	28.702	40.5	40.6	28.672	28.634			39.5	37	2.5	N.W.	Cum. C. S. 9	
Do	3	9 a. m.		392	28.751	45.5	44.6	28.708				43.9	41	2.9	N.W.	Overcast, nim.	Raining; commenced at 8.30 a. m.
Do	3	9 a. m.		977	28.720	45.5	44.6	28.677	28.636			43.9	41	2.9	N.W.	do	
Do	3	10 a. m.		392	28.759	50	49	28.704				48	45	3	N.W.	do	
Do	3	10 a. m.		977	28.729	50	49	28.674	28.645			48	45	3	N.W.	do	
Do	3	11 a. m.		392	28.740	51.5	50	28.681				49	46	3	S.W. 1	do	The sun shows itself occasionally.
Do	3	11 a. m.		977	28.704	51.5	50	28 645	28.639			49	46	3	S.W 1	do	Do. do.
Do	3	12 m.		392	28.728	50	48.9	28 672				48	45.9	2.1	S. 1	do	
Do	3	12 m.		977	28.684	50	48.9	28.628	28.658			48	45.9	2.1	S. 1	do	
Do	3	1 p. m.		392	28.680	48.5	48.5	28.629				47.5	46	1.5	S.W. 1	Overcast, cum., nim.	Raining.
Do	3	1 p. m.		977	28.614	48.5	48 5	28 593	28.662			47.5	46	1.5	S.W. 1	do	Do.
Do	3	2 p. m.		392	28.669	48.5	48.5	28.618				47.5	46	1.5	S.W. 1	do	Do.
Do	3	2 p. m.		977	28.628	48 5	48.5	28.577	28.667			47 5	46	1.5	S.W. 1	do	Do.
Do	3	3 p. m.		392	28.651	47	47.5	28.604				46.5	45	1.5	S.W. 1	do	Do.
Do	3	3 p. m.		977	28.610	47	47.5	28.563	28.670			46.5	45	1.5	S.W. 1	do	Do.
Do	3	4 p. m.		392	28.640	46.5	47	28.594				46.5	45	1.5	S.W. 1	do	Raining very hard.
Do	3	4 p. m.		977	28 600	46.5	47	28.554	28.683			46.5	45	1.5	S.W. 1	do	Do. do.
Do	3	4.35 p. m.		392	28 640	46.5	47	28.594				46.5	45	1.5	S.W. 1	do	Do. do.
Do	3	4.35 p. m.		977	28 600	46.5	47	28.554	28.686			46.5	45	1.5	S.W. 1	do	Do. do.
Do	4	7.40 a. m.		392	28 270	46.5	47.5	28.225				46.5	46.5		S.W. 9	Overcast, nim.	It rained very hard all night. Raining. The wind blew a gale during the night from the S.W. Towards morning it shifted to the S.E.
Do	4	7.40 a. m.		977	28.234	46.5	47.5	28.189	28.358			46.5	46.5		S.W. 9		
Do	4	10 a. m.		392	28.280	50	50.5	28.226				49.5	49.5		S.W. 9.	Overcast, nim. 9	
Do	4	10 a. m.		977	28.246	50	50.5	28.192	28.355			49.5	49.5		S.W. 9	do	
Do	4	11 a. m.		392	28.290	52	52	28.231				51	51		S E. 5	do	Raining. Primary and secondary rainbows in the N.
Do	4	11 a. m.		977	28.254	52	52	28.195	28.369			51	51		S.E. 5	do	
Do	4	12 m.		392	28.302	54.5	52.5	28 237				52.5	52.5		S.E. 1	do	
Do	4	12 m.		977	28.270	54.5	52 5	28.205	28 401			52.5	52.5		S.E. 1	do	
Do	4	1 p. m.		392	28.310	47.5	47.5	28.263				47	47		S.E. 2	Nimbus 9	

Do	4	1 p. m.		977	28.272	47.5	47.5	28.225	28.407			47	47		S.E. 2	Nim. 9	Raining. Primary and secondary rainbows in the north.
Do	4	2 p. m.		392	28.320	47.5	47	28.272				46	45	1	W. 1	Nim. 9	Raining slightly.
Do	4	2 p. m.		977	28.288	47.5	47	28.240	28.466			46	45	1	W. 1	Nim. 9	
Do	4	3 p. m.		392	28.330	45	45.2	28.288				44.5	44	0.5	N.W. 2	Overcast, nim.9	Raining.
Do	4	3 p. m.		977	28.294	45	45.2	28.252	28.487			44.5	44	0.5	N.W. 2	...do...	
Do	4	4 p. m.		392	28.345	43.5	44	28.307				44	43	1	N.W. 1	C.S. cum. nim.7	Stopped raining at 3h. 35m. p. m.
Do	4	4 p. m.		977	28.312	43 5	44	28.274	28.509			44	43	1	N.W. 1	...do...	
Do	4	4.35 p. m.		392	28.359	41.5	42.5	28.326				41	40.5	0.5	N.W. 1	C.S. cum. nim.6	Since 4h. 10m. it has been raining, off and on.
Do	4	4.35 p. m.		9[illegible]	28.328	41.5	42.5	28.295	28.524			41	40.5	0.5	N.W. 1	...do...	Stopped at 4h. 50m. p. m.
Do	4	5 p. m.		392	28.375	41	42	28.343				40.9	39.9	1	N.W. 1	C.S. cum. nim.3	Pretty dark.
Do	4	5 p. m.		977	28.344	41	42	28.312	28.538			40.9	39.9	1	N.W. 1	...do...	
Do	5	7 a. m.		392	28.489	28	29	28.490				28.5	29	0.5	N.W. 1	C. S. 1	
Do	5	7 a. m.		977	28.450	28	29	28.451	28.541			28.5	29	0.5	N.W. 1	C. S. 1	
Do	5	8 a. m.		392	28.509	30.8	31.6	28.503				30.5	30.6	0.1	N.W. 1	C. S. 1	
Do	5	8 a. m.		977	28.468	30.8	31.6	28.462	28.536			30.5	30.6	0.1	N.W. 1	C. S. 1	
Do	5	9 a. m.		392	28.520	34	34.5	28.506				33.5	33.5		N.W. 1	C. S. 1	
Do	5	9 a. m.		977	28.484	34	34.5	28.470	28.522			33.5	33 5		N.W. 1	C. S. 1	
Do	5	10 a. m.		392	28.542	37	37.8	28.520				36.5	34.5	2	N.W. 1	C. S. 1	
Do	5	10 a. m.		977	28.504	37	37.8	28.482	28.527			36.5	34.5	2	N.W. 1	C. S. 1	
Do	5	11 a. m.		392	28.560	41	40 8	28.528				38.5	35	3.5	N.W. 1	C. S. 1	
Do	5	11 a. m.		977	28.524	41	40.8	28.492	28.536			38.5	35	3.5	N.W. 1	C. S. 1	
Do	5	12 m.		392	28.559	42.5	42	28.524				41	35.5	5.5	N.W. 1	C. S. 1	
Do	5	12 m.		977	28.520	42 5	42	28.485	28.542			41	35.5	5.5	N.W. 1	C. S. 1	
Do	5	1 p. m.		392	28.559	43.2	43	28.522				42	36.5	5 5	N.W. 5	Cum. .05	
Do	5	1 p. m.		977	28.520	43.2	43	28.483	28.513			42	36.5	5.5	N.W. 5	Cum. .05	
Do	5	2 p. m.		392	28.556	45	44 5	28.511				43 5	37	6.5	N.W. 2	Cum. C. S. 6	
Do	5	2 p. m.		977	28.518	45	44 5	28.473	28.522			43.5	37	6.5	N.W. 2	Cum. C. S. 6	
Do	5	3 p. m.		392	28.550	45.2	44.8	28.505				43.6	38	5.6	N.W. 2	Cum. C. S. 2	
Do	5	3 p m.		977	28.514	45.2	44.8	28.469	28.514			43.6	38	5.6	N.W. 1	Cum. 2	
Do	5	4 p. m.		392	28.559	42.5	42 5	28.524				41	37.5	3.5	N.W. 1	Cum. 9, nim	Raining slightly.
Do	5	4 p. m.		977	28.520	42.5	42.5	28.485	28.533			41	37.5	3.5	N.W. 1	Cum. 9	
Do	5	4.36 p. m.		392	28.560	41	41 5	28.528				40.5	37.5	3	E. 5	Cum. C.S. nim.9	
Do	5	4.36 p. m.		977	28.522	41	41.5	28.490	28.524			40.5	37.5	3	E. 5	Cum. C.S. nim 9	
Do	5	5 p. m.		392	28.562	40	40 5	28.533				40	37	3	E. 5	Cum. C S. nim.9	
Do	5	5 p. m.		977	28.522	40	40.5	28.493	28.524			40	37	3	E. 5	Cum. C.S. nim.9	
Do	6	7.10 a. m.		392	28.751	29.5	30.5	28.748				30	29	1	E. 5	Cum. C.S. nim.2	
Do	6	7.10 a. m.		977	28.718	29.5	30.5	28.715	28.587			30	29	1	E. 5	Cum. C.S. nim.2	
Do	6	8 a. m.		392	28.770	33	33.5	28.758				32.5	31.5	1	E. 5	Cum. C.S. nim.1	
Do	6	8 a. m.		977	28.740	33	33.5	28.728	28.597			32.5	31.5	1	E. 5	Cum. C.S nim.1	
Do	6	9 a. m.		392	28.785	37.8	37.3	28.762				36.5	33.5	3	E. 5	Cum. C.S. nim.1	
Do	6	9 a. m.		977	28.760	37.8	37.3	28.737	28.583			36.5	33.5	3	E. 5	Cum. C.S. nim.1	
Do	6	10 a. m.		392	28.810	42.2	41.9	28.775				41	35	6	S.E. 2	C. C. S. 2	
Do	6	10 a. m.		977	28.780	42.2	41.9	28.745	28.591			41	35	6	S.E. 2	C. C. S. 2	
Do	6	11 a. m.		392	28.820	45	44.7	28.777				43	36.5	6.5	S.E. 1	C. C. S. 2	
Do	6	11 a. m.		977	28.768	45	44.7	28 745	28.602			43	36.5	6.5	S.E. 1	C. C. S. 2	
Do	6	12 m.		392	28.810	48	47	28.759				45.3	38	7.3	S.E. 1	C. C. S. 4	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		*Miles.*		*Inches.*	°	°	*Inches.*	*Inches.*	*Inches.*	*Feet.*	°	°	°			
Camp No. 14'	Jan. 6	12 m		977	28.772	48	47	28.721	28.598			45.3	38	7.3	S.E. 1	C. C. S. 4	
Do	6	1 p. m.		392	28.808	51	49.4	28 750				47.2	40	7.2	S.E. 1	C. C. S. 7	
Do	6	1 p. m.		977	28.770	51	49.4	28.712	28.612			47.2	40	7.2	S.E. 1	C. C. S. 7	
Do	6	2 p. m.		392	28.808	50	48.9	28.752				47	40	7	W. 1	C. C. S. 5	
Do	6	2 p. m.		977	28.770	50	48.9	28.714	28.623			47	40	7	W. 1	C. C. S. 5	
Do	6	3 p. m.		392	28.800	48.3	48	28.749				45 8	39	6.8	W. 1	C. C. S. 6	
Do	6	3 p. m.		977	28.770	48.3	48	28.719	28.631			45.8	39	6.8	W. 1	C. C. S. 6	
Do	6	4 p. m.		392	28.790	44.5	44.8	28.749				43	39	4	W. 1	C. C. S. 3	
Do	6	4 p. m.		977	28.756	44.5	44.8	28.715	28.631			43	39	4	W. 1	C. C. S. 3	
Do	6	4.35 p. m.		392	28.785	38.5	39.9	28.759				39	36	3	W. 1	C. C. S. 2	Gray sunset.
Do	6	4.35 p. m.		977	28.752	38 5	39.9	28.726	28.632			39	36	3	W. 1	C. C. S. 2	
Do	6	5 p. m.		392	28.782	36.9	38	28.760				37	35	2	W. 1	C. C. S. 2	
Do	6	5 p. m.		977	28.750	36.9	38	28.728	28.625			37	35	2	W. 1	C. C. S. 2	
Do	7	7 10 a. m.		392	28.770	28	29	28.771				28 5	28	.5	W. 1	C. C. S. 5	
Do	7	7.10 a. m.		977	28.734	28	29	28.733	28.578			28.5	28	.5	W. 1	C. C. S. 5	
Do	7	8 a. m.		392	28.772	33	33	28.760				32	31	1	W. 1	C. C. S. 5	
Do	7	8 a. m.		977	28.736	33	33	28.724	28.566			32	31	1	W. 1	C. C. S. 5	
Do	7	9 a. m.		392	28.800	38.5	38.1	28.774				37	34.2	2 8	W. 1	C. C. S. 5	
Do	7	9 a. m.		977	28.770	38.5	38.1	28.744	28.563			37	34.2	2.8	W. 1	C. C. S. 5	
Do	7	10 a. m.		392	28.820	45	44	28.777				42.9	39.1	3.8	W. 1	C. C. S. 9	Appearance of rain.
Do	7	10 a. m.		977	28.782	45	44	28.739	28.564			42.9	39.1	3.8	W. 1	C. C. S. 9	
Do	7	11 a. m.		392	28.825	52	49.4	28.764				47 3	42.5	4.8	W. 1	C. C. S. 9	A little hail fell about 10 30.
Do	7	11 a. m.		977	28.792	52	49.4	28.731	28.558			47.3	42.5	4.8	W. 1	C. C. S. 9	Do. do.
Do	7	12 m.		392	28.802	50.5	48.8	28.745				47	40.8	6.2	W. 1	C. C. S. 9	Do. do.
Do	7	12 m.		977	28.758	50.5	48.8	28.701	28.550			47	40.8	6.2	W. 1	C. C. S. 9	Do. do.
Do	7	1 p. m.		392	28.789	52	50.5	28.728				48.5	40.5	8	W. 1	Overcast, cir., C. S. nim.	Raining slightly.
Do	7	1 p. m.		977	28.750	52	50.5	28.689	28.560			48.5	40.5	8	W. 1	do.	
Do	7	3 p. m.		392	28.759	52.4	50.8	28.697				49.2	41.5	7.7	W. 1	C. C. S. 9	
Do	7	3 p. m.		977	28.734	52.4	50.8	28 672				49.2	41.5	7.7	W. 1	C. C. S 9	
Do	7	3 p. m.		978	28 736	52.2	50.8	28.675	28.544			49.2	41.5	7.7	W. 1	C. C. S. 9	
Do	7	4 p. m.		392	28.750	47.5	48	28.701				46	40.2	5.8	W. 1	C. C. S. 8	
Do	7	4 p. m.		977	28.716	47.5	48	28.667				46	40.2	5.8	W. 1	C. C. S. 8	
Do	7	4 p. m.		978	28.720	47.6	48	28.671	28.545			46	40.2	5.8	W. 1	C. C. S. 8	
Do	7	4.39 p. m.		392	28.749	45.8	46.8	28.694				45	40.5	4.5	W. 1	C. C. S. 8	

Do.	7	4.39 p. m.		977	28.710	45.8	46.8	28.665				45	.5	4.5	W. 1	C. C. S. 8	
Do.	7	4.39 p. m.		978	28.718	45 8	46.8	28.673	28.538			45	40.5	4.5	W. 1	C. C. S. 8	
Do.	7	5 p. m.		392	28.749	45	45.5	28.706				44.5	41	3.5	W. 1	C. C. S. 7	
Do.	7	5 p. m.		977	28.710	45	45.5	28 667				44.5	41	3.5	W. 1	C. C. S. 7	
Do.	7	5 p. m.		978	28.718	45.3	45.5	28.675	28.540			44.5	41	3.5	W. 1	C. C. S. 7	
Do.	8	6.56 a. m.		392	28.760	28	28.8	28.761				28	27 9	0.1	W. 1	C. S 5	Bar. 977, broken, (cistern cracked.)
Do.	8	6.56 a. m.		977	28.718	28	28.8	28.719				28	27 9	0.1	W. 1	C. S. 5	
Do.	8	6.56 a. m.		978	28.738	28	28.8	28 739	28.522			28	27.9	0.1	W. 1	C. S. 5	
Do.	8	7.30 a. m.		392	28.769	30	30	28.765				30	29.2	0.8	W. 1	C. S. 5	
Do.	8	7.30 a. m.		977	28.726	30	30	28.722				30	29 2	0.8	W. 1	C. S. 5	
Do.	8	7.30 a. m.		978	28.742	30	30	28.742	28.515	28.548	1393.5	30	29.2	0.8	W. 1	C. S. 5	
Camp No. 14'', near Camp 14	9	7.05 a. m.		392	29.125	37	37.8	29.103							W. 1	C. S. C. 1	
Do.	9	8 a. m.		392	29.135	37 9	38.2	29.110	28.830						W. 1	C. S C. 1	
Do.	9	8 a. m.		392	29 145	62 5	63.2	29.057							W. 1	C. S. C. 2	
Do.	9	8 a. m.		978	29.120	60.5	63.2	29.037	28 818						W. 1	C. S. C. 2	
Do.	9	1 p. m.		392	29.130	62.5	61.4	29.042				60.5	49	11.5	N. 5	C. C. S. 1	
Do.	9	1 p. m.		978	29.108	62.5	61.4	29 020	28 812			60.5	49	11.5	N. 5	C. C. S. 1	
Do.	9	2 p. m.		392	29.130	62.5	61.4	29.042				61	49.9	11 1	N. 5	C. C. S. .05	
Do.	9	2 p. m.		978	29.108	62.3	61.4	29.021	28.825			61	49.9	11.1	N. 5	C. C. S. .05	
Do.	9	3 p. m.		392	29.125	60	59.5	29.043				59	47	12	N. 5	C. C. S. .05	
Do.	9	3 p. m.		978	29.100	60	59.5	29.018	28.827			59	47	12	N. 5	C. C. S. .05	
Do.	9	4 p. m.		392	29 120	58	58	29.043				57	47	10	N. 5	C. C. S. 1	
Do.	9	4 p. m.		978	29.096	58	58	29.019	28.830			57	47	10	N. 5	C. C. S. 1	
Do.	9	5 p. m.		392	29.120	52	53	29.059				51.5	45	6.5	N. 5	C. C. S. 2	
Do.	9	5 p. m.		978	29.096	53	53	29.0?2	28.840			51.5	45	6 5	N. 5	C. C. S. 2	
Do.	9	7.10 p. m.		392	29.110	42	43.5	29.075				42	40	2	N. 5	C. C. S. 2	Very misty.
Do.	9	7.10 p. m.		978	29.086	42.5	43.5	29.050	28.857			42	40	2	N. 5	C. C. S. 2	
Do.	10	7 a. m.		392	29.145	37.5	39.5	29.122				38	36.5	1.5	N. 5	C. C. S. 2	
Do.	10	7 a. m.		977	29.114	38.5	39.5	29.098	28.906			38	36.5	1.5	N. 5	C. C. S. 2	
Do.	10	7.15 a. m.		392	29.145	38.5	40	29.119				38.2	36.5	1.7	N. 5	C. C. S. 2	
Do.	10	7.15 a. m.		977	29.114	38.5	40	29.087	28.899			38.2	36 5	1.7	N. 5	C. C. S. 2	
Do.	10	8 a. m.		392	29.149	38	39	29.124				38	36.5	1.5	N. 5	C. C. S. 2	
Do.	10	8 a. m.		977	29.116	38.5	39	29.090	28.906			38	36 5	1.5	N. 5	C. C. S. 2	
Do.	10	9 a. m.		392	29.150	46.2	47	29 105				46	42.8	3.2	W. 5	C. C. S. 2	
Do.	10	9 a. m.		977	29.120	46.5	47	29.075	28.884			46	42.8	3.2	W. 5	C. C. S. 2	
Do.	10	10 a. m.		392	29.155	52.6	53	29.093				52	46	6	W. 5	C. C. S. 2	
Do.	10	10 a. m.		977	29.124	52 6	53	29.060	28.872			52	46	6	W. 5	C. C. S. 2	
Do.	10	11 a. m.		392	29.146	60	59	29.064				58	48.5	9.5	W. 5	C. C. S. 2	
Do.	10	11 a. m.		977	29.120	60	59	29.038	28 862			58	48.5	9.5	W 5	C. C. S. 2	
Do.	10	12 m.		392	29.130	64	63.8	29.038				62.2	51.2	11	W. 1	C. C. S. 2	
Do.	10	12 m.		977	29 100	64	63.8	29 008	28.861			62.2	51.2	11	W. 1	C. C. S. 2	
Do.	10	1 p. m.		392	29.110	66	65 4	29.013				64.3	52.4	11.9	W. 1	C. C. S. 2	
Do.	10	1 p. m.		977	29.072	65.6	65.4	28.976	28.855			64.3	52.4	11.9	W. 1	C. C. S. 2	
Do.	10	2 p. m.		392	29.100	68	67.3	28.998				66.2	53.5	12.7	N. 5	C. C. S. 2	
Do.	10	2 p. m.		977	29.066	68	67.3	28.964	28.861			66.2	53.5	12.7	N. 5	C. C. S. 2	
Do.	10	3 p. m.		392	29.100	68	67.5	28.998				66.1	53	13 1	N. 5	C. C. S. 2	
Do.	10	3 p. m.		977	29.060	68	67.5	28.958	28.875			66.1	53	13.1	N. 5	C. C. S. 2	
Do.	10	4 p. m.		392	29.100	65	65	29.005				63	53	10	N. 5	C. C. S. 2	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 14''	Jan. 10	4 p. m.		977	29.060	65	65	28.965	28.889			63	53	10	N. 5	C. C. S. 2	
Do	10	5 p. m.		392	29.096	57.2	57.5	29.022				56	48.5	7.5	N. 5	C. C. S. 2	
Do	10	5 p. m.		977	29.058	57.2	57.5	28.984	28.904			56	48.5	7.5	N. 5	C. C. S. 2	
Do	10	10 p. m.		392	29.075	35	36.5	29.058				36	34.9	1.1	N. 5	C. C. S. 2	
Do	10	10 p. m.		977	29.038	36	36.5	29.021	28.913			36	34.9	1.1	N. 5	C. C. S. 2	
Do	11	7.15 a. m.		392	29.010	29	30	29.009				29.9	29.3	0.6	S. 5	C. C. S. 2	
Do	11	7.15 a. m.		978	28.980	29	30	28.979	28.900			29.9	29.3	0.6	S. 5	C. C. S. 2	
Do	11	8 a. m.		392	29.012	30.8	31 6	29.006				31	30	1	S. 5	C. C. S. 1	
Do	11	8 a. m.		977	28.984	30.8	31.6	28.978	28.896			31	30	1	S. 5	C. C. S. 1	
Do	11	9 a. m.		392	29.030	42.5	42.5	28.994				41	39	2	S. 5	C. C. S. 1	
Do	11	9 a. m.		978	29.012	42.5	42.5	28.976	28.894			41	39	2	S. 5	C. C. S. 1	
Do	11	10 a. m.		392	29.042	48.3	48	28.990				46.5	44	2.5	S. 5	C. S. 1	
Do	11	10 a. m.		978	29.020	48.2	48	28.968	28.890			46.5	44	2.5	S. 5	C. S. 1	
Do	11	11 a. m.		392	29.040	55	54	28.971				53	47	6	S. 5	C. S. 1	
Do	11	11 a. m.		978	29.016	54.5	54	28.948	28.875			53	47	6	S. 5	C. S. 1	
Do	11	12 m.		392	29.030	59.2	58.5	28.951				57	50	7	S. 5	C. S. 1	
Do	11	12 m.		978	29.000	59	58.5	28.921	28.874			57	50	7	S. 5	C. S. 1	
Do	11	1 p. m.		392	29.005	63.9	63	28.913				62	52.5	9.5	S. 5	C. S. 1	
Do	11	1 p. m.		978	28.968	64	63	28.876	28.855			62	52.5	9.5	S. 5	C. S. 1	
Do	11	2 p. m.		392	28.988	68.4	68	28.885				66.2	54.2	12	S. 5	C. S. 1	
Do	11	2 p. m.		978	28.952	68.5	68	28.849	28.837			66.2	54.2	12	S. 5	C. S. 1	
Do	11	3 p. m.		392	28.988	69.8	69.1	28.881				67.2	55.9	11.3	S. 5	C. S. 1	
Do	11	3 p. m.		978	28.952	69.8	69.1	28.845	28.840			67.2	55.9	11.3	S. 5	C. S. 1	
Do	11	4 p. m.		392	28.939	67.8	67.1	28.838				65.5	56	9.5	S. 5	C. S. 2	
Do	11	4 p. m.		978	28.920	67.8	67.1	28.819	28.812			65.5	56	9.5	S. 5	C. S. 2	
Do	11	5 p. m.		392	28.915	53.7	54.6	28.850				52.8	48 2	4.6	S. 5	C. S. 2	
Do	11	5 p. m.		978	28.892	54.2	54.6	28.826	28.819			52.8	48.2	4.6	S. 5	C. S. 2	
Do	12	7.15 a. m.		392	28.869	30.5	31.8	28.864				31	29.5	1.5	S. 5	C. S. 2	
Do	12	7.15 a. m.		978	28.842	30.9	31.8	28.835	28.805			31	29.5	1.5	S. 5	C. S. 2	
Do	12	8 a. m.		392	28.870	32.5	33	28.860				33	30.6	2 4	S. 5	C. S. 2	
Do	12	8 a. m.		978	28.842	32.5	33	28.832	28.800			33	30.6	2.4	S. 5	C. S. 2	
Do	12	9 a. m.		392	28.905	40.9		28.873				40	37.5	2.5	S. 5	C. S. 2	
Do	12	9 a. m.		978	28.876	41	41.5	28.843	28.802			40	37.5	2.5	S. 5	C. S. 2	
Do	12	10 a. m.		392	28.928	50.4	50	28.871				48.2	43.9	4.3	S. 5	C. S. 2	
Do	12	10 a. m.		978	28.904	50	50	28.848	28.805			48.2	43.9	4.3	S. 5	C. S. 2	

Do	12	11.30 a. m.		392	28.935	59	58	28.856				56.5	49	7.5	S. 5	C. S. 2	
Do	12	11.30 a. m.		978	28.906	58.5		28.828	28.800			56.5	49	7.5	S. 5	C. S. 2	
Do	12	12 m		392	28.939	62	61.5	28.852				60.2	51	9.2	S. 5	C. S. 2	
Do	12	12 m		978	28.908	61.9	61.5	28.821	28.804			60.2	51	9.2	S. 5	C. S. 2	
Do	12	1.30 p. m.		392	28.950	69	68.2	28.845				66.5	52	14.5	S.W. 5	C. S. 2	
Do	12	1.30 p. m.		978	28.918	69	68.2	28.813	28.819			66.5	52	14.5	S.W. 5	C. S. 2	
Do	12	2 p. m.		392	28.959	70.3	69.2	28.851				67.5	53.4	14.1	S.W. 5	C. S. 2	
Do	12	2 p. m.		978	28.826	69.9	69.2	28.818	28.824			67.5	53.4	14.1	S.W. 5	C. S. 2	
Do	12	3 p. m.		392	28.960	69.2	68.6	28.855				67	52	15	S.W. 5	C. S. 2	
Do	12	3 p. m.		978	28.928	69	68.6	28.823	28.836			67	52	15	S.W. 5	C. S. 2	
Do	12	4 p. m.		392	28.950	65.9	65.5	28.853				63.5	52	11.5	S.W. 5	C. S. 2	
Do	12	4 p. m.		978	28.912	65.9	65.5	28.815	28.833			63.5	52	11.5	S.W. 5	C. S. 2	
Do	12	5 p. m.		392	28.929	52.5	52.5	28.867				51	46	5	S.W. 5	C. S. 2	
Do	12	5 p. m.		978	28.894	52.5	52.5	28.832	28.836			51	46	5	S.W. 5	C. S. 2	
Do	12	5.20 p. m.		392	28.920	49	50.5	28.867				49	45	4	S.W. 5	C. S. 2	
Do	12	5.20 p. m.		978	28.886	50	50.5	28.832	28.830			49	45	4	S.W. 5	C. S. 2	
Do	13	7.15 a. m.		392	29.030	28	30	29.031				29	27.8	1.2	S.W. 5	C. S. 2	
Do	13	7.15 a. m.		978	29.000	29	30	28.999	28.871	28.873	1085.7	29	27.8	1.2	S.W. 5	C. S. 2	
Camp No. 15, San Luis Pass	13	3 p. m.	195.68	392	29.440	71	69.5	29.328				69.5	52.5	17	S.W. light	0	
Do	13	3 p. m.	195.68	978	29.410	70.5	69.5	29.299	29.180			69.5	52.5	17	0	0	
Do	13	4 p. m.	195.68	392	29.436	65	64.6	29.339				64.8	51.2	13.6	0	0	
Do	13	4 p. m.	195.68	978	29.403	65.5	64.6	29.316	29.196			64.8	51.2	13.6	0	0	
Do	13	5.10 p. m.	195.68	392	29.400	52.8	53.1	29.336				53	49	4	0	0	
Do	13	5.10 p. m.	195.68	978	29.378	53.5	53.1	29.314	29.176			53	49	4	0	0	
Do	14	7.25 a. m.	195.68	392	29.430	49.5		29.375							S.E. 1	0	Commenced at 11.30 p. m. to blow very fresh from the S.E.
Do	14	7.25 a. m.	195.68	978	29.404	50	51	29.317	29.157	29.184	797.0				S.E. 1	0	
San Luis Obispo, level station	14	11.10 a. m.	199.93	392	30.097	69.5	68	29.989							S.E. 1	0	Barometer hung for half an hour.
Do	14	11.20 a. m.	199.93	392	30.080	70.2	69	29.971	29.796	29.755	255.7				S.E. 1	0	
Camp No. 16, Corral de las Piedras	14	5.15 p. m.	207.43	392	29.949	58	58.2	29.871							W. 1	C. C. S. 2	
Do	14	5.15 p. m.	207.43	978	29.918	58.5	58.2	29.839	29.746								
Do	15	7 a. m.	207.43	392	29.900	31.5	32.7	29.894								C. S. C. 8	
Do	15	7 a. m.	207.43	978	29.876	31.9	32.7	29.869	29.737								
Do	15	7.20 a. m.	207.43	392	29.918	33.5	34	29.905									
Do	15	7.20 a. m.	207.43	978	29.882	33.5	31	29.869	29.722								
Do	15	8 a. m.	207.43	392	29.920	36	36.5	29.900									
Do	15	8 a. m.	207.43	978	29.900	36	36.5	29.880	29.724								
Do	15	9 a. m.	207.43	978	29.938	48	46.1	29.886	29.729			46.5	41.2	5.3			
Do	15	10 a. m.	207.43	978	29.964	56.8	56.5	29.889	29.734			55	49	6			
Do	15	11 a. m.	207.43	978	29.982	66.5	66.5	29.880	29.735			64	51.5	12.5			
Do	15	12 m.	207.43	978	29.970	69	71.9	29.861	29.738			70.5	60	10.5		C. C. S. 5	
Do	15	0.30 p. m.	207.43	978	29.964	72	69.5	29.847	29.739	29.733	274.3	73	57	16		C. C. S. 4	In sunshine.
Camp No. 17, Beebe's Rancho	15	3 p. m.	209.93	978	29.906	65.8	65	29.807	29.723			63.9	54.5	9.4		Cirrus, 2	
Do	15	4 p. m.	209.93	978	29.900	58.1	59	29.820	29.738			58.5	52.8	5.7		Cirrus, 2.	
Do	15	4.50 p. m.	209.93	978	29.890	54.5	55	29.821	29.733			54.5	51.6	2.9			
Do	15	6.30 p. m.	209.93	392	29.880	46.5	46	29.832				46.5	45	1.5	0		
Do	15	6.30 p. m.	209.93	978	29.854	46.5	46	29.806	29.709			46.5	45	1.5	0		
Do	16	7.15 a. m.	209.93	392	29.829	36	36.7	29.809				36	35	1	0	C. C. S. 6	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 17, Beebe's rancho	Jan. 16	7.15 a. m.	209.93	978	29.800	36	36.7	29.780	29.673			36	35	1	0	C. C. S. 6	
Do.	16	8 a. m.	209.93	392	29.840	38.3	38.5	29.814				38	37	1	0	C. C. S. 6	
Do.	16	8 a. m.	209.93	978	29.810	38	38.5	29.784	29.686			38	37	1	0	C. C. S. 6	
Do.	16	9 a. m.	209.93	392	29.850	45	45.2	29.806				44.8	43.5	1.3	0	C. C. S. 9	
Do.	16	9 a. m.	209.93	978	29.826	45	45.2	29.782	29.671			44.8	43.5	1.3	0	C. C. S. 9	
Do.	16	10 a. m.	209.93	392	29.880	50	50	29.822				49	47.2	1.8	0	C. C. S. 9	
Do.	16	10 a. m.	209.93	978	29.854	49.5	50	29.798				49	47.2	1.8	0	C. C. S. 9	
Do.	16	10 a. m.	209.93	977	29.862	49.5	50	29.806	29.693			49	47.2	1.8	0	C. C. S. 9	
Do.	16	11 a. m.	209.93	392	29.887	53	52.8	29.821				52	48.1	3.9	0	C. C. S. 7	
Do.	16	11 a. m.	209.93	978	29.860	52.5	52.8	29.796				52	48.1	3.9	0	C. C. S. 7	
Do.	16	11 a.	209.93	977	29.860	52.5	52.8	29.796	29.698			52	48.1	3.9	0	C. C. S. 7	
Do.	16	12 m.	209.93	392	29.880	60	59.9	29.795				59	49	10	0	C. C. S. 6	
Do.	16	12 m.	209.93	978	29.850	59.9	59.9	29.765				59	49	10	0	C. C. S. 6	
Do.	16	12 m.	209.93	977	29.850	59.9	59.9	29.765	29.691			59	49	10	0	C. C. S. 6	
Do.	16	1 p. m.	209.93	392	29.865	64	63	29.770				62	52	10	0	C. C. S. 6	
Do.	16	1 p. m.	209.93	978	29.840	63.5	63	29.746				62	52	10	0	C. C. S. 6	
Do.	16	1 p. m.	209.93	977	29.838	63.5	63	29.744	29.692			62	52	10	0	C. C. S. 6	
Do.	16	2 p. m.	209.93	392	29.858	68.5	67.5	29.751				67	55	12	0	C. C. S. 6	
Do.	16	2 p. m.	209.93	976	29.830	68	67.5	29.721				67	55	12	0	C. C. S. 6	
Do.	16	2 p. m.	209.93	977	29.826	68	67.5	29.720	29.680			67	55	12	0	C. C. S. 6	
Do.	16	3 p. m.	209.93	392	29.835	65.7	65.2	29.735				64.5	55	9.5	0	C. C. S. 5	
Do.	16	3 p. m.	209.93	978	29.802	65	65.2	29.704				64.5	55	9.5	0	C. C. S. 5	
Do.	16	3 p. m.	209.93	977	29.808	[illegible]	65.2	29.710	29.671			64.5	55	9.5	0	C. C. S. 5	
Do.	16	4 p. m.	209.93	392	29.830	61.2	61	29.743				60.5	52.5	8	0	C. C. S. 4	
Do.	16	4 p. m.	209.93	978	29.800	61	61	29.713				60.5	52.5	8	0	C. C. S. 4	
Do.	16	4 p. m.	209.93	977	29.800	61	61	29.713	29.680			60.5	52.5	8	0	C. C. S. 4	
Do.	16	5 p. m.	209.93	392	29.830	55	55	29.749				55	50.5	4.5	0	C. C. S. 5	
Do.	16	5 p. m.	209.93	978	29.788	55	55	29.717				55	50.5	4.5	0	C. C. S. 5	
Do.	16	5 p. m.	209.93	977	29.790	55	55	29.719	29.677			55	50.5	4.5	0	C. C. S. 5	
Do.	16	6 p. m.	209.93	392	29.810	49	49	29.755				48.2	45	3.2	0	C. C. S. 8	
Do.	16	6 p. m.	209.93	978	29.780	49	49	29.725				48.2	45	3.2	0	C. C. S. 8	
Do.	16	6 p. m.	209.93	977	29.778	49	49	29.723	29.686			48.2	45	3.2	0	C. C. S. 8	
Do.	16	7 p. m.	209.93	392	29.820	46.5	47	29.772				46.2	44.2	2	0	C. C. S. 5	
Do.	16	7 p. m.	209.93	978	29.782	46.5	47	29.734				46.2	44.2	2	0	C. C. S. 5	
Do.	16	7 p. m.	209.93	977	29.784	46.5	47	29.736	29.686			46.2	44.2	2	0	C. C. S. 5	

Do.	16	8 p. m.	209.93	392	29.830	43.8	44.2	29.789				43.5	41.5	2	0	C. C. S. 2	‹k haze.
Do.	16	8 p. m.	209.93	978	29.792	43.8	44.2	29.751				43.5	41.5	2	0	C. C. S. 2	Do.
Do.	16	8 p. m.	209 93	977	29.786	43.8	44.2	29.745	29.696			43.5	41.5	2	0	C. C. S. 2	Do.
Do.	16	9 p. m.	209 93	392	29.839	44.5	45	29.796				44	41.9	2.1	0	C. C. S. 6	
Do.	16	9 p. m.	209.93	978	29.806			29.763				44	41.9	2.1	0	C. C. S. 6	
Do.	16	9 p. m.	209.93	977	29.804			29.761	29.696						0	C. C. S. 6	
Do.	16	10 p. m.	209.93	392	29.845	45	45.2	29.801				45	41.2	3.8	0	C. C. S. 2	
Do.	16	10 p. m.	209.93	978	29.816	45	45 2	29.772							0	C. C. S. 2	
Do.	16	10 p. m.	209.93	977	29 810	45	45.2	29.766	29.701						0	C. C. S. 2	
Do.	16	11 p. m.	209.93	392	29.845	46	46.2	29.798				46	41	5	0	C. C. S. 2	
Do.	16	11 p. m.	209.93	978	29.814	46	46.2	29.767							0	C. C. S. 2	
Do.	16	1 . m.	209.93	977	29.810			29.763	29.706						0	C. C. S. 2	
Do.	16	12 m.	209.93	392	29.840	50	50	29.782				49.3	43	6.3	0	C. C. S. 2	
Do.	16	12 m.	209.93	978	29 810	50	50	29 752							0	C. C. S. 2	
Do.	16	12 m.	209 93	977	29.806	50	50	29.748	29.706						0	C. C. S. 2	
Do.	17	a. m.	209.93	392	29.840	52	52	29.777				52	44	8	Lt. breeze from east.	C. C. S. 2	
Do.	17	1 a. m.	209.93	978	29 810	52	52	29.747							do.	C. C. S. 2	
Do.	17	1 a. m.	209.93	977	29.810	52	52	29.747	29.712						do.	C. C. S. 2	
Do.	17	2 a. m.	209.93	392	29 819	47	47.5	29.769				47	41	6	do.	C. C. S. 2	
Do.	17	2 p m.	209 93	978	29.790	47	47.5	29.740							do.	C. C. S 2	
Do.	17	2 a. m.	209 93	977	29.790	47	47.5	29.740	29.706						do.	C. C S. 2	
Do.	17	3 a. m.	209.93	392	29 819	46.5	47	29.771				46.5	40.5	6	do.	C. C. S. 2	
Do.	17	3 a. m.	209.93	978	29.790	46.5	47	29.742							do.	C. C. S. 2	
Do.	17	3 a. m.	209.93	977	29.790	46.5	47	29.742	29.706						do.	C. C. S. 2	
Do.	17	4 a. m.	209.93	392	29.828	43	43.8	29.789				43	38.5	4.5			
Do.	17	4 a. m.	209.93	978	29.798			29.759									
Do.	17	4 a. m.	209 93	977	29.794			29.755	29.706								
Do.	17	5 a. m.	209.03	392	29.814	40.5	41	29.782				40.5	37	3.5			
Do.	17	5 a. m.	209.93	978	29.785	40.5	41	29.753				40.5					
Do.	17	5 a. m.	209.93	977	29.781	40.5	41	29.749	29 706								
Do.	17	6 a. m.	209 93	392	29.808	39.5	39 8	29.779				39	36	3			
Do.	17	6 a. m.	209.93	978	29.778	39	39.8	29.750				39	36	3			
Do.	17	6 a. m.	209 93	977	29.775	39	39.8	29.747	29.706			39	36	3			
Do.	17	7 a. m.	209.93	392	29.820	38	38.8	29 794				38	35.5	2.5	Light easterly.	Light cir. & C.S. 3	
Do.	17	7 a. m.	209.93	978	29.789	38	38.8	29.763				38	35.5	2.5	do.	do.	
Do.	17	7 a. m.	209 93	977	29.789	38	38.8	29.763	29.697			38	35.5	2.5	do.	do.	
Do.	17	7.25 a. m.	209.93	392	29 838	40.2	40.8	29.807				40	37	3	do.	Light cir. & C.S. 4	
Do.	17	7.25 a. m.	209.93	978	29.808	40	40.8	29.777				40	37	3	do.	do.	
Do.	17	7.25 a. m.	209.93	977	29 802	40	40.8	29.771	29.698			40	37	3	do.	do.	
Do.	17	8 a. m.	209.93	392	29.845	42		29.809				42	38.5	3.5	do.	do.	
Do.	17	8 a. m.	209.93	978	29.814	42.2	42 5	29.778				42	38.5	3.5	do.	do.	
Do.	17	8 a. m.	209.93	977	29.808	42.2	42.5	29.772	29.698			42	38 5	3.5	do.	do.	
Do.	17	9 a. m.	209.93	978	29.832	46	47	29.785				46	42	4	do.	do.	
Do.	17	9 a. m.	209.93	977	29.836	46	47	29 789	29.700			46	42	4	do.	do.	
Do.	17	10 a. m.	209.93	978	29.878	57.5	57	29 801				56	48	8	do.	do.	
Do.	17	10 a. m.	209.93	977	29.880	57.5	57	29.803	29.717			56	48	8	do	do.	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		*Miles.*		*Inches.*	°	°	*Inches.*	*Inches.*	*Inches.*	*Feet.*	°	°	°			
Camp No. 17	Jan. 17	11 a. m.	209.93	978	29.892	64	64	29.797				63	52.5	10.5	Light easterly.	Light cir.&S.C.4	
Do.	17	11 a. m.	209.93	977	29.896	64	64	29.801	29.719			63	52.5	10.5	do.	do.	
Do.	17	12 m.	209.93	978	29.876	69.5	69.5	29.766				68.5	53	15.5	do.	do.	
Do.	17	12 m.	209.93	977	29.874	69.5	69.5	29.764	29.702			68.5	53	15.5	do.	do.	
Do.	17	1 p. m.	209.93	978	29.866	71	71.2	29.752				70.5	56	14.5	do.	Light cir.&C.S.7	
Do.	17	1 p. m.	209.93	977	29.866	71	71.2	29.752	29.712			70.5	56	14.5	do.	do.	
Do.	17	2 p. m.	209.93	978	29.850	70	70.3	29.739				69.5	56	13.5	do.	do.	
Do.	17	2 p. m.	209.93	977	29.850	70	70.3	29.739	29.708			69.5	56	13.5	do.	do.	
Do.	17	3 p. m.	209.93	978	29.836	64.9		29.738				64	54	10	do.	Light cir.&C.S.4	
Do.	17	3 p. m.	209.93	977	29.831	64.9	64.8	29.736	29.713			64	54	10	do.	do.	
Do.	17	4 p. m.	209.93	978	29.824	62	62	29.734				61	53	8	do.	do.	
Do.	17	4 p. m.	209.93	977	29.822	62	62	29.732	29.711			61	53	8	do.	do.	
Do.	17	5 p. m.	209.93	978	29.808	56	56	29.734				56	50	6	do.	do.	
Do.	17	5 p. m.	209.93	977	29.804	56	56	29.730	29.707			56	50	6	do.	C. & C. S. 4	
Do.	17	6.45 p. m.	209.93	392	29.849	51.9	52	29.786				52	47	5	do.	C. & C. S. 4	
Do.	17	6.45 p. m.	209.93	978	29.812	52	52	29.749				52	47	5	do.	C. & C. S. 4	
Do.	17	6.45 p. m.	209.93	977	29.814	52	52	29.751	29.719			52	47	5	do.	C. & C. S. 4	
Do.	18	7.20 a. m.	209.93	392	29.823	38	38.2	29.797				38	35.5	2.5	do.	C. & C. S. 4	
Do.	18	7.20 a. m.	209.93	978	29.790	38	38.2	29.764				38	35.5	2.5	do.	C. & C. S. 4	
Do.	18	7.20 a. m.	209.93	977	29.780	38	38.2	29.754	29.708			38	35.5	2.5	do.	C. & C. S. 4	
Do.	18	8 a. m.	209.93	392	29.839	43.9	44	29.800				44	40	4	do.	C. & C. S. 4	
Do.	18	8 a. m.	209.93	978	29.814	44	44	29.772				44	40	4	do.	C. & C. S. 4	
Do.	18	8 a. m.	209.93	977	29.814	44	44	29.772	29.718			44	40	4	do.	C. & C. S. 4	
Do.	18	9 a. m.	209.93	392	29.879	56	56	29.802				55.5	48	7.5	do.	C. & C. S. 4	
Do.	18	9 a. m.	209.93	978	29.852	56	56	29.778				55.5	48	7.5	do.	C. & C. S. 4	
Do.	18	9 a. m.	209.93	977	29.850	56	56	29.776	29.718			55.5	48	7.5	do.	C. & C. S. 4	
Do.	18	10 a. m.	209.93	392	29.900	61.5	61.8	29.812				61	56	5	do.	C. & C. S. 4	
Do.	18	10 a. m.	209.93	978	29.866	62	61.8	29.776				61	56	5	do.	C. & C. S. 4	
Do.	18	10 a. m.	209.93	977	29.870	62	61.8	29.780	29.723			61	56	5	do.	C & C. S. 4	
Do.	18	11 a. m.	209.93	978	29.879	67.5	67	29.775				67.3	53.8	13.5	E.	C. & C. S. 4	
Do.	18	11 a. m.	209.93	977	29.884	67.5	67	29.780	29.727			67.3	53.8	13.5	do.	C. & C. S. 4	
Do.	18	0.45 p. m.	209.93	978	29.864	71	71.5	29.750				71	55	16	N.W. 3.	Clear	
Do.	18	0.45 p. m.	209.93	977	29.864	71	71.5	29.750	29.717			71	55	16	N.W. 3.	Clear	
Do.	18	1 p. m.	209.93	978	29.860	71.5	72	29.745				71.5	56	15.5	N.W. 3.	Clear	

Do.	18	1 p. m.	209.93	977	29.855	71.5	72	29.730	29.727			71.5	56	15.5	N.W. 3.	Clear.
Do.	18	2 p. m.	209.93	978	29.851	73		29.732				73			N.W. 3.	Clear.
Do.	18	2 p. m.	209.93	977	29.847	73		29.728	29.729			73			N.W. 3.	Clear.
Do.	18	2.45 p. m.	209.93	978	29.844	73	72	29.725				73	57	16	N.W. 3.	Clear.
Do.	18	2.45 p. m.	209.93	977	29.840			29.721	29.725			73	57	16	N.W. 3.	Clear.
Do.	18	5 p. m.	209.93	392	29.850	62		29.760							N.W. 3.	C. S. 2.
Do.	18	5 p. m.	209.93	978	29.818	63	61.9	29.725	29.717			61	53.2	8.2	N.W. 3.	C. S. 2.
Do.	18	9 p. m.	209.93	392	29.861	44.5	44.9	29.818				44.9	43	1.9	N.W. 3.	C. S. 2.
Do.	18	9 p. m.	209.93	978	29.820	44.5	44.9	29.777				44.9	43	1.9	N.W. 3.	C. S. 2.
Do.	18	9 p. m.	209.93	977	29.816	44.5	44.9	99.773	29.722			44.9	43	1.9	N.W. 3.	C. S. 2.
Do.	19	7.30 a. m.	209.93	392	29.880	47	48	29.830				47	45	2	N.W. 3.	C. S. 2.
Do.	19	7.30 a. m.	209.93	978	29.842	47.5	48	29.791				47	45	2	N.W. 3.	C. S. 2.
Do.	19	7.30 a. m.	209.93	977	29.842	47.5	48	29.791	29.727			47	45	2	N.W. 3.	C. S. 2.
Do.	19	9 a. m.	209.93	392	29.910	55.5	56	29.838				56	51	5	N.W. 3.	C. S. 2.
Do.	19	9 a. m.	209.93	978	29.868	55.9	56	29.795				56	51	5	N.W. 3.	C. S. 2.
Do.	19	9 a. m.	209.93	977	29.870	55.9	56	29.797	29.722			56	51	5	N.W. 3.	C. S. 2.
Do.	19	10 a. m.	209.93	392	29.930	59.5	59.5	29.847				59.2	52	7.2	N. 5.	C. S. 2.
Do.	19	10 a. m.	209.93	978	29.900	59.5	59.5	29.817				59.2	52	7.2	N. 5.	C. S. 2.
Do.	19	10 a. m.	209.93	977	29.902	59.5	59.5	29.819	29.742			59.2	52	7.2	N. 5.	C. S. 2.
Do.	19	11 a. m.	209.93	392	29.930	61.5	61.5	29.842				61.5	53.5	8	S. 5.	C. S. 2.
Do.	19	11 a. m.	209.93	978	29.900	61.8	61.5	29.812				61.5	53.5	8	S. 5.	C. S. 2.
Do.	19	11 a. m.	209.93	977	29.902	61.8	61.5	29.814	29.737			61.5	53.5	8	S. 5.	C. S. 2.
Do.	19	12 m.	209.93	392	29.920	64.5	64	29.824				63.5	53	10.5	S. 5.	C. S. 2.
Do.	19	12 m.	209.93	978	29.890	64.5	64	29.794				63.5	53	10.5	S. 5.	C. S. 2.
Do.	19	12 m.	209.93	977	29.896	64.5	64	29.800	29.742			63.5	53	10.5	S. 5.	C. S. 2.
Do.	19	1 p. m.	209.93	392	29.900	66.5	66	29.797				65	55	10	S. 5.	C. S. 2.
Do.	19	1 p. m.	209.93	978	29.870	66	66	29.769				65	55	10	S. 5.	C. S. 2.
Do.	19	1 p. m.	209.93	977	29.866	66	66	29.765	29.750			65	55	10	S. 5.	C. S. 2.
Do.	19	2 p. m.	209.93	392	29.899	66.6	66.3	29.797				65.5	54	11.5	N.W. 5.	C. S. 2.
Do.	19	2 p. m.	209.93	978	29.866	66.6	66.3	29.764				65.5	54	11.5	N.W. 5.	C. S. 2.
Do.	19	2 p. m.	209.93	977	29.864	66.6	66.3	29.762	29.737			65.5	54	11.5	N.W. 5.	C. S. 2.
Do.	19	3 p. m.	209.93	392	29.899	64.5	64	29.803				63	53	10	N.W. 5.	C. S. 2.
Do.	19	3 p. m.	209.93	978	29.866	64	64	29.771				63	53	10	N.W. 5.	C. S. 2.
Do.	19	3 p. m.	209.93	977	29.864	64	64	29.769	29.746			63	53	10	N.W. 5.	C. S. 2.
Do.	19	4 p. m.	209.93	392	29.885	61	61	29.798				61	51.5	9.5	N.W. 5.	C. S. 2.
Do.	19	4 p. m.	209.93	978	29.846	61	61	29.759				61	51.5	9.5	N.W. 5.	C. S. 2.
Do.	19	4 p. m.	209.93	977	29.850	61	61	29.763	29.740			61	51.5	9.5	N.W. 5.	C. S. 2.
Do.	19	5.15 p. m.	209.93	392	29.875	55.3	55.5	29.804				55	48.5	7.5	N.W. 5.	C. S. 2.
Do.	19	5.15 p. m.	209.93	978	29.840	55.3	55.5	29.769				55	48.5	7.5	N.W. 5.	C. S. 2.
Do.	19	5.15 p. m.	209.93	977	29.838	55.3	55.5	29.767	29.733			55	48.5	7.5	N.W. 5.	C. S. 2.
Do.	20	7.20 a. m.	209.93	392	29.940	45	45.2	29.896				45	41	4	N.W. 5.	C. S. 2.
Do.	20	7.20 a. m.	209.93	978	29.906	45	45.2	29.862				45	41	4	N.W. 5.	C. S. 2.
Do.	20	7.20 a. m.	209.93	977	29.910	45	45.2	29.866	29.758			45	41	4	N.W. 5.	C. S. 2.
Do.	20	8 a. m.	209.92	392	29.950	50	51	29.892				50.5	44	6.5	N.W. 5.	C. S. 2.
Do.	20	8 a. m.	209.93	978	29.912	50.4	51	29.853				50.5	44	6.5	N.W. 5.	C. S. 2.
Do.	20	8 a. m.	209.93	977	29.920	50.4	51	29.861	29.751			50.5	44	6.5	N.W. 5.	C. S. 2.
Do.	20	9 a. m.	209.93	392	29.970	53	53.4	29.904				53	45.5	7.5	S.E. 1.	
Do.	20	9 a. m.	209.93	978	29.940	53.2	53.4	29.874				53	45.5	7.5	S.E. 1.	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 17	Jan. 20	9 a. m.	209.93	977	29.946	53.2	53.4	29.880	29.748	....	....	53	45.5	7.5	S.E. 1	....	
Do.	20	10.15 a. m	209.93	978	29.968	55	55 5	29.897	....	....	....	55	47	9	S.E. 1	....	
Do.	20	10.15 a. m.	209.93	977	29 973	55	55 5	29.902	29.769	....	....	55	47	9	S.E. 1	....	
Do.	20	10.30 a. m.	209.93	978	29 974	55.8	56	29.900	....	....	....	55 8	47	8.8	S.E. 1	....	
Do.	20	10.30 a. m.	209.93	977	29.986	55.8	56	29.912	29.781	....	....	55.8	47	8.8	S.E. 1	....	
Do.	20	10 45 a. m.	209.93	978	29.976	56	56 8	29.902	....	....	....	57	47.2	10 2	S.E. 1	....	
Do.	20	10 45 a. m.	209 93	977	29.988	56	56.8	29.914	29.783	....	....	57	47.2	10.2	S E. 1	....	
Do.	20	11 a. m.	209.93	978	29.971	56	56.5	29.897	....	....	....	57.2	47	10.2	S.E. 1	....	
Do.	20	11 a. m.	209.93	977	29.976	56	56.5	29.902	29.784	....	....	57.2	47	10 2	S.E. 1	....	
Do.	20	11.15 a. m.	209.93	978	29.964	56.5	57	29.889	....	....	....	56.8	47.2	9.6	S.E. 1	....	
Do.	20	11.15 a. m.	209.93	977	29 964	56.5	57	29.889	29.768	....	....	56.8	47.2	9.6	S.E. 1	....	
Do.	20	11.30 a. m.	209.93	978	29.962	57.2	58	29.886	....	....	....	57	47.8	10.8	S E. 1	....	
Do.	20	11.30 a. m.	209 93	977	29 960	57 2	58	29.884	29.771	....	....	57	47.8	10.8	S.E. 1	....	
Do.	20	11.45 a. m.	209 93	978	29.959	59	58.2	29.877	....	....	....	57.8	48	9.8	S.E. 1	....	
Do.	20	11.45 a. m.	209.93	977	29 954	59	58.2	29.872	29.769	....	....	57.8	48	9.8	S.E. 1	....	
Do.	20	12 m.	209.93	978	29.950	58.8	58 8	29.870	....	....	....	58.5	47.8	10.7	S.E. 2	C. S. 2	
Do.	20	12 m	209 93	977	29 950	58.8	58.8	29.870	29.766	....	....	58.5	47.8	10.7	S.E. 2	C. S. 2	
Do.	20	1 p. m.	209.93	392	39.960	60.2	60	29.869	....	....	....	59.8	48	11.8	S.E. 2	C. S. 2	
Do.	20	1 p. m.	209.93	978	29 930	60	60	29.845	....	....	....	59.8	48	11 8	S.E. 2	C. S. 2	
Do.	20	1 p. m.	209.93	977	29.928	60	60	29.843	29.764	....	....	59.8	48	11.8	S.E 2	C. S. 2	
Do.	20	2 p. m.	209.93	392	29.950	60.5	60.4	29 864	....	....	....	60	48	12	S.E. 2	C. S. 2	
Do.	20	2 p. m.	209.93	978	29.920	60.5	60.4	29.834	....	....	....	60	48	12	S.E. 2	C. S. 2	
Do.	20	2 p. m.	209.93	977	29.920	60.5	60.4	29.834	29.757	....	....	60	48	12	S.E. 2	C. S. 2	
Do.	20	3 p. m.	209.93	392	29.945	61	60	29.858	....	....	....	59.8	47.2	12.6	S.E. 1	C. S. 2	
Do.	20	3 p. m.	209.93	978	29.910	60.5	60	29.824	....	....	....	59.8	47.2	12.6	S.E. 1	C. S. 2	
Do.	20	3 p. m.	209.93	977	29.910	60 5	60	29.824	29.750	....	....	59.8	47.2	12.6	S.E. 1	C. S. 2	
Do.	20	4.15 p. m.	209.93	392	29 934	57.5	57.4	29.857	....	....	....	57	47	10	S.E. 1	C. S. 2	
Do.	20	4.15 p. m.	209 93	978	29.900	57.5	57.4	29.823	....	....	....	57	47	10	S.E. 1	C. S. 2	
Do.	20	4.15 p. m.	209.93	977	29.894	57.5	57.4	29.817	29.749	....	....	57	47	10	S.E. 1	C. S. 2	
Do.	20	5.15 p. m.	209 93	392	29.925	52	52.2	29.862	....	....	....	52	44	8	S.E. 1	C. S. 2	
Do.	20	5.15 p. m.	209.93	978	29.896	....	....	29 833	....	....	....	52	44	8	S.E 1	C. S. 2	
Do.	20	5.15 p. m.	209.93	977	29.886	....	....	29.823	29.743	....	....	52	44	8	S.E. 1	C. S. 2	
Do.	21	7.15 a. m.	209.93	392	29.935	34 5	35	29.919	....	....	....	34	32	2	S.E. 5	C. S. 2	
Do.	21	7.15 a. m.	209 93	978	29.902	34.5	35	29.886	....	....	....	34	32	2	S.E. 5	C. S. 2	
Do.	21	7.15 a. m.	209.93	977	29.900	34.5	35	29.884	29.725	....	....	34	32	2	S.E. 5	C. S. 2	

Do.	21	8 a. m.	209.93	392	29.960	37.8	38.4	29 935				38	35	3	S.E. 5	C. S. 2
Do.	21	8 a. m.	209.93	978	29.924	37.5	38.4	29.900				38	35	3	S.E. 5	C. S. 2
Do.	21	8 a. m.	209.93	977	29.926	37.5	38.4	29.902	29.739			38	35	3	S.E. 5	C. S. 2
Do.	21	9 a. m.	209.93	392	29.971	46.8	47	29 922				46.5	42	4.5	S E. 5	C. S. 2
Do.	21	9 a. m.	209.93	978	29.940	46.5		29.891				46.5	42	4.5	S.E. 5	C. S. 2
Do.	21	9 a. m.	209.93	977	29.946			29.897	29.715			46.5	42	4.5	S.E. 5	C. S. 2
Do.	21	10 a. m.	209.93	392	30.010	55.9	56	29.937				55	47	8	S.E. 5	C. S. 2
Do.	21	10 a. m.	209 93	978	29.984	55.5	56	29.911				55	47	8	S.E. 5	C. S. 2
Do.	21	10 a. m.	209.93	977	29.988	55.5	56	29.915	29.735			55	47	8	S.E. 5	C. S. 2
Do.	21	11 a. m.	209.93	392	30.015	60.4	60.4	29.929				59	48.5	10.5	S.E. 5	C. S. 2
Do.	21	11 a. m.	209.93	978	29.984	60		29.899				59	48.5	10.5	S.E. 5	C. S. 2
Do.	21	11 a. m.	209.93	977	29.990	60	60.4	29.905	29.735			59	48.5	10.5	S.E. 5	C. S. 2
Do.	21	12 m.	209.93	392	30.012	66.4	66.2	29.910				65.5	51	14.5	S.E. 5	C. S. 2
Do.	21	12 m.	209.93	978	29.980	66.4	66.2	29.878				65.5	51	14.5	S.E. 5	C. S. 2
Do.	21	12 m.	209.93	977	29.988	66.4	66.2	29.886	29.738			65.5	51	14.5	S.E. 5	C. S. 2
Do.	21	1 p. m.	209.93	392	29.990	72	71.5	29.873				71	52	19	N.W. 5	C. S. 2
Do.	21	1 p. m.	209.93	978	29.952	71	71.5	29.838				71	52	19	N.W. 5	C. S. 2
Do.	21	1 p. m.	209.93	977	29.954	71	71.5	29.840	29.719			71	52	19	N.W. 5	C. S. 2
Do.	21	3 p. m.	209.93	392	29.980	70.6	70.3	29.868				69.8	53	16.8	N.W. 5	C. S. 2
Do.	21	3 p. m.	209.93	978	29.942	70	70.3	29.831				69.8	53	16.8	N.W. 5	C. S. 2
Do.	21	3 p. m.	209.93	977	29.938	70	70.3	29.827	29.712			69.8	53	16.8	N.W. 5	C. S. 2
Do.	21	4 p. m.	209.93	392	29.976	69	69	29.867				68.8	51.5	17.3	N.W. 5	C. S. 2
Do.	21	4 p. m.	209.93	978	29.942	68.9	69	29.833				68.8	51.5	17.3	N.W. 5	C. S. 2
Do.	21	4 p. m.	209.93	977	29.933	68.9	69	29.829	29.715			68.8	51.5	17.3	N.W. 5	C. S. 2
Do.	21	5 p. m.	209.93	392	29.968	59.8	59.8	29.884				59	48.2	10.8	N.W. 5	C. S. 2
Do.	21	5 p. m.	209.93	978	29 938	59	59.8	29.856				59	48.2	10.8	N.W. 5	C. S. 2
Do.	21	5 p. m.	209.93	977	29.931	59	59.8	29.852	29.723			59	48.2	10.8	N.W. 5	C. S. 2
Do.	22	7.15 a. m.	209.93	392	29.940	37.5	38	29.926				37	33	4	N.W. 5	C. S. 2
Do.	22	7.15 a. m.	209.93	978	29.906	37.5	38	29.882				37	33	4	N.W. 5	C. S. 2
Do.	22	7.15 a. m.	209.93	977	29.906	37.5	38	29.882	29.741			37	33	4	N.W. 5	C. S. 2
Do.	22	8 a. m.	209.93	392	29.950	41	42.2	29.916				41	36.2	4.8	N.W. 5	C. S. 2
Do.	22	8 a. m.	209.93	978	29.910	41	42.2	29.876				41	36.2	4.8	N.W. 5	C. S. 2
Do.	22	8 a. m.	209.93	977	29.912	41	42.2	29.878	29.732			41	36.2	4.8	N.W. 5	C. S. 2
Do.	22	9 a. m.	209.93	392	29.969	51.8	52	29.907				51.5	44	7.5	N.W. 5	C. S. 2
Do.	22	9 a. m.	209.93	978	29.936	51.9	52	29.874				51.5	44	7.5	N.W. 5	C. S. 2
Do.	22	9 a. m.	209.93	977	29.938	51.9	52	29.876	29.728			51.5	44	7.5	N.W. 5	C. S. 2
Do.	22	11 a. m.	209 93	392	30.005	71	71	29.891				71	51.5	19.5	S.E. 5	C. S. 2
Do.	22	11 a. m.	209.93	978	29.970	70.9	71	29.856				71	51.5	19.5	S.E. 5	C. S. 2
Do.	22	11 a. m.	209.93	977	29.926	70.9	71	29.862	29.729			71	51.5	19.5	S.E. 5	C. S. 2
Do.	22	12 m.	209.93	392	29.985	74	74	29.863				73.5	54.2	19.3	S.E. 5	C. S. 2
Do.	22	12 m.	209.93	978	29.958	73.9	74	29.836				73.5	54.2	19.3	S.E. 5	C. S. 2
Do.	22	12 m.	209.93	977	29.952	73.9	74	29.830	29.729			73.5	54.2	19.3	S.E. 5	C. S. 2
Do.	22	2 p. m.	209.93	392	29.928	75.2	75	29.803				74 9	55	19.9	S.E. 5	C. S. 2
Do.	22	2 p. m.	209.93	978	29.892	75.2	75	29.767				74.9	55	19.9	S.E. 5	C. S. 2
Do.	22	2 p. m.	209.93	977	29.896	75.2	75	29.771	29.703			74.9	55	19.9	S.E. 5	C. S. 2
Do.	22	3 p. m.	209.93	392	29.925	74.5	74.2	29.800				73.9	53	20.9	S.E. 5	C. S. 2
Do.	22	3 p. m.	209.93	978	29.890	74.3	74.2	29.767				73.9	53	20.9	S.E. 5	C. S. 2
Do.	22	3 p. m.	209.93	977	29.890	74.3	74.2	29.767	29.713			73.9	53	20.9	S.E. 5	C. S. 2

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 17	Jan. 22	4 p. m.	209.93	392	29.915	71.5	71.2	29.800				70.5	53.5	17	S.E. 5	C. S. 2	
Do.	22	4 p. m.	209.93	978	29.880	71	71.2	29.766				70.5	53.5	17	S.E. 5	C. S. 2	
Do.	22	4 p. m.	209.93	977	29.878	71	71.2	29.764	29.714			70.5	53.5	17	S.E. 5	C. S. 2	
Do.	22	5.15 p. m.	209.93	392	29.910	65	65.5	29.812				65	48.2	16.8	S.E. 5	C. S. 2	
Do.	22	5.15 p. m.	209.93	978	29.876	65.3	65.5	29.777				65	48.2	16.8	S.E. 5	C. S. 2	
Do.	22	5.15 p. m.	209.93	977	29.872	65.3	65.5	29.773	29.722			65	48.2	16.8	S.E. 5	C. S. 2	
Do.	23	7.20 a. m.	209.93	392	29.879	39	39.7	29.851				39	36	3	S.E. 5	C. S. 2	
Do.	23	7.20 a. m.	209.93	978	29.838	39.5	39.7	29.809				39	36	3	S.E. 5	C. S. 2	Not used.
Do.	23	7.20 a. m.	209.93	977	29.840	39.5	39.7	29.811	29.768	29.722	286.8	39	36	3	S.E. 5	C. S. 2	
Between stations 1 & 2, summit	23	9.30 a. m.	210.73	392	29.839	65.4	65	29.740	29.651		355.1				E. 5	C. S. 2	
Station 71, level station 71, (Arroyo Grande)	23	10.45 a. m.	210.73	392	30.039	76	75	29.912			198.5				N.E. 5	C. S. 2	
Do.	23	10.55 a. m.	210.73	392	29.039	76.4	76	29.911	29.820	29.820	198.5				N.E. 5	C. S. 2	
Station 6, R. survey on high hill	23	1.45 p. m.	214.73	392	29.690	74.2	73	29.568	Not used						S. 5	C. S. 2	Not used.
Do.	23	2.20 p. m.	214.73	392	29.680	74.5	73.5	29.557							S. 5	C. S. 2	
Do.	23	2.40 p. m.	214.73	392	29.680	72.5	72.5	29.562	29.465	29.468	540.7				S. 5	C. S. 2	
Camp No. 18, near Arroyo Grande	23	4.45 p. m.	215.63	392	29.820	61.3	62	29.732	29.640						S. 5	C. S. 2	
Do	23	5.15 p. m.	215.63	392	29.812	58.5	59	29.732	29.632						S. 5	C. S. 2	
Do.	23	7.40 p. m.	215.63	392	29.819	52	52.8	29.756				52	46	6	S. 5	C. S. 2	
Do.	23	7.40 p. m.	215.63	978	29.800	53	52.8	29.734	29.708			52	46	6	S. 5	C. S. 2	
Do.	24	7.20 a. m.	215.63	392	29.790	49	49.5	29.735				49	44	5	S. 5	C. C. S. 6	
Do.	24	7.20 a. m.	215.63	978	29.758	49.5	49.5	29.702	29.656			49	44	5	S. 5	C. C. S. 6	
Do.	24	8 a. m.	215.63	392	29.805	53	53.4	29.739				52.5	47	5.5	S. 5	C. C. S. 6	
Do.	24	8 a. m.	215.63	978	29.770	53	53.4	29.704	29.668			52.5	47	5.5	S. 5	C. C. S. 6	
Do.	24	9 a. m.	215.63	392	29.832	63	63	29.741				62	55	7	S. 5	C. C. S. 5	
Do.	24	9 a. m.	215.63	978	29.798	62.5	63	29.709	29.662			62	55	7	S. 5	C. C. S. 5	
Do.	24	11.30 a. m.	215.63	978	29.821	65	65	29.726	29.686			64.8	55.5	9.3	S. 5	C. C. S. 4	
Do.	24	0.15 p. m.	215.63	978	29.802	67	67	29.699	29.686			66.5	56.5	10	S. 5	C. C. S. 4	
Do.	24	1.30 p. m.	215.63	978	29.766	70	70	29.655	29.669			69.5	57.5	12	S. 5	C. C. S. 3	
Do.	24	2 p. m.	215.63	978	29.764	70	70	29.653	29.672			69.5	58	11.5	S. 5	C. C. S. 3	
Do.	24	3 p. m.	215.63	978	29.763	68	68.5	29.657	29.683			68	56.5	11.5	S. 5	C. C. S. 5	
Do.	24	4 p. m.	215.63	978	29.759	66	66.8	29.658	29.686			66	58	8			
Do.	24	5 p. m.	215.63	978	29.755	60.8	61.2	29.668	29.693			61	56	5			
Do.	25	6.50 a. m.	215.63	392	29.710	45.6	47	29.665							S. 5	C. C. S. 2	

Do	25	6.50 a. m.	215.63	978	29.678	47	47	29.628	29.668	29.672	334.0				S. 5	C. C. S. 2	
Station 1 + 2457	25	7.25 a. m.	216 28	392	29.779	56	55.5	29.705	29.677		327.7				S. 5	C. C. S. 1	
Station 1 + 2511	25	7 35 a. m.	216.41	392	29.745	57	56	29.669	29.646		356.9				S. 5	C. C. S. 1	
Station 2	25	8 a. m.	216.72	392	29.830	57.8	58	29 752	29.728		281.1				S. 5	C. C. S. 1	
Station 3	25	8.20 a. m.	217.45	392	29.750	61	61.2	29.663	29.634		359.9				S. 5	C. C. S. 1	
Station 3 + 3355	25	8 50 a. m.	218.45	392	29.830	67	67.5	29.727	29.696		313.8					C. C. S. 1	
Station 4	25	9 a. m.	218.65	392	29.915	68	69.5	29.809	29.780		235.0				E. 1	C. C. S. 1	
Station 5	25	9.25 a. m.	219.88	392	29.720	71.9	72 5	29.603	29.575		430.8				E. 2		
Between stations 6 and 7	25	10.55 a. m.	222.79	392	29.785	76.5	75.5	29.657	29.641		368.6				E. 1		
Station 7, west side Guadalupe Largo	25	0.20 p. m.	226.29	392	29.840	82	81	29.697	29.690		315.5						
Station 8, on bluff, east side do.	25	2.20 p. m.		392	29.745	83	82	29.599	29.575		434.8						
Between stations 8 and 9, east side of sand hill	25	3.45 p. m.	236.29	392	29.430	78.5	78.2	29.296									
Do	25	4.10 p. m.	236.29	392	*29.425	77	77	29.295	29.268	29.268	728.8						
Camp No. 19, east Guadalupe Largo	25	5.05 p. m.	237.29	392	29.410	70	71.5	29.299									
Do	25	5.05 p. m.	237.29	978	29.372	69	71.5	29.263	29.335								
Do	25	5.20 p. m.	237.29	392	29.400	61	61.5	29.314				61	55	6	N. of W. 5	C. S. 1	
Do	25	5.20 p. m.	237.29	978	29.394	61	61.5	29.298	29.361			61	55	6	N. of W. 5	C. S. 1	
Do	25	8.20 p. m.	237.29	392	29.410	54.5	56	29.342				54.5	47	7.5	N. of W. 5	C. S. 1	
Do	25	8.20 p. m.	237.29	978	29.370	54.5	56	29.302	29.351			54.5	47	7.5	N. of W. 5	C. S. 1	
Do	26	6.45 a. m.	237.29	392	29.460	63	63.5	29.369				63	47	16	E. 5	C. S. 1	
Do	26	6.45 a. m.	237.29	978	29.426	63	63.5	29.335	29.326			63	47	16	E. 5	C. S. 1	
Do	26	7.05 a. m.	237.29	392	29.470	65	65.8	29.374							E. 5	C. S. 1	
Do	26	7.05 a. m.	237.29	978	29.438	65.2	65.8	29.311	29.326	29.339	651.2				E. 5	C. S. 1	
Between stations 0 and 1	26	7.55 a. m.	238.29	392	29.380	68	67	29.276	29.227		760.3				E 1	C. S. 1	
Station 1	26	8.30 a. m.	239.68	392	29.225	68	67.5	29.121	29 067		914.9				E. 1	C. S. 1	
Station 2, summit	26	9 a. m.		392	29.092	69.9	70	28.983	28.921		1,056.9				E. 5	C. S. 1	
Station 5	26	9.50 a. m.	242.86	392	29.470	69	68.5	29 363	29.306		685.6				E. 5	C. S. 1	
Station 6, crossing of creek	26	11 a. m.	244.96	392	29.680	52.5	81.5	29.538	29.486		527.5				E. 5	C. S. 1	
Station 7	26	0.50 p. m.	245.80	392	29.530	81.5	84.5	29.383	29.368		636.5					C. S. cum. 2	
Camp No. 20, Rancho Laguna	26	3 p. m.	250.30	392	29.420	78.5	77.8	29.289							W. 1		
Do	26	4 p. m.	250.30	978	29.386	78.5	77.8	29.255	29.287						W. 1	C. S. cum. 2	
Do	26	4 p. m.	250.30	392	29.425	73.4	73.5	29.307				73	56	17	W. 1	C. S. cir. 3	
Do	26	4 p. m.	250.30	978	29.390	73.5	73.5	29.272	29.306			73	56	17	W. 1	C. S. cir. 3	
Do	26	5.10 p. m.	250.30	392	29 405	63	63.2	29.314				61 5	51.5	10	W. 1	C. S. cir. 3	
Do	26	5.10 p. m.	250.30	978	29.372	63.5	63.2	29.280	29.311			61.5	51.5	10	W. 1	C. S. cir. 3	
Do	26	7.30 p. m.	250.30	392	29.480	46	47	29.434				47	42.5	4.5	W. 1	C. S. cir. 3	Not used.
Do	26	7.30 p. m.	250.30	978	29.348	46	47	29.302	29.364			47	42.5	4.5	W. 1	C. S. cir. 3	Do.
Do	27	6.40 a. m.	250.30	392	29.330	37	38	29.308								C. S. cir. 3	Do.
Do	27	6.40 a. m.	250.30	978	29.294	37.5	38	29.271	29.238	29.301	684.6					C. S. cir. 3	Do.
Between stations 1 and 2	27	8.15 a. m.	253.71	392	29.030	58.5	59.4	28.951	28.882		1084.5					C. S. cir. 3	
Station 2	27	8.50 a. m.	254.87	392	28.395	64.2	61.5	28.305	28.229							C. S. cir. 3	Do.
Station 2, lowest point of divide	27	9.10 a. m.	254.87	392	28.450	65.9	66	28.351	28.275		1592.0				E. 5	C. S. cir. 3	
Between stations 2 and 3	27	9.50 a. m.	255.04	392	28.720	68.9	69.5	28.617	28.539		1434.9				E. 5	C. S. cir. 3	
Do	27	11.55 a. m.	255.04	392	29.415	75.5	75.4	29.292	29.252		743.3				E. 5	C. S. cir. 3	
Station 3	27	0.20 p. m.	259.24	392	29.480	80	81	29.343	29.321		681.5				E. 5	C. S. cir. 3	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches	Inches.	Inches.	Feet.	°	°	°			
Between stations 4 and 5	Jan. 27	1.50 p. m.	262.34	392	29.600	77	76 9	29.472	29.463	....	540.3	......	......	......	S.E. 2	C. S. cir. 3	
Camp No. 21, near Santa Inez.	27	4.30 p. m.	266.08	392	29.470	67	67.1	29.368	....	....	....	67	52	15	N. of W. 5	C. S. cir. 1	
Do	27	4.30 p. m.	266.08	978	29.438	67	67.1	29.336	....	....	....	67	52	15	....do....	C. S. cir. 1	
Do	27	4.30 p. m.	266.08	977	29.440	67	67.1	29 338	29.359	....	....	67	52	15	....do....	C. S. cir. 1	
Do	27	5.15 p. m.	266.08	392	29.480	63	61.8	29.389	....	....	....	61	50.5	10.5	....do....	C. S. cir. 2	
Do	27	5.15 p. m.	266.08	978	29.450	62.9	61.8	29.359	....	....	....	61	50.5	10.5	....do....	C. S. cir. 2	
Do	27	5.15 p. m.	266.08	977	29.448	62.9	61.8	29.357	29.377	....	....	61	50.5	10.5	....do....	C. S. cir. 2	
Do	27	8.30 p. m.	266.08	392	29.460	41.5	42	29.427	....	....	....	42	39.9	2.1	....do....	C. S. cir. 2	
Do	27	8.30 p. m.	266.08	978	29.430	41.6	42	29.397	....	....	....	42	39.9	2.1	....do....	C. S. cir. 2	
Do	27	8.30 p. m.	266.08	977	29.426	41.6	42	29.393	29.376	....	....	42	39.9	2.1	....do....	C. S. cir. 2	
Do	28	7.10 a. m.	266.08	392	29.445	33	33.5	29.433	....	....	....	33	32.5	0.5	....do....	C. S. cir. 4	
Do	28	7.10 a. m.	266.08	978	29.408	33	33.5	29.297	....	....	....	33	32.5	0.5	....do....	C. S. cir. 4	
Do	28	7.10 a. m.	266.08	977	29.404	33	33.5	29.292	29.431	....	....	33	32.5	0.5	....do....	C. S. cir. 4	
Do	28	8 a. m.	266.08	392	29.470	38	37.9	29.445	....	....	....	37.8	36.5	1.3	....do....	C. S. cir. 4	
Do	28	8 a. m.	266.08	978	29.430	37.4	37.9	29.407	....	....	....	37.8	36.5	1.3	....do....	C. S. cir. 4	
Do	28	8 a. m.	266.08	977	29.432	37.4	37.9	29.409	29.392	....	....	37.8	36.5	1.3	....do....	C. S. cir. 4	
Do	28	9 a. m.	266.08	978	29.490	49.5	49	29.434	....	....	....	47.8	45	2.8	...do....	C. S. cir. 7	
Do	28	9 a. m.	266.08	977	29.488	49.5	49	29.433	29.406	....	....	47.8	45	2.8	....do....	C. S. cir. 7	
Do	28	10 a. m.	266.08	978	29.500	56.6	56.6	29.426	....	....	....	55.4	48.4	7	....do....	C. S. cir. 2	
Do	28	10 a. m.	266.08	977	29.496	56.6	56.6	29.422	29.392	....	....	55.4	48.4	7	....do....	C. S. cir. 2	
Do	28	11 a. m.	266.08	978	29.492	61.2	60.9	29.405	....	....	....	60	51	9	....do....	C. S. cir. 1	
Do	28	11 a. m.	266.08	977	29.488	61.2	60.9	29.401	29.394	....	....	60	51	9	....do....	C. S. cir. 1	
Do	28	12 m	266.08	978	29.476	66	65	29.377	....	....	....	64.5	33.5	31	....do....	C. S. cir. 1	
Do	28	12 m	266.08	977	29.470	66	65	29.371	29.391	....	....	64.5	33.5	31	....do....	C. S. cir. 1	
Do	28	1 p. m.	266.08	978	29.444	71	70.5	29.332	....	....	....	70	57	13	....do....	C. S. cir. 1	
Do	28	1 p. m.	266.08	977	29.440	71	70.5	29.328	29.370	....	....	70	57	13	....do....	C. S. cir. 1	
Do	28	2 p. m.	266.08	978	29.444	73.6	73.5	29.326	....	....	....	72.2	57	15.2	....do....	C. S. cir. 2	
Do	28	2 p. m.	266.08	977	29.440	73.6	73.5	29.322	29.378	....	....	72.2	57	15.2	....do....	C. S. cir. 2	
Do	28	3 p. m.	266.08	978	29.424	69	68.8	20.317	....	....	....	68	58	10	....do....	C. S. cir. 1	
Do	28	3 p. m.	266.08	977	29.420	69	68.8	29.313	29.376	....	....	68	58	10	....do....	C. S. cir. 1	
Do	28	4 p. m.	266.08	978	29.416	65.9	65.5	29.317	....	....	....	65	56.5	8.5	....do....	C. S. cir. 2	
Do	28	4 p. m.	266.08	977	29.410	65.9	65.5	29.311	29.377	....	....	65	56.5	8.5	....do....	C. S. cir. 2	
Do	28	5.10 p. m.	266.08	978	29.398	58	58	29.320	....	....	....	57.9	53	4.9	...do....	C. S cir. 4	
Do	28	5.10 p. m.	266.08	977	29.398	58	58	29.320	29.375	....	....	57.9	53	4.9	..do....	C. S. cir. 4	
Do	29	7 a. m.	266.08	978	29.299	41.5	42	29.265	....	....	....	41.8	41	8	...do....	C. S. cir. 3	

Do.		29	7 a. m.	266.08	977	28.300	41.5	42	29.266	29.330	......	......	41.8	41	0.8	....do....	C. S. cir. 3	
Do.		29	8 a. m.	266.08	978	29.304	45	45.4	29.260	......	......	......	44.5	43.9	0.6	....do....	C. S. cir. 3	
Do.		29	8 a. m.	266 08	977	29.300	45	45.4	29.236	29.331	......	......	44.5	43.9	0.6	....do....	C. S. cir. 3	
Do.		29	9 a. m.	266.08	977	29.304	......	52	29.247	29.320	......	......	50.9	49	1 9	....do....	C. S. cir. 3	
Do.		29	10 a. m.	266.08	977	29.314	......	67	29.241	29.316	......	......	67	63.5	3.5	S.E. 1	C. S. cir. 1	
Do.		29	11 a. m.	266.08	977	29.340	......	68.5	29.236	29.315	......	......	63	55	13	S.E. 2	C. S. cir. 1	
Do.		29	12 m.	266.08	977	29.360	......	65.5	29.243	29.340	......	......	65.2	56	9.2	S.E. 2	C. C. S. cum. 3	Frequent gusts of wind.
Do.		29	1 p. m.	266.08	977	29.360	......	65.5	29.263	29.383	......	......	65.2	57.2	8	S.E. 1	C. C. S. 4	
Do.		29	2 p. m.	266.08	977	29.340	......	64.2	29.246	29.375	......	......	64	56	8	S.E. 1	C. C. S. 2	
Do.		29	3 p. m.	266.08	977	29.320	......	62.5	29.221	29.357	......	......	62	56	6	S.E. 1	C. C. S. 2	
Do.		29	4 p. m.	266.08	977	29.316	......	61.5	29.214	29.352	......	......	61	54.3	6.7	S.E. 1	C. C. S. 2	
Do.		29	5 p. m.	266.08	977	29.320	......	60.2	29.224	29.354	......	......	60	52.5	7.5	E. 1	C. C. S. cum. 9	
Do.		29	5.25 p. m.	266.08	977	29.320	......	59	29.233	29.363	......	......	58.5	52	6.5	S.E. 2	C. C. S. cum. 9	Commenced sprinkling about midnight. Slight showers occasionally since. Strong southeast wind during the night.
Do.		30	8 a. m.	266.08	977	29.438	......	57	29.352	29.408	......	......	57	53	4	S E 2	C. C. S. cum. nimb. 9.	
Do.		30	9 a. m.	266.08	977	29.440	......	58.5	29.361	29.404	......	......	58	54.2	3 8	S.E. 1	C. cum. C. S. 9	
Do.		30	10 a. m.	266.08	977	29.450	......	60.5	29.366	29.404	......	......	60.4	54.5	5.9	S.E. 2	C. cum. C. S. 8	
Do.		30	11 a. m.	266.08	977	29.454	......	60.5	29.370	29.412	......	......	60.2	54	6.2	S.E 2	C. cum. C. S. 7	
Do.		30	12 m	266.08	977	29.454	......	62.5	29.365	29.422	......	......	62	55.5	6.5	S.E. 2	C. cum. C. [illegible] 7	
Do.		30	1 p. m.	266.08	977	29.452	......	59.5	29.371	29.447	......	......	59	54	5	E. 2	C. cum. C. S. 9	
Do.		30	2 p. m.	256.08	977	29.434	......	65.3	29.338	29.431	......	......	64	56	8	E. 2	C. cum. C. S. 8	
Do.		30	3 p. m.	266.08	977	29.468	......	59.8	29.386	29.462	......	......	59	55	4	S E. 1	C. cum. C. S. 9	
Do.		30	4 p. m.	266.08	977	29.480	......	59.5	29.399	29.480	......	......	59	55	4	S.E. 1	C.S. cum. nim 9	Raining slightly. Commenced at 3.50, stopped 4.15.
Do.		30	5 p. m.	256.08	977	29.474	......	58	29.396	29.463	......	......	57.5	54.5	3	S E. 1	C S cum. nim 10	
Do.		30	5.25 p. m.	266.08	977	29.470	......	58.3	29.391	29.455	......	......	58	55	3	S.E. 1	C.S. cum. nim. 9	
Do.		31	7.20 a. m.	256.08	977	29.574	......	57	29.489	29.453	......	......	57	53.5	3.5	S.E. 1	C.S. cum. nim 4	
Do.		31	8 a. m.	266.08	977	29.580	......	57	29.500	29.460	......	......	58.5	55	3.5	S.E. 1	C.S. cum. nim. 4	
Do.		31	9 a. m.	266.08	977	29.590	......	62.1	29.502	29.447	......	......	61.5	56	5.5	S.E. 1	C. C S. 5	
Do.		31	10 a. m.	266.08	977	29.600	......	65	29.504	29.455	......	......	64.2	57	7.2	S.E. 1	C. C. S. 3	
Do.		31	11 a. m.	266.08	977	29.606	......	65.8	29.509	29.471	......	......	65	57.8	7.2	S.E. 1	C. C. S. cum. 5	
Do.		31	12 m	266.08	977	29.576	......	64.2	29.482	29.469	......	......	64	57.2	6.8	S.E. 1	C. C. S. cum. nim. 5.	
Do.		31	1 p. m.	263.08	977	29.550	......	65	29.454	29.470	......	......	64.4	57.2	7.2	S.E. 1	....do....4	
Do.		31	2 p. m.	256.08	977	29.530	......	64.6	29.435	29.460	......	......	64	58	6	S.E. 2	....do....2	
Do.		31	3 p. m.	266.08	977	29.524	......	64	29.430	29.476	......	......	63	57	6	S.E. 2	....do....2	
Do.		31	4 p. m.	266.08	977	29.520	......	61.5	29.433	29.475	......	......	61	56	5	S.E. 2	....do....2	
Do.		31	5.35 p. m.	266.08	977	29.500	......	59	29.420	29.458	......	......	58.5	55	3.5	S.E. 2	....do....1	
Do.	Feb.	1	7.50 a. m.	263.08	977	29.456	......	56.2	29.383	29.480	......	......	56	54.2	1.8	S.E. 1	Overcast nimb.	Raining.
Do.		1	9 a. m.	266.08	977	29.490	......	57.2	29.415	29.508	......	......	57	55	2	S.E. 2	....do....	A hard rain last night. Commenced about 2 a. m. Wind force 7. Raining slightly.
Do..		1	10 a. m.	266.08	977	29.504	......	56.5	29.425	29.520	......	......	53.2	55.5	2.7	S.E. 2	Overcast C. S. cum. nim. 9.	
Do.		1	11 a. m.	266.08	977	29.520	......	59.5	29.439	29.544	......	......	59	56	3	S.E. 2	....do....	
Do.		1	12 m.	266.08	977	29.510	......	58	29.432	29.559	......	......	58	56	2	S.E. 1	C.S. cum. nim. 9	
Do.		1	2 p. m.	266.08	392	29.472	58.5	58	29.393	29.527	......	......	58	56	2	S.E. 1	C S. cum. nim. 9	Commenced raining at 12.20, stopped at 1.15.
Do.		1	2 p. m.	266.08	977	29.490	58.5	58	29.394	......	......	......	......	......	......	S.E. 1	C.S. cum. nim. 7	
Do.		1	2 p. m.	266.08	392	29.458	62.5	......	29.369	......	......	......	......	......	......	S.E. 1	C.S. cum. nim. 7	
Do.		1	2 p. m.	266.08	978	29.492	61	......	29.406	29.529	......	......	......	......	......	S.E. 1	C.S. cum. nim. 7	
Do.		1	3 p. m.	266.08	392	29.570	......	59.5	29.489	......	......	......	59	56	3	S.E. 1	C.S. cum. nim. 7	

APPENDIX E—Continued.

Station.	Date.		Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.			Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 21	Feb.	1	3 p. m.	266.08	978	29.470	59.5	59.5	29.399				59	56	3	S.E. 1	C.S. cum.-nim. 7	
Do.		1	3 p. m.	266.08	977	29.464	59.5	59.5	29.383	29.537			59	56	3	S.E. 1	C.S. cum. nim. 7	
Do.		1	4 p. m.	266.08	392	29.570	58.2	57.8	29.492				57.5	56	1.5	S.E. 1	Overcast, nim.	Raining.
Do.		1	4 p. m.	266.08	978	29.470	58	57.8	29.400				57.5	56	1.5	S.E. 1	Overcast, nim.	
Do.		1	4 p. m.	266.08	977	29.462	58	57.8	29.384	29.537			57.5	56	1.5	S.E. 1	Overcast, nim.	
Do.		1	5.10 p. m.	266.08	392	29.492	57.5	58	29.416				57.8	56	1.8	S.E. 2	Overcast, nim. cum	
Do.		1	5.10 p. m.	266.08	978	29.456	57.5	58	29.380				57.8	56	1.8	S.E. 2	do.	
Do.		1	5.10 p. m.	266.08	977	29.450	57.5	58	29.374	29.510			57.8	56	1.8	S.E. 2	do.	
Do.		2	7 a. m.	266.08	392	29.480	50.5	51.2	29.422				51	51		S.E. 2	C. C.S.cum.nim 6	Raining hard all night.
Do.		2	7 a. m.	266.08	977	29.438	50.5	51.2	29.380				51	51		S.E. 2	C. C.S.cum.nim.6	
Do		2	7 a. m.	266.08	978	29.433	50.5	51.2	29.378	29.377	29.424	563.5	51	51		S.E. 2	C. C S.cum.nim.6	Slight fall of rain.
First summit, the lowest point of divide is about 30 feet below station 1		2	9.20 a. m.	267.47	978	28.866	62.5	60	28.777	28.751		1207.4				S.E. 2	C. C.S.cum.nim.6	Slight fall of rain.
Between stations 1 and 2		2	9.55 a. m.	267.58	978	29.066	60.5	60.4	28.982			997.1				S.E. 2	C. C.S cum.nim.6	
Do.		2	10.20 a. m.	267.58	978	29.070	61.8	61.3	28.985	28.967						S.E. 2	C. C S.cum.nim.6	
Foot of the hill and valley, stations 2 and 3		2	11.45 a. m.		978	29.268	58.5	58.5	29.189	29.210		763 9				S E. 4	C. C.S cum.nim.8	Raining.
Station 3, summit		2	12.10 a. m.	269.88	978	29.614	59.5	59.9	28.933	28.960		1004.0				S.E. 3	C. C.S.cum.nim.7	
Station, junction of road & creek		2	1.10 a. m.		978	29.228	61.2	60.8	29.142	29.200		771.7				S.W. 2	C. C.S.cum.nim.6	
Station 1, of Feb. 4, at house		2	2.10 a. m.		978	29.664	63.9	63	29.570	29.609						S.W. 1	C. C.S.cum.nim.3	
Camp No. 22, Gaviote pass		2	5.28 a. m.	272.46	977	29.536		56	29.442	29.537			56	53	3	S.W. 1	C. S. 1	
Do		2	8.25 a. m.	272.46	977	29.601		55	29.531	29.526			51.5	53	1.5	E. 1	C. S. 1	
Do		3	7 a. m.	272.46	977	29.684		54	29.617	29.562			54	49	5	E. 1	C. S. 1	
Do.		3	8 a. m.	272.46	977	29.700		54.2	29.633	29.566						E. 1	C. S. 1	
Do.		3	9 a. m.	272.46	977	29.714	59	58.5	29.635	29.548			58	53	5	E. 1	C. S. 1	Barometer 392 refilled.
Do.		3	10 a. m.	272.46	977	29.738		86.5	29.638	29.543			66	55	11	E. 1	C. S. 1	
Do.		3	10.30 a. m.	272.46	977	29.750		67	29.648	29.553			66	57.5	8.5	E. 1	C. S. 1	
Do.		3	11 a. m.	272.46	977	29.750		70	29.639	29.544			70	59	11	E. 1	C. S. 1	Clear.
Do.		3	11.30 a. m.	272.46	977	29.752			29.641	29.552						E. 1	C. S. 1	
Do.		3	12 m	272.46	977	29.748			29.633	29.550						E. 1	C. S. 1	
Do.		3	0.30 p. m.	272.46	977	29.734			29.616	29.540						E. 1	C. S. 1	
Do.		3	1 p. m.	272.46	977	29.728			29.607	29.540						E. 1	C. S. 1	
Do.		3	1.30 p. m.	272.46	977	29.716			29.592	29.526						E. 1	C. S. 1	

Do.	3	2 p. m.	272.46	977	29.710			29.584	29.520						E. 1	C. S. 1	
Do.	3	2 30 p. m.	272.46	977	29.710			29.585	29.521						E. 1	C. S. 1	
Do.	3	3 p. m.	272.46	977	29.710		77	29.580	29 516			76	61	15	E. 1	C. C. S. 1	
Do.	3	4 p. m.	272.46	392	29.732	74.9	74	29.597				73.5	57	16.5	E. 1	C. C. S. 2	
Do.	3	4 p. m.	272.46	977	29.710	74.9	74	29.585	29.516			73.5	57	16.5	E. 1.	C. C. S. 2	
Do.	3	5.10 p. m.	272.46	392	29.710	60	59.9	29.625				59.2	54.2	5	E. 1	C. C. S. 2	
Do.	3	5.10 p. m.	272.46	977	29.688	60	59.9	29.603	29.527			59.2	54.2	5	E. 1	C. C. S. 2	
Do.	3	8 20 p. m.	272.46	392	29.740	61.5	62	29.652				62	46	16	E. 1	C. C. S. 2	
Do.	3	8.20 p. m.	272.46	977	29.720	61.5	62	29.632	29.525			62	46	16	E. 1	C. C. S. 2	
Do.	4	6.30 a. m.	272.46	392	29.770	52	53.2	29.708				52.5	46	6.5	E. 2	C. C. S. 2	Not used.
Do.	4	6.30 a. m.	272.46	977	29.750	52	53.2	29.688	29.590	29.538	456.6	52.5	46	6.5	E. 2	C. C. S. 2	
Stat. 1, railroad survey, Santa Cruces	4	7.20 a. m.	273.55	392	29.935	47.5	47.8	29.885	29.715		283.7				E. 2	Cum. C. S. 5	
Between stations 2 and 3, 30 feet above stream	4	8.45 a. m.	275.55	392	30.100	57	59	30.024							E. 2	Cum. C. S. 5	
Do.	4	10.30 a. m.	275.55	392	30.120	72	70	30.093							E. 2	Cum. C. S. 5	
Do.	4	11.10 a. m.	275.35	392	30.135	75	76.5	30.010	29.847		162.7				E. 2	Cum. C. S. 5	
Between stations 3 and 4	4	1.15 p. m.	276.55	392	30.142	73 5	72	30.022							E. 2	Cum. C. S. 7	
Do.	4	1.30 p m.	276.55	392	30.134	74	72	30.012							E. 2	Cum. C. S. 7	
Do.	4	2 p. m.	276.55	392	30.125	71.8	71.5	30.008	29.906		109.0				E. 2	Cum. C. S. 7	
Camp No. 23, Gaviote creek	4	4.30 p. m.	277.36	392	30.186	67	65.5	30.083							E. 2	Cum. C. S. 5	
Do.	4	4.30 p. m.	277.36	977	30.174	67	65.5	30.071	29.996						E. 2	Cum. C. S. 5	
Do.	4	5 p. m.	277.36	392	30.179	60.5	60.8	30.093				60	53.5	6.5	E. 2	Cum. C. S. 4	
Do.	4	5 p. m.	277.36	977	30.162	60.5	60.8	30.076	30.001	29.998	23.2	60	53.5	6.5	E. 2	Cum. C. S. 4	
Station 1, on a bluff 150 feet above sea	5	6.45 a. m.	277.75	392	29.982	57.5	58	29.905	29.879		133.6				N. 1	Cum. C. S. 1	Sunrise.
Station 2, in a gulch about 20 feet above level of sea	5	7.20 a. m.	278.97	392	30.070	47.5	48	30.019	29.997		23.8				N. 1	Cum. C. S. 1	
Between stations 2 and 3, in a valley about 25 feet above level of sea	5	8 a. m.	279.47	392	30.100	55.5	56.9	30.028	29.948		69.4					Cum. C. S. 1	
Station on a bluff about 60 feet above level of sea	5	8 a. m.	279 47	977	30.086	55.5	56.9	30.014	29.954		63.4					Cum. C. S. 1	
Station 3, on a bluff about 70 feet above level of sea	5	8.35 a. m.	281.24	392	30.040	65.5	66	29.941	29.862		150.4					Cum. C. S. 1	
Between stations 3 and 4, four feet above sea level	5	9.50 a. m.	281.54	392	30.205	66	65.2	30.104								Cum. C. S. 1	
Do.	5	9.50 a. m.	281.54	977	30.192	66	65.2	30.091	30.023		Sea level					Cum. C. S. 1	
Station 4, level of sea, (Arroyo Hondo)	5	10.30 a. m.	282.78	392	30.205	69.5	69	30.095								Cum. C. S. 3	
Do.	5	10.30 a. m.	282.78	977	30.180	69.5	69	30.070	30.017		5.5					Cum. C. S. 3	
Station 5	5	11.30 a. m.	284.52	392	30.148	71	69.9	30.034								Cum. C. S. 2	
Do.	5	11.30 a. m.	284.52	977	30.130	71	69.9	30.016	29.980		40.2					Cum. C. S. 2	
Camp No. 21, Cañada del Corral	5	2.10 p. m.	288.82	392	30.085	68.5	67.5	29.978	30.017						S. 1	C. C. S. 8	
Do.	5	3 p. m.	288.82	392	30.065	67.9	67.2	29.959							S. 1	C. C. S. 8	
Do.	5	3 p. m.	288.82	977	30.059	67.9	67.2	29.953	30.012						S. 1	C. C. S. 8	
Do.	5	4.30 p. m.	288.82	392	30.070	64.5	65	29.974							S. 1	C. C. S. 9	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 24	Feb. 5	4.30 p. m.	288.82	977	30.060	64.5	65	29.964	30.021						S. 1	C. C. S. 9	
Do	5	5.25 p. m.	288.82	392	30.070	61	61.5	29.983							S. 1	C. C. S. 7	
Do	5	5.25 p. m.	288.82	977	30.060	61	61.5	29.973	30.028						S. 1	C. C. S. 7	
Do	6	6.45 a. m.	288.82	977	30.020		57.5	29.943	29.999	30.015	7.2				S. 1	C. C. S. 7	
Between stations 0 and 1, (Ortegas,) house, top of a hill	6	7.20 a. m.	289.10	392	29.975	60	59.9	29.890	29.943		73.9				S. 1	C. C. S. 6	
Between stations 0 and 1, in an arroyo, — feet above sea	6	8.20 a. m.	290.34	392	30.035	60.2	60	29.950							S. 1	C. C. S. 8	
Do	6	8.20 a. m.	290.34	977	30.020	60.2	60	29.935	30.003		18.5				S. 1	C. C. S. 8	
Station 1, on a bluff	6	8.50 a. m.	290.42	392	29.975	65.9	64	29.875	29.849		161.9				S. 1	C. C. S. 8	
Seacoast, est. 2 feet above sea	6	10.05 a. m.		392	30.150	67	64	30.047							S. 1	C. C. S. 7	
Do	6	10.05 a. m.		977	30.130	67	64	30.027	30.022		0.8				S. 1	C. C. S. 7	
Between stations 3 and 4 (in woods, point where cart trail joins main road)	6	11.15 a. m.	291.42	392	30.025	65	63.9	29.927	29.912		103.1				S. 1	C. C. S. 7	
Station 9	6	1.55 p. m.	297.42	392	29.935	65.2	63.4	29.837	29.876		202.1				S. 1	C. C. S. 6	
Station 12 (where road crosses stream in valley)	6	3 p. m.	299.67	392	30.090	75	72	29.965	30.011		11.1				S. 1	C. C. S. cum. 7	
Where roads divide	6	4.25 p. m.		392	30.069	67	65	29.966	30.010		11.9				S. 1	C. C. S. cum. 8	
Camp No. 25 (near S. Barbara)	7	9.45 a. m.	304.74	392	30.125	59	58.4	30.013							S. 1	C. C. S. cum. nim. 9.	Occasional showers during the night.
Do	7	9.45 a. m.	304.74	977	30.110	59	58.4	30.028	29.992						S. 1	do	
Do	7	11 a. m.	304.74	392	30.130	59.9	59.4	30.046				58.5			S. 1	do	
Do	7	11 a. m.	304.74	977	30.114	59.9	59.4	30.030	29.998			58.5			S. 1	do	
Do	7	12 m.	304.74	392	30.125	59	58.9	30.043				58.5	57	1.5	W. 5	Overcast, C. C. S. cum. nim. 9.	
Do	7	12 m.	304.74	977	30.100	59	58.9	30.018	30.010			58.5	57	1.5	W. 5	do	
Do	7	1 p. m.	304.74	392	30.100	60.7	59.8	30.014				59.5	57.5	2	W. 5	C. cum. C. S. nim. 9	
Do	7	1 p. m.	304.74	977	30.076	60.7	59.8	29.990	29.992			59.5	57.5	2	W. 5	do	
Do	7	2 p. m.	304.74	392	30.098	59.9	59	30.013				58.9	57.2	1.7	N.W. 1	do	Slight sprinkling of rain.
Do	7	2 p. m.	304.74	977	30.076	59.9	59	29.991	30.006			58.9	57.2	1.7	N.W. 1	do	
Do	7	3 p. m.	304.74	392	30.100	62	60.9	30.010				60.5	57	3.5	N.W. 1	do	
Do	7	3 p. m.	304.74	977	30.080	62	60.9	29.990	30.009			60.5	57	3.5	N.W. 1	do	
Do	7	4 p. m.	304.74	392	30.100	58.5	58.7	30.020				58	56.5	1.5	N.W. 1	C. cum. C. S. nim. 8	
Do	7	4 p. m.	304.74	977	30.080	58.5	58.7	30.000	30.013			58	56.5	1.5	N.W. 1	do	

Do.	7	6.35 a. m.	304.74	392	30.160	48	48	30.108	......	......	......	47.5	47	0.5	N.W. 1	C.cum.C.S.nim.9	
Do.	7	6.35 a. m.	304.74	977	30.140	48	48	30.088	29.999	......	......	47.5	47	0.5	N.W. 1	C.cum.C.S.nim.9	
Do.	7	7 a. m.	304.74	392	30.175	49.2	50	30.120	......	......	......	50	50	......	N.W. 1	C.cum.C.S.nim.9	
Do.	7	7 a. m.	304.74	977	30.156	49.2	50	30.101	30.011	......	......	50	50	......	N.W. 1	C.cum.C.S nim.9	
Do.	7	8 a. m.	304.74	392	30.210	58.5	58.8	30.130	......	......	......	58	54	4	W. 5	C.cum.C.S.nim.9	
Do.	7	8 a. m.	304.74	977	30.190	58.5	58.8	30.110	30.017	......	......	58	54	4	W. 5	C.cum.C.S nim 9	
Do.	7	9 a. m.	304.74	392	30.230	40.5	60	30.144	......	......	......	60	55.5	4.5	W. 5	C.cum C S nim.6	
Do.	8	9 a. m.	304.74	977	30.210	60.5	60	30.124	30.019	......	......	60	55.5	4.5	W. 5	C. C. S. cum. 6	
Do.	8	3 p. m.	304.74	392	30.185	62.3	61.8	30.094	......	......	......	61	57.7	3.3	W. 5	C. C. S. cum. 6	
Do.	8	3 p. m.	304.74	977	30.164	62.3	61.8	30.073	30.012	......	......	61	57.7	3.3	W. 5	C. C. S. cum. 6	
Do.	9	7 a. m.	304.74	392	30.170	44.2	45	30.128	......	......	......	44.5	44	0.5	W. 5	C. C. S. cum. 2	
Do.	9	7 a. m.	304.74	977	30.150	44.2	45	30.108	29.967	......	......	44.5	44	0.5	W. 5	C. C. S. cum. 2	
Do.	9	8 a. m.	304.74	392	30.204	48.4	48.5	30.151	......	......	......	47.9	47.5	0.4	W. 5	C. C. S. cum. 3	
Do.	9	8 a. m.	304.74	977	30.184	48.4	48.5	30.131	29.990	......	......	47.9	47.5	0.4	W. 5	C. C. S. cum. 3	
Do.	9	9 a. m.	304.74	392	30.260	60	59.4	30.175	......	......	......	58.1	56.5	1.6	W. 5	C. C. S. cum. 3	
Do.	9	9 a. m.	304.74	977	30.238	60	59.4	30.153	30.004	......	......	58.1	56.5	1.6	W. 5	C. C. S. cum. 3	
Do.	9	10 a. m.	304.74	392	30.265	60	59	30.180	......	......	......	58.5	55.5	3	W. 5	C. C. S. cum. 7	
Do.	9	10 a. m.	304.74	977	30.240	60	59	30.155	30.001	......	......	58.5	55.5	3	W. 5	C. C. S. cum. 7	
Do.	9	11 a. m.	304.74	392	30.265	61.5	61	30.177	......	......	......	61	58	3	W. 5	C. C. S. cum. 3	
Do.	9	11 a. m.	304.74	977	30.242	61.5	61	30.154	30.021	......	......	61	58	3	W. 5	C. C. S. cum. 3	
Do.	9	12 m.	304.74	392	30.240	63.5	62.6	30.146	......	......	......	62	58.5	3.5	W. 5	C. C. S. cum. 2	
Do.	9	12 m.	304.74	977	30.216	63.5	62.6	30.122	29.913	......	......	62	58.5	3.5	W. 5	C. C. S. cum. 2	
Do.	9	1 p. m.	304.74	392	30.215	62.2	61	30.125	......	......	......	61	57.5	3.5	W. 5	C. C. S. cum. 1	
Do.	9	1 p. m.	304.74	977	30.190	62.2	61	30.100	30.018	......	......	61	57.5	3.5	W. 5	C. C. S. cum. 1	
Do.	9	2 p. m.	304.74	392	30.195	62.2	60.9	30.105	......	......	......	60.5	57.5	3	W. 5	C. C. S. cum. 1	
Do.	9	2 p. m.	304.74	977	30.170	62.2	60.9	30.080	30.011	......	......	60.5	57.5	3	W. 5	C. C. S. cum. 1	
Do.	9	3 p. m.	304.74	392	30.180	63	61.5	30.087	......	......	......	61	57	4	W. 5	C. C. S. cum. 1	
Do.	9	3 p. m.	304.74	977	30.150	63	61.5	30.057	30.000	......	......	61	57	4	W. 5	C. C. S. cum. 1	
Do.	9	4 p. m.	304.74	392	30.165	63	61	30.072	......	......	......	60.5	57	3.5	W. 5	C. C. S. cum. 1	
Do.	9	4 p. m.	304.74	977	30.140	63	61	30.047	29.990	......	......	60.5	57	3.5	W. 5	C. C. S. cum. 1	
Do.	9	5 p. m.	304.74	392	30.180	61	60	30.093	......	......	......	59.2	57	2.2	W. 5	C. C. S. cum. 1	
Do.	9	5 p. m.	304.74	977	30.156	61	60	30.069	30.004	......	......	59.2	57	2.2	W. 5	C. C. S. cum. 1	
Do.	9	6 p. m.	304.74	392	30.150	51.9	52	30.087	......	......	......	52	50	2	W. 5	C. C. S. cum. 1	A heavy dew falling.
Do.	9	6 p. m.	304.74	977	30.130	51.9	52	30.067	30.001	......	......	52	50	2	W. 5	C. C. S. cum. 1	
Do.	9	7 p. m.	304.74	392	30.150	53.9	54	30.065	......	......	......	54	53	1	W. 5	C. C. S. cum. 1	
Do.	9	7 p. m.	304.74	977	30.130	53.9	54	30.045	29.966	......	......	54	53	1	W. 5	C. C. S. cum. 1	
Do.	9	8 p. m.	304.74	392	30.170	50	51	30.112	......	......	......	50	49.5	10.5	W. 5	C. C. S. cum. 1	
Do.	9	8 p. m.	304.74	977	30.152	50	51	30.094	30.100	......	......	50	49.5	10.5	W. 5	C. C. S. cum. 1	
Do.	9	9 p. m.	304.74	392	30.180	49.9	50.5	30.122	......	......	......	49	47.5	1.5	W. 5	C. C. S. cum. 1	
Do.	9	9 p. m.	304.74	977	30.158	49.9	50.5	30.100	29.997	......	......	49	47.5	1.5	W. 5	C. C. S. cum. 1	
Do.	9	10 p. m.	304.74	392	30.165	48	48.7	30.113	......	......	......	48	47.5	0.5	W. 5	C. C. S. cum. 1	
Do.	9	10 p. m.	304.74	977	30.142	48	48.7	30.090	29.988	......	......	48	47.5	0.5	W. 5	C. C. S. cum. 1	
Do.	9	11 p. m.	304.74	392	30.150	45.5	46.5	30.106	......	......	......	46	45.5	0.5	W. 5	C. C. S. cum. 1	
Do.	9	11 p. m.	304.74	977	30.130	45.5	46.5	30.086	29.988	......	......	46	45.5	0.5	W. 5	C. C. S. cum. 1	
Do.	9	12 p. m.	304.74	392	30.150	45.5	46	30.106	......	......	......	45.2	45	0.2	W. 5	C. C. S. cum. 1	
Do.	9	12 p. m.	304.74	977	30.130	45.5	46	30.086	30.014	......	......	45.2	45	0.2	W. 5	C. C. S. cum. 1	
Do.	10	1 a. m.	304.74	392	30.150	45.5	46.2	30.106	......	......	......	45	45	......	W. 5	C. C. S. cum. 1	Very light breeze from the east.
Do.	10	1 a. m.	304.74	977	30.130	45.5	46.2	30.086	30.031	......	......	45	45	......	W. 5	C. C. S. cum. 1	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.	°	Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 25	Feb. 10	2 a. m.	304.74	392	30.140	45.5	46	30.096				45	45		W. 5	C. C. S. cum. 1	
Do	10	2 a. m.	304.74	977	30.118	45.5	46	30.074	30.017			45	45		W. 5	C. C. S. cum. 1	
Do	10	3 a. m.	304.74	392	30.140	45.5	46	30.096				45	45		W. 5	C. C. S. cum. 1	
Do	10	3 a. m.	304.74	977	30.118	45.5	46	30.074	30.012			45	45		W. 5	C. C. S. cum. 1	
Do	10	4 a. m.	304.74	392	30.134	45	46	30.090				45	45		W. 5	C. C. S. cum. 1	
Do	10	4 a. m.	304.74	977	30.108	45	46	30.064	29.991			45	45		W. 5	C. C. S. cum. 1	
Do	10	5 a. m.	304.74	392	30.150	44.5	46.5	30.107				45	45		E. 5	C. C. S. 4	Clouds forming fast in W. and S.W.
Do	10	5 a. m.	304.74	977	30.130	44.5	46.5	30.087	30.034			45	45		E. 5	C. C. S. 4	
Do	10	6 a. m.	304.74	392	30.130	45	45.9	30.084				45	44.5	.5	E. 5	C. C. S. 4	
Do	10	6 a. m.	304.74	977	30.110	45	45.9	30.066	30.027			45	44.5	.5	E. 5	C. C. S. 4	
Do	10	7 a. m.	304.74	392	30.160	49	49.8	30.105				49.5	49	.5	E. 5	C. C. S. 4	
Do	10	7 a. m.	304.74	977	30.138	49	49.8	30.083	30.018			49.5	49	.5	E. 5	C. C. S. 9	
Do	10	8 a. m.	304.74	392	30.180	53.9	54	30.114				53.5	53.5		E. 5	Overcast	A dense fog.
Do	10	8 a. m.	304.74	977	30.160	53.9	54	30.094	30.032			53.5	53.5				
Do	10	9 a. m.	304.74	392	30.165	55.5	56	30.094									
Do	10	9 a. m.	304.74	977	30.200	55.5	56	30.129							E. 5	Overcast	
Do	10	10 a. m.	304.74	392	30.208	60.4	59	30.122				58.6	56.1	2.5	E. 5	C. C. S. 7	
Do	10	10 a. m.	304.74	977	30.190	60.4	59	30.104	30.040			58.6	56.1	2.5	E. 5	C. C. S. 7	
Do	10	11 a. m.	304.74	392	30.200	65.4	65	30.101				65	57.9	7.1	W. 1	C. C. S. 4	
Do	10	11 a. m.	304.74	977	30.182	65.4	65	30.083	30.029			65	57.9	7.1	W. 1	C. C. S. 4	
Do	10	12 m	304.74	392	30.180	64	63.5	30.085				63.5	59.5	4	W. 1	C. C. S. 4	
Do	10	12 m	304.74	977	30.165	64	63.5	30.070	30.037			63.5	59.5	4	W. 1	C. C. S. 4	
Do	10	1 p. m.	304.74	392	30.150	65.9	64.9	30.051				64.2	60.5	3.7	W. 1	C. C. S. 7	
Do	10	1 p. m.	304.74	977	30.128	65.9	64.9	30.029	30.015			64.2	60.5	3.7	W. 1	C. C. S. 7	
Do	10	2 p. m.	304.74	392	30.130	66.5	65.5	30.029				65	60.2	4.8	W. 1	C. C. S. 7	
Do	10	2 p. m.	304.74	977	30.110	66.5	65.5	30.009	29.994			65	60.2	4.8	W. 1	C. C. S. 7	
Do	10	5.20 p. m.	304.74	392	30.110	61	61.2	30.023				61	56.5	4.5	W. 1	C. C. S. 3	
Do	10	5.20 p. m.	304.74	977	30.090	61	61.2	30.003	29.979			61	56.5	4.5	W. 1	C. C. S. 3	
Do	11	7.10 p. m.	304.74	392	30.045	47.9	48	29.995				47	45	2	W. 1	C. C. S. 3	
Do	11	7.10 p. m.	304.74	977	30.020	47.9	48	29.970	29.870			47	45	2	W. 1	C. C. S. 3	
Do	11	8 p. m.	304.74	392	30.060	54.2	55	29.992				55	50.5	4.5	W. 1	C. C. S. 3	
Do	11	8 p. m.	304.74	977	30.038	54.2	55	29.970	29.866			55	50.5	4.5	W. 1	C. C. S. 3	
Do	11	9 p. m.	304.74	392	30.090	64	63.5	29.995				63	55	8	W. 1	C. C. S. 1	
Do	11	9 p. m.	304.74	977	30.070	64	63.5	29.975	29.860			63	55	8	W. 1	C. C. S. 1	
Do	11	10 p. m.	304.74	392	30.100	66.9	66	29.998				65	53.9	11.1	W. 5	C. C. S. 1	

Do.	11	10 p. m.	304.74	977	30.084	66.9	66	29.982	29.867			63	53.9	11.1	W. 5	C. C. S. 1
Do.	11	11 p. m.	304.74	392	30.115	66.9	66	30.012				66.2	54.9	11.3	W. 5	C. C. S. 1
Do.	11	11 p. m.	304.74	977	30.094	66.9	66	29.991	29.889			66.2	54.9	11.3	W. 5	C. C. S. 1
Do.	11	0.20 p. m.	304.74	392	30.095	70.5	69.5	29.984				69.5	56	13.5	S. 1	C. C. S. 1
Do.	11	0.20 p. m.	304.74	977	30.070	70.5	69.5	29.959	29.881			69.5	56	13 5	S. 1	C. C. S. 1
Do.	11	1 p. m.	304.74	392	30.068	69.9	69.3	29.957				69	51.9	17.1	N. 1	C. C. S. 1
Do.	11	1 p. m.	304.74	977	30.050	69.9	69.3	29.939	29.879			69	51.9	17.1	N. 1	C. C. S. 1
Do.	11	2 p. m.	304.74	392	30.050	70.2	69.9	29.939				69.8	52	17.8	E. 1	C. C. S. 1
Do.	11	2 p. m.	304.74	977	30.030	70.2	69.9	29.919	29.874			69.8	52	17.8	E. 1	C. C. S. 1
Do.	11	3 p m.	304.74	392	30.050	70	69.4	29.939				69	52	17	E. 1	C. C. S. 1
Do.	11	3 p. m.	304.74	977	30.030	70	69.4	29 919	29.887			69	52	17	E. 1	C. C. S. 1
Do.	11	4 p. m.	304.74	392	30.050	70	68.5	29.939				68	53	15	E. 1	C. C. S. 1
Do.	11	4 p. m.	304.74	977	30.030	70	68.5	29.919	29.889			68	53	15	E. 1	C. C. S. 1
Do.	11	5 p. m.	304.74	392	30.040	67	66.2	29.937				66	51	15	E. 1	C. C. S. 6
Do.	11	5 p. m.	304.74	977	30.020	67	66.2	29.917	29.879			66	51	15	E. 1	C. C. S. 6
Do.	11	5.40 p. m.	304.74	392	30.038	61	61.2	29.951				61.2	48.2	13	E. 1	C. C. S. 4
Do.	11	5.40 p. m.	304 74	977	30.020	61	61.2	29.933	29.891			61.2	48.2	13	E. 1	C. C. S. 4
Do.	12	7.10 a. m.	304.74	392	30.062	45.5	46.3	30.018				46	43	3	E. 1	C. C. S. 7
Do.	12	7.10 a. m.	304.74	977	30.040	45 5	46.3	29.996	29.903			46	43	3	E. 1	C. C. S. 7
Do.	12	8 a. m.	304.74	392	30.100	57	57.2	30.024				57	52	5	E. 1	C. C. S. 6
Do.	12	8 a. m.	304.74	977	30.080	57	57.2	30.004	29.906			57	52	5	E. 1	C. C. S. 6
Do.	12	9 a. m.	304 74	392	30.120	64	63.5	30.025				59	54	5	E. 1	C. C. S. 6
Do.	12	9 a. m.	304.74	977	30.100	64	63.5	30.005	29.995			59	54	5	E. 1	C. C. S. 6
Do.	12	11 a. m.	304.74	392	30.125	68		30.019							S.E.	C. C. S. 2
Do.	12	11 a. m.	304.74	977	30.105		67	29.999	29.898						S.E.	C. C. S. 2
Do.	12	4 p. m.	304.74	392	30.040	68	65.8	29.934				64.5	57	7.5	S.E.	C. C. S. 6
Do.	12	4 p. m.	304.74	977	30.020	68	65.8	29.914	29.877			64.5	57	7.5	S.E.	C. C. S. 6
Do.	12	5.35 p. m.	304.74	392	30.015	57	57.5	29.939				57	52.5	4.5	S.E.	C. C. S. 3
Do.	12	5.35 p. m.	304.74	977	30.000	57	57.5	29.924	29.875			57	52.5	4.5	S.E.	C. C. S. 3
Do.	13	6.50 a. m.	304.74	392	30 000	43	44	29.961				43.5	41.5	2	S.E.	C. C. S. 4
Do.	13	6.50 a. m.	304.74	977	29.980	43	44	29.941	29.891			43.5	41.5	2	S.E.	C. C. S. 4
Do.	13	8 a. m.	304.74	392	30.010	54.9	56	29.939				55	57	2	S.E.	C. C. S. 5
Do.	13	8 a. m.	304.74	977	29.982	54.9	56	29.911	29.847			55	57	2	S.E.	C. C. S. 5
Do.	13	9 a. m.	304.74	392	30.050	63.6	63	29.957				62.8	56.2	6.6	S E.	C. C. S. 3
Do.	13	9 a. m.	304.74	977	30 036	63.6	63	29.943	29.866			62.8	56.2	6.6	S.E.	C. C. S. 3
Do.	13	10 a. m.	304.74	392	30.069	66.2	64.9	29.968				64.5	58	6.5	W. 5	C. C. S. 3
Do.	13	10 a. m.	304.74	977	30.050	66.2	64.9	29.949	29.876						S.E.	C. C. S. 3
Do.	13	11 a. m.	304.74	392	30.080	69.5	68.5	29.970				67.9	59 1	8.8	W. 5	C. C. S. 3
Do.	13	11 a. m.	304.74	977	30.062	69.5	68.5	29.952	29.889			67.9	59.1	8.8	W. 5	C. C. S. 3
Do.	13	12 m.	304.74	392	30 062	72.2	71.2	29.945				70	59.5	10.5	W. 5	C. C. S. 3
Do.	13	12 m.	304.74	977	30.044	72.2	71.2	29.927	29.886			70	59.5	10.5	W. 5	C. C. S 3
Do.	13	1 p. m.	304.74	392	30.040	72.2	71	29.923				70.6	50.5	20.1	W. 5	C. C. S. 5
Do.	13	1 p. m.	304.74	977	30.020			29.903	29.847			70.6	50.5	20.1	W. 5	C. C. S. 5
Do.	13	2 p. m.	304.74	392	30.025	69	67.8	29.916				67.4	58.8	8 6	W. 5	C. C. S. 3
Do.	13	2 p. m.	304.74	977	30.004	69	67.8	29.895	29.884			67.4	58.8	8.6	W. 5	C. C. S. 3
Do.	13	3 p. m.	304.74	392	30.020	69.5	67.8	29.911				68.2	57.5	10.7	W. 5	C. C. S. 2
Do.	13	3 p. m.	304.74	977	30.002	69.5	67.8	29.893	29.891			68.2	57.5	10.7	W. 5	C. C. S. 2
Do.	13	4 p. m.	304.74	392	30.010	71.5	69 5	29.895				68.9	57.5	11.4	W. 5	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 25	Feb. 13	4 p. m.	304.74	977	29.992	71.5	69.5	29.877	29.879			68.9	57.5	11.4	W. 5	C. C. S. 3	
Do.	13	5 p. m.	304.74	392	30.010	71.5	63	29.895				63	59	4	W. 5	C. C. S. 2	
Do.	13	5 p. m.	304.74	977	29.992	71.5	63	29.877	29.875			63	59	4	W. 5	C. C. S. 2	
Do.	13	5.30 p. m.	304.74	392	29.995	59	58.8	29.913				58.5	55.5	3	W. 5	C. C. S. 2	
Do.	13	5.30 p. m.	304.74	977	29.970	59	58.8	29.888	29.897			58.5	55.5	3	W. 5	C. C. S. 2	
Do.	14	6.50 a. m.	304.74	392	30.030	46.5	47.2	29.982				47.2	45	2.2	W. 5	C. C. S. 2	
Do.	14	6.50 a. m.	304.74	977	30.012	46.5	47.2	29.964	29.925			47.2	45	2.2	W. 5	C. C. S. 2	
Do.	14	8 a. m.	304.74	392	30.070	58	58.4	29.991				57	53	4	W. 5	C. C. S. 2	
Do.	14	8 a. m.	304.74	977	30.050	58	58.4	29.971	29.924			57	53	4	W. 5	C. C. S. 2	
Do.	14	9 a. m.	304.74	392	30.120	65.4	64.7	30.021				65.4	64.7	0.7	W. 5	C. C. S. 2	
Do.	14	9 a. m.	304.74	977	30.100	65.4	64.7	30.001	29.946			65.4	64.7	0.7	W. 5	C. C. S. 2	
Do.	14	12 m.	304.74	977	30.080			29.955							W. 5	C. C. S. 2	
Do.	14	12 m.	304.74	392	30 100	69	68	29.991	29.937			67.5	61	6.5	W. 5	C. C. S. 2	
Do.	14	1 p. m.	304.74	392	30.100	72	71.5	29.983				71	60	11	W. 5	C. C. S. 2	
Do.	14	1 p. m.	304.74	977	30.080	72	46.5	30.036	29.977			45.5	44.5	1	W. 5	C. C. S. 2	
Do.	15	6.55 a. m.	304.74	392	30.065	45.9	46.5	30.018				45.5	44.5	1	W. 5	C. C. S. 2	
Do.	15	6.55 a. m.	304.74	977	30.043	45.9	46.5	29.996	29.940			45.5	44.5	1	W. 5	C. C. S. 2	
Do.	15	8 a. m.	304.74	392	30 100	53.3	53.5	30.034				53.5	51.5	2	W. 5	C. C. S. 3	
Do.	15	8 a. m.	304.74	977	30.080	53.3	53.5	30.014	29.942			53.5	51.5	2	W. 5	C. C. S. 3	
Do.	15	10 a. m.	304.74	392	30.160	68.5	68	30.054				68	59	9	W. 5	C. C. S. 3	
Do.	15	10 a. m.	304.74	977	30.142	68.5	68	30.036	29.953			68	59	9	W. 5	C. C. S. 3	
Do.	15	12 m.	304.74	392	30.130	72.5	71.5	30.013				71	61	10	W. 5	C. C. S. 3	
Do.	15	12 m.	304.74	977	30.110	72.5	71.5	29.993	29.937			71	61	10	W. 5	C. C. S. 3	
Do.	15	2 p. m.	304.74	392	30.110	73.5	73	29.991				72.5	62	10.5	W. 5	C. C. S. 3	
Do.	15	2 p. m.	304.74	977	30.090	73.5	73	29.971	29.944			72.5	62	10.5	W. 5	C. C. S. 3	
Do.	15	3 p. m.	304.74	392	30.100	75	74	29.975				73.5	61	12.5	W. 5	C. C. S. 3	
Do.	15	3 p. m.	304.74	977	30.080	75	74	29.955	29.938			73.5	61	12.5	W. 5	C. C. S. 3.	
Do.	16	6.30 a. m.	304.74	392	30.020	45	45.9	29.976							W. 5	C. C. S. 3	Not used.
Do.	16	6.30 a. m.	304.74	977	30 000	45	45.9	29.956	29.896	29.956	61.8				W. 5	C. C. S. 3	
Station 3, about 100 yards beyond American house	16	8 a. m.	304.74	392	29.940	60	60 2	29.855	29.773		232.8				W. 5	C. C. S. 3	
Between stations 3 and 4, on hill near Mission creek	16	8.20 a. m.	304.74	392	29.870	64.5	66	29.775	29.788		219.8				W. 5	C. C. S. 3	
Station 6	16	12.30 p. m.	315.61	392	30.005	80	78	29.867	29.801		209.5				S.E. 5	C. C. S. 3	
Stat. 7, about 150 ft. above sea.	16	1.30 p. m.	316.84	392	29.900	76	75	29.773	29.734		272.7				S.E. 5	C. C. S. 3	

Station 8	16	2.15 p. m.	318.87	392	30.082	70	67	29.971	29.939	....	78.4	......	......	......	E. 1	C. C. S. 3	
Camp No. 26, La Carpinteria	16	5 p. m.	323.07	392	30.100	63.2	64	30.007	....	....	....	63.9	56.8	7.1	E. 1	C. C. S. 3	
Do	16	5 p. m.	323.07	977	30.086	63.2	64	29.993	29.970	....	....	63.9	56.8	7.1	E. 1	C. C. S. 3	
Do	16	5.30 p. m.	323.07	392	30.090	55	56.5	30.019	....	....	....	56	53	3	E. 1	C. C. S. 3	
Do	16	5.30 p. m.	323.07	977	30.070	55	56.5	29.999	29.973	....	....	56	53	3	E. 1	C. C. S. 3	
Do	17	6.50 a. m.	323.07	392	30.210	42.5	43	30.174	....	....	....	44	40	4	E. 1	C. C. S. 3	
Do	17	6 50 a. m.	323.07	977	30.196	42.5	43	30.160	30.000	....	....	44	40	4	E. 1	C. C. S. 3	
Do	17	7.30 a. m.	323.07	392	30.240	47	46.8	30.190	....	....	....	46	44	2	W. 5	C. C. S. 3	
Do	17	7.30 a. m.	323.07	977	30.230	47	46.8	30.180	30.003	....	....	46	44	2	W. 5	C. C. S. 3	
Do	17	9.45 a. m.	323 07	392	30.305	64	63.2	30.210	....	....	....	62.5	54	8.5	W. 5	C. C. S. 3	
Do	17	9.45 a. m.	323.07	977	30.288	64	63.2	30.193	29.997	29.988	46.8	62.5	54	8.5	W. 5	C. C. S. 3	
Between stations 0 and 1	17	11.45 a. m.	325.48	392	30.330	71	70	30.216	30.017	....	3.2	......	......	......	W. 5	C. C. S. 3	
Station 1	17	12 m.	325.73	392	30.335	65	66	30.237	30.029	....	....	......	......	......	W. 5	C. C. S. 3	
Between stations 1 and 2	17	1 p. m.	327.60	392	30.305	70.9	71.2	30.191	30.024	....	....	......	......	......	W. 5	C. C. S. 3	
Station 6	17	3.50 p. m.	332.93	392	30.300	71	72	30.186	30.020	....	....	......	......	......	W. 5	C. C. S. 3	
Camp No. 27, S. Buenaventura	17	5.50 p. m.	337.37	392	30.300	65.5	67	30.217	....	....	....	65.5	50	15.5	N.W. 1	C. C. S. 3	
Do	17	5.50 p. m.	337.37	977	30.282	65.5	67	30.214	30.048	....	....	65.5	50	15.5	N.W. 1	C. C. S. 3	
Do	18	6.35 a. m.	337.37	392	30.305	37	38	30.282	....	....	....	37.5	34.5	3	N.E. 1	C. C. S. 3	Very chilly.
Do	18	6.35 a. m.	337.37	977	30.290	37	38	30.267	30.110	....	....	37.5	34.5	3	N.E. 1	C. C. S. 3	
Do	18	7 a. m.	337.37	392	30.312	39.8	39.9	30.284	....	....	....	38.8	36	2.8	N.E. 1	C. C. S. 3	
Do	18	7 a. m.	337.37	977	30.296	39.8	39.9	30.268	30.107	....	....	38.8	36	2.8	N.E. 1	C. C. S. 3	
Do	18	8 a. m.	337.37	392	30.315	44.5	45	30.273	....	....	....	44.5	40	4.5	N.E. 1	C. C. S. 3	
Do	18	8 a. m.	337.37	977	30.300	44.5	45	30.258	30.098	....	....	44.5	40	4.5	N.E. 1	C. C. S. 3	
Do	18	9 a. m.	337.37	392	30.335	57	57.2	30.259	....	....	....	57	48.8	8.2	N.E. 1	C. C. S. 3	
Do	18	9 a. m.	337.37	977	30.326	57	57.2	30.250	30.080	....	....	57	48.8	8.2	N.E. 1	C. C. S. 3	
Do	18	10 a. m.	337.37	392	30.355	64.8	64	30.258	....	....	....	64	56	8	N.E. 5	C. C. S. 3	
Do	18	10 a. m.	337.37	977	30.342	64.8	64	30.243	30.082	....	....	64	56	8	N.E. 5	C. C. S. 3	
Do	18	2 p. m.	337.37	392	30.240	65.4	64.9	30.142	....	....	....	64.5	59	5.5	S. 5	C. C. S. 3	
Do	18	2 p. m.	337.37	977	30.228	65.4	64.9	30.130	30.045	....	....	64.5	59	5.5	S. 5	C. C. S. 3	
Do	18	3 p. m.	337.37	392	30.230	64	64	30 135	....	....	....	63.2	57	6.2	S. 5	C. C. S. 3	
Do	18	3 p. m.	337.37	977	30.212	64	64	30.117	30.044	....	....	63.2	57	6.2	S. 5	C. C. S. 3	
Do	18	4 p. m.	337.37	392	30.200	62.9	63.2	30.107	....	....	....	62.2	65	2.8	S. 5	C. C. S. 3	
Do	18	4 p. m.	337.37	977	30.190	62.9	63.2	30.097	30.025	....	....	62.2	65	2.8	S. 5	C. C. S. 3	
Do	18	5 p. m.	337.37	392	30.180	58.4	59	30.101	....	....	....	58	54.2	3.8	S. 5	C. C. S. 3	
Do	18	5 p. m.	337.37	977	30.162	58.4	59	30.083	30.011	....	....	58	54.2	3.8	S. 5	C. C. S. 3	
Do	18	5.28 p. m.	337.37	392	30.169	54.5	55	30.101	....	....	....	54	51.9	2.1	S. 5	C. C. S. 3	
Do	18	5.28 p. m.	337.37	977	30.150	54.5	55	30.082	30.016	....	....	54	51.9	2.1	S. 5	C. C. S. 3	
Do	19	6.50 a. m.	337.37	392	29.875	38.9	39.4	29.849	....	....	....	38.4	37	1.4	N.E. 1	C. S. & cum. 2.	
Do	19	6.50 a. m.	337.37	977	29.856	38.9	39.4	29.830	29.885	....	....	38.4	37	1.4	N.E. 1	C. S. & cum. 2.	
Do	19	8 a. m.	337.37	392	29.905	47	46.7	29.855	....	....	....	46	42.8	3.2	N.E. 5	C. S. & cum. 1.	
Do	19	8 a. m.	337.37	977	29.890	47	46.7	29.840	29.913	....	....	46	42.8	3.2	N.E. 5	C. S. & cum. 1.	
Do	19	9 a. m.	337.37	392	29.915	57	56.5	29.839	....	....	....	56	49	7	N.W. 5	C. S. & cum. 2.	
Do	19	9 a. m.	337.37	977	29.902	57	56.5	29.826	29.918	....	....	56	49	7	N.W. 5	C. S. & cum. 2.	
Do	19	10.10 a. m.	337.37	392	29.915	58	57.7	29.836	....	....	....	57.4	51	6.4	N.W. 2	C. S. & cum. 1.	
Do	19	10.10 a. m.	337.37	977	29.902	58	57.7	29.823	29.938	....	....	57.4	51	6.4	N.W. 2	C. S. & cum. 1.	
Do	19	11.10 a. m.	337.37	392	29.880	58.7	58.2	29.799	....	....	....	58	51	7	N.W. 3	C. S. & cum. 2.	
Do	19	11.10 a. m.	337.37	977	29.860	58.7	58.2	29.779	29.907	....	....	58	51	7	N.W. 3	C. S. & cum. 2.	
Do	19	12 m.	337.37	392	29.860	58.5	58	29.781	....	....	....	57.5	50	7.5	N.W. 5	C. S. & cum. 1.	Wind increasing.

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 27	Feb. 19	12 m.	337.37	977	29.840	58.5	58	29.761	29.910			57.5	50	7.5	N.W. 5	C. S. & cum. 1.	
Do.	19	1 p. m.	337.37	392	29.810	58.2	58.5	29.731				58	50	8	N.W. 7	C. S. & cum. 2.	Not used.
Do.	19	1 p. m.	337.37	977	29.780	58.2	58.5	29.701	29.885			58	50	8	N.W. 7	C. S. & cum. 2.	Do.
Do.	19	2 p. m.	337.37	392	29.790	57.5	57.8	29.713				57.2	49.9	7.3	N.W. 8	C. S. & cum. 1.	Do.
Do.	19	2 p. m.	337.37	977	29.770	57.5	57.8	29.693	29.897			57.2	49.9	7.3	N.W. 8	C. S. & cum. 1.	Do.
Do.	20	8.15 a. m.	337.37	392	29.705	39	39.9	29.677							N.N.E. 5	Overcast, cum. nim.	Commenced raining slightly at 6 a. m.
Do.	20	8.15 a. m.	337.37	977	29.692	39	39.9	29.664	29.957						N.N.E. 5	....do....	
Do.	20	9.30 a. m.	337.37	392	29.730	43.5	44	29.690							N.N.E. 5	....do....	
Do.	20	9.30 a. m.	337.37	977	29.714	43.5	44	29.674	29.948						N.N.E. 5	....do....	
Do.	20	11 a. m.	337.37	392	29.750	47.9	48	29.698							N.N.E. 5	....do....	Stopped raining at 10.25 a. m.
Do.	20	11 a. m.	337.37	977	29.730	47.9	48	29.678	29.962						N.N.E. 5	....do....	Commenced raining at 11.05; stopped at 0.25 p. m.
Do.	20	1 p. m.	337.37	392	29.735	50.4	49.8	29.677				49.5	45.4	4.1	N.E. 5	Cum.nim.C.C.S.7	
Do.	20	1 p. m.	337.37	977	29.720	50.4	49.8	29.662	29.975			49.5	45.4	4.1	N.E. 5	Cum.nim.C.C.S.7	
Do.	20	2 p. m.	337.37	392	29.730	55	57.2	29.659				57	53.3	3.7	N.E. 5	Cum.nim.C.C.S.6	
Do.	20	2 p. m.	337.37	977	29.716	55	57.2	29.645	29.961			57	53.3	3.7	N.E. 3	Cum.nim.C.C.S.6	
Do.	20	3 p. m.	337.37	392	29.730	53.2	55.5	29.664				55	50	5	N.E. 5	Cum.nim.C.C.S.4	
Do.	20	3 p. m.	337.37	977	29.716	53.2	55.5	29.650	29.966			55	50	5	N.E. 5	Cum.nim.C.C.S.4	
Do.	20	4 p. m.	337.37	392	29.730	52	53	29.667				52.2	48	4.2	N.E. 5	Cum.C.C.S.nim.3	
Do.	20	4 p. m.	337.37	977	29.716	52	53	29.653	29.967			52.2	48	4.2	N.E. 5	C.C.S.cum.nim.3	
Do.	20	5.30 p. m.	337.37	392	29.730	42.5	43.5	29.694				42.5	40.5	2	N.E. 5	C.C.S.cum.nim.4	
Do.	20	5.30 p. m.	337.37	977	29.716	42.5	43.5	29.680	29.994			42.5	40.5	2	N.E. 5	C.C.S.cum.nim.4	
Do.	21	7 a. m.	337.37	392	29.895	37.5	37.3	29.871	30.048	30.001	20.1				N.E. 5	C.C.S.cum.nim.5	Commenced raining at 8.30 a. m.; stopped at 2 p. m.
Camp No. 28, rancho Comisario	21	5 p. m.	344.66	392	29.315	45.5	46	29.270				45	43	2	N.E. 5	C.C.S.cum.nim.2	
Do.	21	5 p. m.	344.66	977	29.300	45.5	46	29.255	29.427			45	43	2	N.E. 5	C.C.S.cum.nim.2	
Do.	21	5.30 p. m.	344.66	977	29.300		43.5	29.255	29.462			42.5	41	1.5	N.E. 5	C.C.S.cum.nim.2	
Do.	21	7.30 p. m.	344.66	977	29.316	36.2	36.5	29.296	29.450			36	36		N.E. 5	C.C.S.cum.nim.2	
Do.	22	4 p. m.	344.66	977	29.350	54	53.2	29.282	29.413			53	46.5	6.5	N.E. 2	C. C. S. cum. 5	
Do.	23	7.30 a. m.	344.66	978	29.420	44	44	29.378	29.457			43.5	43	0.5	N.E. 2	C.C.S.cum.nim.9	Frequent showers during the night.
Do.	25	7 a. m.	344.66	978	29.574	46	46.5	29.527	29.486			45.2	45	0.2	N.E. 2	C. S. cum. 95.	
Do.	25	8 a. m.	344.66	978	29.610	51.2	51.7	29.550	29.505			50.5	49	1.5	N.E. 2	C. S. cum. 9.	
Do.	25	9 a. m.	344.66	978	29.624	57	58	29.548	29.491			56	52.5	3.5	N.E. 2	C. S. cum. 9.	
Do.	25	12 m.	344.66	978	29.592	65	64	29.494	29.471			64	54.5	9.5	W.N.W. 5	C. S. cum. 3.	
Do.	25	1 p. m.	344.66	978	29.580	67.2	66.3	29.476	29.476			64	53	11	N.W. 1	C. S. cum. 7.	
Do.	25	5 p. m.	344.66	978	29.546	57.9	57.7	29.468	29.478			57.1	51	6.1	N.W. 1	C. S. cum. 5.	

Do.		25	5.35 p. m.	344.66	978	29.546	55.2	55.8	29.475	29.494			55	49.9	5.1	N.W. 1	C. S. cum. 1	
Do.		26	6.30 a. m.	344.66	978	29.452	38.5	39	29.425	29.425			39	39		N.W. 1	C. S. cum. 6	
Do.		26	7 a. m.	344.66	978	29.464	39.8	40.2	29.434	29.406	29.460	503.6	39.5	38.5	1	N.W. 1	C. S. cum. 9	
Crossing of creek		26	9.30 a. m.		978	29.772	57	58	29.696	29 669						N.W. 1	C. S. cum. 9	
Do.		26	10 a. m.		978	29.840	59	59.5	29.758	29.730						N.W. 1	C. S. cum. 8	
Do.		26	11.20 a. m.		978	30.028	60.9	59.8	29.917	29.905						S.E. 1	C. S. cum. 7	
Near San Buenaventura		26	12 m.		978	30.100	63	62.5	30.007	30.004						S.E. 1	C. S. cum. 9	This point is near camp 27.
Do.		26	2 p. m.		978	30.060	60.5	60	29.974	29.988						S.E. 1	C. S. cum. 9	
Do.		26	2.45 p. m.		978	29.984	58	57.5	29 905	30.020						S.E. 1	C. S. cum. 9	
Do.		26	3.30 p. m.		978	30.050	58	57	29.971	29.988						S.E. 1	C. S. cum. 9	
Camp No. 29, Santa Clara plain		26	5.35 p. m.	345.56	978	30 022	54.9	55	29.951	29.970			54	52	2	S.E. 1	C. S. cum. 8	
Do.		27	6.35 a. m.	345.56	978	30.050	47	47.5	30.000	29.972			47	45.5	1.5	N.E. 1	C. S. cum. 8	
Do.		27	6.50 a. m.	345.56	978	30.040	47	47.5	29.990	29.971						N.E. 1	C. S. cum. 8	
In valley of Rio Santa Clara, about 6 miles from Camp 28		27	10 a. m.		978	29.928	65.4	65.9	29.880	29.852						N.E. 1	C. S. C. cum. 6.	
About ¾ of a mile east of running stream		27	11.15 a. m		978	29.880	66	64.9	29.779	29.757						N.E. 1	C. S. C. cum. 8	
Do.		27	11.30 a. m.		978	29.876	67	65	29.773	29.760	29.971	47.6				N.E. 1	C. S C. cum. 8.	
Camp No. 30, R. Cespe		27	4 p. m.	363.41	978	29 704	62.9	62.5	29.611	29.645			62	58	4	S.W. 1	C. S. C. cum. 9.	
Do.		27	5 p. m.	363.41	978	29.692	60	60	29.607	29 634			60	54.5	5.5	S.W. 1	C. S. C. cum. 9	
Do.		27	5.30 p. m.	363.41	978	29.692	59.3	59.5	29.609	29.639			59	54	5	S.W. 1	C. S. C. cum. 9.	
Do.		28	7.10 a. m.	363.41	978	29.686	57.1	57	29.610	29.669			57	54.5	2.5	E. 1	C.S.C.cum.nim.9	
Do.		28	7.20 a. m.	363.41	978	29.686	57.5	58	29.609	29.668			57	55	2	E. 1	C.S.C.cum nim.9	
Do.		28	11.45 a. m.	363.41	978	29.626	67.5	67	29.523	29.643						E. 1	C.S C cum.nim.8	
Do.		28	1.15 p. m.	363.41	978	29.416	69.9	67	29.311	29.460	29.622	359.1				E. 1	C.S.C.cum.nim.8	
Camp No. 31, San Francisquito		28	4 p. m.	382.90	978	29.080	65.8	66	29.980	29.138			65	55	10	S. 1	C.S.C.cum.nim.8	
Do.		28	5 p. m.	382.90	978	29.080	62.5	63	29.989	29.139	29.138	806.3	62.2	54	8 2	S. 1	C.S.C.cum.nim.9	A slight fall of rain.
Do.	Mar.	1	7.20 a. m.	382.90	978	29.172	48	48.1	29.120	29.048			46.5	45	1.5	S. 1	C S.C.cum nim.6	Rained from 6 p. m. until 12 p. m.
Camp No. 31′, near San Francisquito		5	6.25 a. m.	383.99	392	28.970	39.6	40	28.943	28.930			40	39.5	0.5	S. 1	C. C. S. 6	Barometer 392 repaired.
Do.		5	7 a. m.	383.99	392	28 970	40	40.6	28.940	28 903			40	39.5	0.5	S. 1	C. C. S. 7	
Do.		5	8 a. m.	383.99	392	29 025	48.8	48.8	28.972	28.933			48.3	46	2.3	S. 1	C. C. S. 8	
Do.		5	9 a. m.	383.99	392	29.025	55	54.9	28.956	28.904			54.5	50.9	3.6	S. 1	C. C. S. 8	
Do.		5	10 a. m.	383.99	392	29.030	61.2	61.2	28.946	28.899			60.5	52.5	8	S. 1	C. C. S. 4	
Do.		5	11 a. m.	383.99	392	29.030	68	67.8	28.928	28.891			67	58	9	S. 1	C. C. S. 5	
Do.		5	12 m.	383.99	392	29.020	72	71.4	28.907	28.891			70	58	12	S. 1	C. C. S. 7	
Do.		5	1 p. m.	383.99	392	29.015	73.5	73	28.900	28.913			72.5	60	12.5	S. 1	C. C. S. 8	
Do.		5	2 p. m.	383.99	392	29.008	75.2	74.9	28.888	28.915			74.5	61.3	13.2	S. 5	C. C. S. 8	
Do.		5	3 p. m.	383 99	392	29.008	72	71.9	28.895	28.934			71.6	59.5	12.1	S. 5	C. C. S. 8	
Do.		5	4 p. m.	383.99	392	29.000	69	68.9	28.895	28.941			68.9	59	9.9	S. 5	C. C. S 6	
Do.		5	5 p. m.	3-3.99	392	28.990	65.5	65.5	28.895	28 930			65.5	61.2	4.3	S. 5	C. C. S. 8	
Do.		5	5.40 p. m.	383.99	392	28 985	63	63.5	28.896	28.946			63.2	59.5	3.7	S. 5	C. C. S. 7	
Do.		6	6.30 a. m.	383.99	392	29.020	44	44.9	28.980	29.050			44.9	44	0.9	S. 5	C. C. S. 6	
Do.		6	7 a. m.	383.99	392	29.024	45	45.5	28.981	29.056			45.2	44	1.2	S. 5	C. C. S. 4	
Do.		6	8 a. m.	383 99	392	29.050	54.5	53.9	28.984	29.063			53	50	3	S. 5	C. C. S. 3	
Do.		6	9 a. m.	383.99	392	29.075	60.2	60.2	28 993	29.069			59.5	55	4.5	S. 5	C. C. S. 3	
Do.		6	10 a. m.	383.99	392	29.080	67.5	68	28.980	29.055			68	61	7	S. 5	C. C. S. 1	
Do.		6	11 a. m.	383.99	392	29.090	74.2	74	28.972	29.053			74	63.4	10.6	S. 5	C. C. S. 1	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 31′	Mar. 6	12 m.	383.99	392	29.090	76	76	28.967	29.067			75.5	61	14.5	S. 5.	C. C. S. 1.	
Do.	6	1 p. m.	383.99	392	29.072	78.2	78	28.944	29.054			78	64.5	13.5	S. 5.	C. C. S. 2.	
Do.	6	2 p. m.	383.99	392	29.065	77	76.5	28.939	29.044			76.2	60	16.2	S.W. 1.	C. C. S. 3.	
Do.	6	3 p. m.	383.99	392	29.060	76.1	75.9	28.937	29.036			75.2	61.9	13.3	S.W. 1.	C. C. S. 3.	
Do.	6	4 p. m.	383.99	392	29.055	74.2	73.9	28.936	29.027			73	59	14	S.W. 5.	C. C. S. .05.	
Do.	6	5 p. m.	383.99	392	29.050	70.5	70.2	28.941	29.014			70	62	8	S.W. 5.	C. C. S. .05.	
Do.	6	5.40 p. m.	383.99	392	29.045	65.2	66	28.950	29.017			65	60	5	S.W. 5.	C. C. S. .05.	
Do.	7	6.20 a. m.	383.99	392	29.065	39	40	28.038	29.025			39	39	......	S.W. 5.	C. C. S. .05.	
Do.	7	7 a. m.	383.99	392	29.070	40	41	28.040	29.001			40.5	40	0.5	S.W. 5.	C. C. S. .05.	
Do.	7	8 a. m.	383.99	392	29.082	51	51.8	28.024	28.982			51.2	49.9	1.3	S.W. 5.	C. C. S. .05.	
Do.	7	9 a. m.	383.99	392	29.120	59.7	60.2	28.040	28.986			60.3	56	4.3	S.W. 5.	C. C. S. .05.	
Do.	7	10 a. m.	383.99	392	29.130	66.9	67	28.030	28.978			67	59	8	S.W. 5.	C. C. S. .005.	
Do.	7	11 a. m.	383.99	392	29.132	72.2	72	28.019	28.977			71.5	62	9.5	S.W. 5.	C. C. S. .005.	
Do.	7	12 m.	383.99	392	29.125	74.9	74	28.005	28.985			74	62	12	S.W. .05	C. C. S. .005.	
Do.	7	1 p. m.	383.99	392	29.110	76	75.5	28.987	28.990			75.5	63.2	12.3	S.W. .05	C. C. S. .005	
Do.	7	2 p. m.	383.99	392	29.090	75.5	75.5	28.969	28.981			75.5	63.8	11.7	S.W. .05	C. C. S. .005.	
Do.	7	3 p. m.	383.99	392	29.080	74.8	74.5	28.961	28.980			74.2	63.2	11	S.W. 5.	C. C. S. .005.	
Do.	7	4 p. m.	383.99	392	29.070	73	73	28.955	28.976			72.5	63	9.5	S.W. 1.	C. C. S. .005.	
Do.	7	5 p. m.	383.99	392	28.070	69.5	69.5	28.964	28.977			69	62.9	6.1	S.W. 5.	....	
Do.	7	5.45 p. m.	383.99	392	29.072	65.5	65.5	28.977	28.994			64.5	60	4.5	S.W. 5.	C. C. S. .005.	A heavy dew and dense fog last night.
Do.	8	6.42 a. m.	383.99	392	29.060	40.2	41	29.030	28.983			40.5	40.5	......	S.W. 5.	C. C. S. .005.	
Do.	8	7 a. m.	383.99	392	29.060	41	41.9	29.027	28.968			41.5	41.5	......	S.W. 5.	C. C. S. .005.	
Do.	8	8 a. m.	383.99	392	29.070	50.5	51.7	29.013	28.946			51.6	50.3	1.3	S.W. 5.	C. C. S. .005.	
Do.	8	9 a. m.	383.99	392	29.082	59	59.1	29.003	28.939			59	55	4	S.W. 5.	C. S. 1	
Do.	8	10 a. m.	383.99	392	29.100	67.2	66.8	29.000	28.941			66.3	59	7.3	S.W. 5.	C. S. C. 2	
Do.	8	11 a. m.	383.99	392	29.105	72.8	72.5	28.991	28.946			72.5	62.5	10	S.W. 5.	C. S. C. 6.	
Do.	8	12 m.	383.99	392	29.100	74.9	74.5	28.980	28.960			74.5	63	11.5	S.W. 5.	C. S. C. 7.	
Do.	8	1 p. m.	383.99	392	29.085	79	78	28.954	28.964			77.9	65.2	12.7	S.W. 5.	C. S. C. 7.	
Do.	8	2 p. m.	383.99	392	29.065	76.5	76	28.941	28.966			75.5	64.5	11	S.W. 5.	C. S. C. 7.	
Do.	8	3 p. m.	383.99	392	29.058	74.4	73.8	28.939	28.978			73	64.5	8.5	S.W. 5.	C. S. C. 8.	
Do.	8	4 p. m.	383.99	392	29.046	68.5	68.8	28.943	28.991			68	62.5	5.5	S.W. 5.	C. S. C. 8.	
Do.	8	5 p. m.	383.99	392	29.030	66.1	66.7	28.933	28.979			66	61.9	4.1	S.W. 5.	C. S. C. 7.	
Do.	9	7 a. m.	383.99	392	28.950	48	48.9	28.899	28.957			48.5	48.5	......	S.W. 5.	C. S. C. 8.	
Do.	9	8 a. m.	383.99	392	28.955	53	53	28.891	28.947			52	52	......	S.W. 5.	C. S. C. 8	
Do.	9	9 a. m.	383.99	392	28.955	62.9	62.5	28.866	28.912			63	60	3	S.W. 5.	C. S. C. 6.	

Do..........................	9	10 a. m....	383.99	392	28.950	69.7	69.5	28.843	28.894	....	....	69.5	62.9	6.6	S.W. 5..	C. S. C. 5......	
Do..........................	9	11 a. m....	383.99	392	28.935	69.8	69.5	28.828	28.893	....	....	70	60	10	N.W. 3..	C. S. C. 7......	
Do..........................	9	12 m	3-3.99	392	28.915	73.9	73.2	28.728	28.888	....	....	73.5	62	11.5	N. 1.....	C. S. C. 7......	
Do..........................	9	1 p. m....	383.99	392	28.900	75.1	73.5	28.790	28.906	....	....	73	61.5	11.5	N. 1.....	C. S. C. 6......	
Do..........................	9	2 p. m....	383.99	392	28.880	71.4	69.8	28.770	28.899	....	....	69.8	64	5.8	S.E. 1...	C. C. S. cum. 6	
Do..........................	9	3 p. m....	383.99	392	28.875	72.5	71.2	28.761	28.900	....	....	71.2	63.9	7.3	S.E. 1...	C. C. S. cum. 6	Heavy cum. clouds in the north.
Do..........................	9	4 p. m....	382.99	392	28.872	70.5	70.2	28.763	28.904	....	....	70.1	63.9	6.2	S.E. 1...	C. C. S. cum. 7	
Do..........................	9	5 p. m....	383.99	392	28.865	66.2	66	28.768	28.901	....	....	65.5	60.1	5.4	N. 1.....	C. C. S. cum. 7	
Do..........................	10	7 a. m....	383.99	392	28.880	49	49.6	28.827	28 948	....	....	49.2	45.6	3.6	N. 1.....	C. C. S. cum. 7	
Do..........................	10	8 a. m....	383.99	392	28.860	51.9	52	28.799	28.922	....	....	52	49	3	N. 1	C. C. S. cum. 7	
Do..........................	10	9 a. m....	383.99	392	28.905	59	59.3	28.826	28.942	....	....	58.5	53	5.5	N. 1.....	C. C. S. cum. 4	
Do..........................	10	10 a. m....	383.99	392	28.915	65.2	65.8	28.820	28.931	....	....	65	57	8	N. 1.....	C. C. S. cum. 7	
Do..........................	10	11 a. m....	383.99	392	28.920	61.8	60	28.834	28.949	....	....	59.5	55	4.5	E. 1.....	C. C. S. cum. 7	
Do..........................	10	12 m	383.99	392	28.910	62.8	62.5	28.822	28.952	....	....	62.5	57	5.5	S E. 1...	C. C. S. cum. 6	
Do..........................	10	1 p. m....	383.99	392	28.905	65	64.2	28.810	28.953	....	....	63.5	56	7.5	S E. 1...	C. C. S. cum. 6	
Do..........................	10	2 p. m....	383.99	392	28.890	63.9	63.7	28.798	28.940	....	....	63.5	58	5.5	S.E. 1...	C. C. S. cum. 7	
Do..........................	10	3 p. m....	383.99	392	28.880	58.9	59.5	28.802	28.941	....	....	59	55	4	S.E. 1...	C. C. S. cum. 8	Appearance of rain.
Do..........................	10	4 p. m....	383.99	392	28.875	57.5	58	28.800	28.941	....	....	58	55	3	S.E. 1...	C. C. S. nim. 9	Raining slightly.
Do..........................	10	5 p. m....	383.99	392	28.880	55.9	56.5	28.809	28.942	....	....	56	53.5	2.5	S.E. 1...	C.S.C.cum.nim.9	
Do..........................	11	8 a. m. ...	383.99	392	28.950	49.4	50.5	28.896	28.952	....	....	49	47	2	S E. 1...	C S.C.cum.nim.6	
Do..........................	11	9 a. m. ...	383.99	392	28.955	53	53.2	28.891	28.947	....	....	52.5	50	2.5	S.E. 1...	C.S.C.cum.nim.6	Raining slightly.
Do..........................	11	10 a. m. ..	383.99	392	28.970	53.9	51.8	28.904	28.952	....	....	54	51.5	2.5	S.E. 1...	C S.C.cum.nim.9	
Do..........................	11	11 a. m. ..	383.99	392	28.965	53.5	54	28.900	28.958	....	....	53.2	51.2	2	S.E. 1...	C S C.cum.nim.9	
Do..........................	11	12 m	383.99	392	28.955	55.5	56	28.885	28.965	....	....	55	53	2	S.E. 1...	C.S.C.cum.nim.9	
Do..........................	11	1 p. m....	383.99	392	28.940	55.8	56.2	28.870	28.935	....	....	55.4	53.5	1.9	S.E. 1...	C.S.C cum.nim.9	
Do..........................	11	2 p. m....	383.99	392	28.929	53.1	53.8	28.865	28.977	....	....	53.2	51.9	1.3	S.E. 1...	Overcast.	
Do..........................	11	3 p. m....	383.99	392	28.925	53.5	54	28.860	28.979	....	....	53.8	52.5	1.3	S.E. 1...	Overcast......	
Do..........................	11	4 p. m....	383.99	392	28.920	53.6	54	28.855	28.979	....	....	53.8	52.2	1.6	E. 5....	Overcast.	
Do..........................	11	5 p. m....	383.99	392	28.904	52.6	53	28.841	28.961	....	....	52.5	51.9	0.6	N. 5.. ...	Overcast......	
Do..........................	12	8 a. m. ...	383.99	392	28.970	55	55.2	28.901	29.010	....	....	54	53.5	0.5	N. 5.....	Overc't; cum.nim	
Do..........................	12	9 a. m. ...	383.99	392	28.975	57	58	28.901	28.902	....	....	57.5	56	1.5	N. 5.....	Overcast; cum. nim. 9......	Slight fall of rain.
Do..........................	12	10 a. m. ..	383.99	392	28.985	58.2	58.5	28.908	29.018	....	....	58	55.5	2.5	N. 5.....	......do........	
Do..........................	12	11 a. m. ..	383 99	392	28.990	60	60	28.908	29.024	....	....	59.5	57	2.5	N. 5.....	C.S. cum. nim.8	
Do..........................	12	12 m	383.99	392	28.979	61.8	61 5	28.893	29.033	....	....	61	57.5	3.5	S.W. 5 .	C.S. cum. nim.9	
Do..........................	12	1 p. m....	383.99	392	28.970	59	59.2	28.891	29.057	....	....	59	55.5	3.5	S.W. 5..	C.S. cum. nim.9	
Do..........................	12	2 p. m....	383.99	392	28.965	61	61	28.881	29.060	....	....	61	57	4	S.W. 5..	C.S. cum. nim.9	
Do..........................	12	5 p. m....	383.99	392	28.950	57.7	58.2	28.874	29.057	....	....	58	55.5	2.5	S. 1.....	C.S. cum. nim.9	
Do..........................	14	7 a. m....	383.99	392	28.942	50.2	50.6	28.886	29.013	....	....	50	49	1	S. 1.....	Overcast......	Raining.
Do..........................	14	8 a. m....	383.99	392	28.945	50.5	50.8	28.888	29.017	....	....	50	48.5	1.5	S. 1.....	Overcast......	
Do..........................	14	9 a. m....	383.99	392	28.940	51.8	52	28.880	29.016	....	....	51	49	2	S. 1.....	Overcast......	Do.
Do..........................	14	10 a. m....	383.99	392	28.930	52	52.8	28.869	29.007	....	....	51.9	49.9	2	S. 1.....	Overcast	Do.
Do..........................	14	11 a. m....	383.99	392	28.925	53.2	53.5	28.861	29.009	....	....	53	51	2	S. 1.....	Overcast	Do.
Do..........................	14	12 m	383.99	392	28.920	52.5	52.9	28.857	29.027	....	....	52.5	51	1 5	S. 1.....	Overcast	Do.
Do..........................	14	1 p. m....	383.99	392	28.900	53.1	53.3	28.836	29.029	....	....	52.5	51.4	1.1	S. 1.....	Overcast	Do.
Do..........................	14	4 p. m....	383.99	392	28.888	51	51.8	28.830	29.041	....	....	51	50.3	0.7	S. 1.....	Overcast	Do.
Do..........................	15	9 a. m....	383.99	392	28.885	51	52.9	28.819	....	....	....	53	50.5	2.5	S. 1.....	C. S. cum. 1...	
Do..........................	15	9 a. m....	383.29	978	28.882	53	52.9	28.818	28.883	....	....	53	50.5	2.5	S. 1.....	C. S. cum. 1...	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 31′	Mar. 15	10 a. m.	383.99	392	28.888	58	56.9	28.811				56.8	51.3	5.5	S. 1	C. S. cum. 1	
Do.	15	10 a. m.	383.99	978	28.884	56.9	56.9	28.810	28.867			56.8	51.3	5.5	S. 1	C. S. cum. 1	
Do.	15	11 a. m.	383.99	392	28.882	59.8	58.2	28.800				59	53	6	S. 1	C. S. cum. 1	
Do.	15	11 a. m.	383.99	978	28.880	58.8	58.2	28.802	28.857			59	53	6	S. 1	C. S. cum. 1	
Do.	15	12 m	383.99	392	28.875	61	59.9	28.791				59.9	52.5	6.4	S. 1	C. S. cum. 1	
Do.	15	12 m	383.99	978	28.872	61	59.9	28.790	28.859			59.9	52.5	6.4	S. 1	C. S. cum. 1	
Do.	15	3 p. m.	383.99	392	28.832	59.6	58.5	28.752				58	48	10	S.W. 2	C. S. cum. 2	
Do.	15	3 p. m.	383.99	978	28.838	58.5	58.5	28.760	28.813	28.975	954.1	58	48	10	S.W. 2	C. S. cum. 2	
Camp No. 32, Rio Peru	16	5.45 p. m.	370.10	978	29.472	54.5	54.5	29.405	29.344						S.W. 2	C. S. cum. 4	
Do.	16	6 p. m.	370.10	978	29.468	53.8	54	29.403	29.342	29.343	612.2	53.9	47	6.9	W. 5	C. S. cum. 3	
Camp No. 33, S. Clara river	17	5 p. m.	351.02	978	29.970	58	58	29.893	29.845						W. 5	C. S. cum. 3	
Do.	17	5.45 p. m.	351.02	978	29.962	53.5	54	29.897	29.845			53.2	48.9	4.3	S.W. 5	Cum. C. S. 2	
Do.	18	6.20 a. m.	351.02	978	29.978	48.2	48.9	29.927	29.867	29.852	149.2	48	44	4	E. 5	Cum. C. S. 8	
Station 2	18	8.15 a. m.	349.56	978	29.978	61.5	59.8	29.892	29.806		201.5				E. 5	Cum. C. S. 5	
Between stations 3 and 4	18	9.45 a. m.	352.97	978	29.830	71	69.5	29.720	29.635		365.5				E. 5	Cum. C. S. 6	
1st summit, (on divide)	18	1 p. m.	360.81	978	29.484	69.5	69	29.378	29.348		639.6				W. 1	Cum. C. S. 1	
2d summit	18	1.40 p. m.	363.75	978	29.372	69.5	69	29.266	29.242		741.0				W. 1	Cum. C. S. 1	
3d summit	18	2.10 p. m.	367.14	978	29.322	70	68.8	29.214	29.294		690.3				W. 1	Cum. C. S. .05	
Camp No. 34, Semi	18	4.30 p. m.	367.83	978	29.424	65.2	65	29.329	29.319			64	54.5	9.5	W. 1	Cum. C. S. .05	
Do.	18	5 p. m.	367.83	978	29.410	62.8	62.8	29.321	29.301			62	54	8	W. 1	Cum. C. S. .05	
Do.	18	6 p. m.	367.83	978	29.400	52.7	53	29.337	29.319			52	47.4	4.6	W. 1	Cum. C. S. .05	
Do.	19	5.50 a. m.	367.83	978	29.328	37.8	38.8	29.305	29.273			38	36	2	W. 1	Cum. C. S. .05	
Do.	19	6.05 a. m.	367.83	978	29.328	37.8	38.8	29.305	29.273	29.297	676.1	38	36		1	Cum. C. S. .05	
Station 4, on summit	19	10 a. m.	373.02	978	28.850	74	72	28.732	28.657		1,311.8				W. 1	Cum. C. S. .05	
Station 6, intersection of Los Angeles road	19	10.50 a. m.	375.97	978	29.274	75	73.5	29.154	29.085		896.1				W. 1	Cum. C. S. .05	
Stations 8 and 9, point where road strikes stream	19	11.35 a. m.	377.90	978	29.278	74	73.5	29.160	29.101		881.7				W. 1	Cum. C. S. .05	
Camp No. 35, Triompho	19	4 p. m.	381.28	978	29.060	68.5	67.7	28.956	28.954			67	59	8	W. 1	Cum. C. S. .05	
Do.	19	6 p. m.	381.28	978	29.040	59.5	59.3	28.960	28.952			59	52.5	6.5	W. 1	Cum. C. S. .05	
Do.	19	7.30 p. m.	381.28	978	29.036	51	51.2	28.978	28.963			51	47.5	3.5	W. 1	Cum. C. S. .05	
Do.	20	6.30 a. m.	381.28	392	29.082	44	44.5	29.042				45	42.8	2.2	W. 1	Cum. C. S. .05	
Do.	20	6.30 a. m.	381.28	978	29.084	43.9	44.5	29.044	29.004			45	42.8	2.2	W. 1	Cum. C. S. .05	
Do.	20	7 a. m.	381.28	392	29.100	48.5	48.6	29.048				48	45	3	W. 1	Cum. C. S. .05	
Do.	20	7 a. m.	381.28	978	29.104	48.5	48.6	29.052	28.993			48	45	3	W. 1	Cum. C. S. .05	

Do		20	8 a. m.	381.28	392	29.155	64.5	63.8	29.062	29.006	......	......	64	56.5	7.5	W. 1	Cum. C. S. .05
Do		20	9 a. m.	381.28	392	29.165	69.9	69	29.058	28.994	......	......	69	54	15	S. of E. 1	Cum. C. S. .05
Do		20	10 a. m.	381.28	392	29.180	72	71	29.067	29.007	......	......	70.5	51.9	15.6	S. of E. 1	Cum. C. S. .05
Do		20	11 a. m.	381.28	392	29.180	73	72.2	29.075	29.026	......	......	72	55.5	16.5	N.E. 3	Cum. C. S. .05
Do		20	12 m.	381.28	392	29.180	75	73.9	29.060	29.035	......	......	73.9	58	14.9	N.E. 3	Cum. C. S. .05
Do		20	1 p. m.	381.28	392	29.165	75.2	74.5	29.045	29.045	......	......	74	56	18	N.W. 5	Cum. C. S. .05
Do		20	2 p. m.	381.28	392	29.150	74.8	74.2	29.031	29.041	......	......	74	55.2	18.8	N. 5	Cum. C. S. .05
Do		20	3 p. m.	381.28	392	29.138	75.3	75	29.017	29.036	......	......	74.5	56.5	18	N. 5	Cum. C. S. .05
Do		20	4 p. m.	381.28	392	29.125	72.9	73	29.011	29.032	......	......	72.5	55	17.5	N.W. 5	Cum. C. S. .05
Do		20	5 p. m.	381.28	392	29.125	71.5	72	29.013	29.026	......	......	71.5	54	17.5	N.W. 5	Cum. C. S. .05
Do		20	6 p. m.	381.28	392	29.105	61.7	63	29.019	29.034	......	......	62.2	53	9.2	N.W. 5	C. O. S. 2
Do		21	5.40 a. m.	381.28	392	29.065	36.5	37	29.041	29.030	......	......	35	32.5	2.5	N.W. 5	C. C. S. 2
Do		21	6 a. m.	381.28	392	29.070	37	37.2	29.048	29.049	29.012	957.6	36	33	3	N.W. 5	C. C. S. 1
Station 1		21	7.15 a. m.	383.01	392	29.215	44	42.5	29.175	29.150	......	807.7	......	......	......	N.W. 5	C. C. S. 1
Station 2		21	8 a. m.	384.81	392	29.310	55	56.5	29.241	29.220	......	753.0	......	......	......	N.W. 5	C. C. S. 1
Station 3, on summit		21	8.20 a. m.	385.16	392	29.200	60	62.7	29.118	29.094	......	922.4	......	......	......	N.W. 5	C. C. S. 2
Station 5		21	9 a. m.	386.99	392	29.385	66	66	29.286	29.262	......	720.3	......	......	......	N.W. 5	C. C. S. 2
Station 7		21	9.40 a. m.	389.24	392	29.000	70.5	70	28.891	28.868	......	1,103.1	......	......	......	N.W. 5	C. C. S. 3
Station 12		21	0.30 p. m.	395.99	392	29.320	80.5	80	28.183	29.199	......	791.7	......	......	......	N.W. 5	C. C. S. 3
Camp No. 36, Encina		21	3 p. m.	397.50	392	29.320	78.5	78	29.189	29.228	......	......	77.5	62.5	15	N.W. 5	C. C. S. 3
Do		21	4 p. m.	397.50	392	29.305	76.8	76	29.178	29.222	......	......	76	60	16	N.W. 5	C. C. S. 2
Do		21	5 p. m.	397.50	392	29.300	74	73.5	29.220	29.260	......	......	73	53.8	19.2	N.W. 5	C. C. S. 2
Do		21	6 p. m.	397.50	392	29.285	59.3	60	29.204	29.249	......	......	57.5	53	4.5	N.W. 5	C. C. S. 2
Do		22	6 a. m.	397.50	392	29.250	39.8	40.8	29.221	29.252	29.242	738.6	40	38	2	N.W. 5	C. C. S. 5
Between stations 1 and 2		22	8.40 a. m.	403.54	392	29.535	66.5	65.5	29.435	29.420	......	565.5	......	......	......	N.W. 5	C. C. S. 6
Station —		22	0.10 p. m.	......	392	29.725	77	74	29.597	29.600	......	400.5	......	......	......	N.W. 5	C. C. S. 2
Camp No. 37, near Los Angeles		22	4 p. m.	412.04	392	29.700	70.5	70.2	29.590	29.621	......	......	70	61	6	N.W. 5	C. C. S. 2
Do		22	5 p. m.	412.04	392	29.675	64.5	64.2	29.580	29.603	......	......	63.3	59.5	3.8	N.W. 5	C. C. S. 2
Do		22	6 p. m.	412.04	392	29.670	60	60.2	29.587	29.612	......	......	59.5	56	3.5	S.W. 5	C. C. S. 1
Do		26	5 p. m.	412.04	392	29.555	62.9	63.2	29.465	29.625	......	......	62	57.5	4.5	S.W. 5	C. C. S. 3
Do		26	6 p. m.	412.04	392	29.535	57.9	58.8	29.457	29.622	......	......	58.8	56	2.8	S.W. 5	C. C. S. 5
Do		27	6.30 a. m.	412.04	392	29.510	39.8	40.8	29.481	29.644	29.621	376.1	40	38.8	1.2	N.E. 1	C. C. S. 9
Los Angeles	......	......	......	417.79	......	......	......	......	......	......	......	......	......	......	......	......	......
Camp No. 40, Sycamore Grove, Cajon pass		31	10 a. m.	475.21	392	27.990	63	61	27.904	......	......	......	60.2	53	7.2	S.E. 5	C. C. S. cum. 8
Do		31	10 a. m.	475 21	790	27.992	61.4	61	27.960	27.699	......	......	60.2	53	7.2	S.E. 5	C. C. S. cum. 8
Do		31	12 m.	475.21	392	27.985	59.7	58.5	27.908	......	......	......	58	50	8	N.E. 5	C. C. S. cum. 9
Do		31	12 m.	475.21	790	27.980	58.9	58.5	27.904	27.725	......	......	58	50	8	N.E. 5	C. C. S. cum. 9
Do	April	6	9 a. m.	475.21	392	28.350	71.9	......	28.242	......	......	......	72.5	50.5	22	N.W. 2	C. C. S. cum. 9
Do		6	9 a. m.	475.21	790	28.346	71.5	......	28.239	28.056	......	......	72.5	50.5	22	N.W. 2	C. C. S. 9
Do		6	10 a. m.	475.21	392	28.340	74.9	......	28.224	......	......	......	75	54	21	N.W. 3	C. C. S. 9
Do		6	10 a. m.	475.21	790	25.338	74.5	......	28.223	28.045	......	......	75	54	21	N.W. 3	C. C. S. 9
Do		6	11 a. m.	475.21	392	28.335	75.2	......	28.218	......	......	......	75	52.4	22.6	N.W. 3	C. C. S. 9
Do		6	11 a. m.	475.21	790	28.330	75.2	......	28.214	28.050	......	......	75	52.4	22.6	N.W. 3	C. C. S. 9
Do		6	12 m.	475.21	392	28.315	76.9	......	28.192	......	......	......	76.9	55.6	21.3	N.W. 5	C. C. S. 9
Do		6	12 m.	475.21	790	28.320	76.5	......	28.198	28.059	......	......	76.9	55.6	21.3	N.W. 5	C. C. S. 9
Do		6	1 p. m.	475.21	392	28.300	78.8	......	28.173	......	......	......	78.2	54.2	24	N.W. 3	C. C. S. 9
Do		6	1 p. m.	475.21	790	28.302	78.5	......	28.175	28.059	......	......	78.2	54.2	24	N.W. 3	C. C. S. 9

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 40	April 6	2 p. m.	475.21	392	28.285	80		28.154				80	56.5	23.5	N.W. 1	C. C. S. 9	
Do	6	2 p. m.	475.21	790	28.288	79.5		28.159	28.052			80	56.5	23.5	N.W. 1	C. C. S. 9	
Do	6	3 p. m.	475.21	392	28.260	81.8		28.125				81	57.5	23.5	N.W. 3	C. C. S. 9	
Do	6	3 p. m.	475.21	790	28.258	81.2		28.124	28.024			81	57.5	23.5	N.W. 3	C. C. S. 9	
Do	6	4 p. m.	475.21	392	28.240	81		28.114				80.5	56	24.5	N.W. 2	C. C. S. 9	
Do	6	4 p. m.	475.21	790	28.238	80		28.107	28.012			80.5	56	24.5	N.W. 2	C. C. S. 9	
Do	6	6 p. m.	475.21	392	28.230	76		28.109				77	54	23	N.W. 2	C. C S. 9	
Do	6	6 p. m.	475.21	790	28.226	75.8		28.106	28.012	27,991	1,906.3	77	54	23	N.W. 2	C. C. S. 9	
Camp No. 41, near S. Bernardino	10	9 a. m.	489.21	392	29.000	61.5	64	28.907							N.W. 2	C. C. S. 8	
Do	10	9 a. m.	489.21	790	29.002	64	64	28.910	28.977						N.W. 2	C. C. S. 8	
Do	10	10 a. m.	489.21	392	29.005	67	63	28.905				63	59.5	3.5	N.W. 2	C. C. S. cum. 8	
Do	10	10 a. m.	489 21	790	29.010	65.9	63	28.913	29.082			63	59.5	3.5	N.W. 2.	C. C. S. cum. 8	
Do	10	11 a. m.	489.21	392	29.018	75	75	28.898				75			N.W. 2	C. C. S. cum. 8	
Do	10	11 a. m.	489.21	790	29.022	72.5	75	28.903	29.087			75			N.W. 2	C. C. S. cum. 8	
Do	10	12 m.	489.21	392	29.018	75.5	75	28.897				75			N.W. 2	C. C. S. cum. 8	
Do	10	12 m	489.21	790	29.022	73		28.907	29.108			75			N.W. 2	C. C. S. cum. 8	
Do	10	1 p. m.	489.21	392	29.000	80	79.5	28.867				79.5	64.5	15	N.W. 2	C. C. S. cum. 8	
Do	10	1 p. m.	489.21	790	29.003	77.5	79.5	28.876	29.100			79 5	64.5	15	N.W. 2	C. C. S. cum. 8	
Do.	10	2 p. m.	489.21	392	28.982	75.4	75.4	28.859				75.4	63.7	11.7	N.W. 2.	C. C. S. cum. 6	
Do.	10	2 p. m.	489.21	790	28.982	73.9	75.4	28.864	29.097			75.4	63.7	11.7	N W. 2	C. C. S. cum. 6	
Do.	10	4 p. m.	489.21	392	28.940	71.5	71.9	28.829				71.9	62	9.9	N.E. 1	C. C. S. cum. 4	
Do	10	4 p. m.	489.21	790	28.942	70	71.9	28.834	29.077			71.9	62	9.9	N.E. 1	C. C. S. cam. 4	
Do.	10	5 p. m.	489.21	392	28.940	68.5	69	28.837				69	61.5	7.5	N.W. 2	C. C. S. cum. 4	
Do.	10	5 p. m.	489.21	790	28.942	68	69	28.840	29.074			69	61.5	7.5	N.W. 2	C. C. S. cum. 4	
Do.	10	6 p. m.	489.21	392	28.930	63.2	61	28.841				64	59	5	N.W. 2	C. C. S. cum. 4	
Do.	10	6 p. m.	489.21	790	28.935	63.2	64	28.846	29.082			64	59	5	N W. 2	C. C. S. cum. 4	
Do.	11	7 a. m.	489.21	392	29.010	57.5	58	28.935				58	54.5	3.5	N.W. 2	C. C. S. cum. 6	
Do.	11	7 a. m.	489.21	790	29.016	57.5	58	28.941	29.103			58	54.5	3.5	N.W. 2	C. C. S. cum. 6	
Do	11	8 a. m.	489.21	392	29.045	62.2	61	28.958				61	55	6	N.W. 2	C. C. S. cum. 4	
Do	11	8 a. m.	489.21	790	29.050	62.2	61	28.965	29.109			61	55	6	N.W. 2	C. C. S. cum. 4	
Do	11	9 a. m.	489.21	392	29.065	65.7	64	28.969				64	56	8	N.W. 2	C. C. S. cum. 6	
Do	11	9 a. m.	489.21	790	29.068	65	64	28 973	29.110			64	56	8	N.W. 2	C. C. S. cum. 6	
Do	11	10 a. m.	489.21	392	29.070	66.8	65.9	28.972				65.9	57.9	8	N.W. 2	C. C. S. cum. 7	
Do	11	10 a. m.	489.21	790	29.076	65.4	65.9	28.981	29.103			65.9	57.9	8	N.W. 2	C. C. S. cum. 7	
Do	11	11 a. m.	489.21	392	29.075	73.4	72	28.959				72	61	11	N.W. 2	C. C. S. cum. 5	

Do.	11	11 a. m.	489.21	790	29.080	70.8	72	28.971	29.087	....	....	72	61	11	N.W. 2.	C. C. S. cum. 5	
Do.	11	12 m.	489.21	392	29.072	72	71	28.959	....	....	....	71	59.5	11.5	E. 5.	C. C. S. cum. 7	
Do.	11	12 m	489 21	790	29.078	70.5	71	28.969	29.090	....	....	71	59.5	11.5	E. 5.	C. C. S. cum. 7	
Do.	11	1 p. m.	489.21	392	29.065	67.3	67.5	28.964	....	....	....	67.5	59	8.5	N.E. 1.	C. C. S. cum. 7	
Do.	11	1 p. m.	489.21	790	29.068	67	67.5	28.968	29.105	....	....	67.5	59	8.5	N.E. 1.	C. C. S. cum. 7	
Do.	11	2 p. m.	489.21	392	29.050	68	68	28.948	....	....	....	68	59.5	8.5	N.E. 1.	C. C. S. cum. 7	
Do.	11	2 p. m.	489.21	790	29.058	67	68	28.958	29.093	....	....	68	59.5	8.5	N.E. 1.	C. C. S. cum. 7	
Do.	11	3 p. m.	489.21	392	29.045	64.7	65	28.952	....	....	....	65	57.5	7.5	N.E. 2.	C. C. S. cum. 7	Appearance of rain.
Do.	11	3 p. m.	489.21	790	29.050	64	65	28.958	29.098	....	....	65	57.5	7.5	N.E. 2.	C. C. S. cum. 7	Do. do.
Do.	11	5 p. m.	489.21	392	29.045	63.8	64	28.953	....	....	....	64	56.5	7.5	N.E. 2.	C. C. S. cum. 8	
Do.	11	5 p. m.	489.21	790	29.050	63	64	28 961	29.082	....	....	64	56.5	7.5	N.E. 2.	C. C. S. cum. 8	
Do.	11	6 p. m.	439.21	392	29.035	59.9	60.5	28.953	....	....	....	60.5	55	5.5	N.E. 3.	C. C. S. cum. 8	
Do.	11	6 p. m.	489.21	790	29.038	59.5	60.5	28.957	29.073	....	....	60.5	55	5.5	N.E. 3.	C. C. S. cum. 8	
Do.	12	7 a. m.	489.21	392	29.115	54.3	54.5	28.048	....	....	....	54.5	54	0.5	N.E. 3.	C. C. S. cum. 8	
Do.	12	7 a. m.	489.21	790	29.120	53.9	54.5	28.054	29.040	....	....	54.5	54	0.5	N.E. 3.	C. C. S. cum. 8	
Do.	12	8 a. m.	489.21	392	29.122	60	60	28.040	....	....	....	57	......	......	N.E. 3.	C. C. S. cum. 8	
Do.	12	8 a. m.	489.21	790	29.130	59.7	60	28.050	29.030	....	....	57	......	......	N.E. 3.	C. C. S. cum. 8	
Do.	12	9 a. m.	489.21	392	29.150	67.2	65.5	28.050	....	....	....	65.5	59.5	6	N.E. 3.	C. C. S. cum. 8	
Do.	12	9 a. m.	489.21	790	29.160	65.5	65.5	28.064	29.031	....	....	65.5	59.5	6	N.E. 3.	C. C. S. cum. 8	
Do.	12	10 a. m.	489.21	392	29.166	72.9	69.9	28.052	....	....	....	69.9	61	8.9	N.E. 3.	C. C. S. cum. 8	
Do.	12	10 a. m.	489.21	790	29.172	69.8	69.9	28.065	29.044	....	....	69.9	61	8.9	N E. 3.	C. C. S. cum. 8	
Do.	12	11 a. m.	489.21	392	29.167	75	72	28.047	....	....	....	72	62	10	N.E. 3.	C. C. S. cum. 6	
Do.	12	11 a. m.	489.21	790	29.174	72	72	28.061	29.040	....	....	72	62	10	N.E. 3.	C. C. S. cum. 6	
Do.	12	12 m	489.21	392	29.167	79	76	28.036	....	....	....	76	61	15	N.E. 3.	C. C. S. cum. 6	
Do.	12	12 m	489.21	790	29.174	76.4	76	28.050	29.051	....	....	76	61	15	N.E. 3.	C. C. S. cum. 6	
Do.	12	1 p. m.	489.21	392	29.160	78	76	28.032	....	....	....	76	60	16	N.E. 1.	C. C. S. cum. 6	
Do.	12	1 p. m	489.21	790	29.168	75.5	......	28.046	29.067	....	....	76	60	16	N.E. 1.	C. C. S. cum. 6	
Do.	12	2 p. m.	489.21	392	29.150	78.5	77.5	28.021	....	....	....	77.5	61	16.5	N.W. 1.	C. C. S. cum. 3	
Do.	12	2 p. m.	489.21	790	29.150	77	77.5	28.024	29.050	....	....	77.5	61	16.5	N.W. 1.	C. C. S. cum. 3	
Do.	12	3 p. m.	489.21	392	29.145	74.5	74	28.026	....	....	....	74	59	15	N.W. 1.	C. C. S. cum. 3	
Do.	12	3 p. m.	489.21	790	29.146	73.2	74	28.030	29.080	....	....	74	59	15	N.W. 1.	C. C. S. cum. 3	
Do.	12	4 p. m.	489.21	392	29.130	68.5	68.5	28.037	....	....	....	68.5	57	11.5	N.W. 1.	C. C. S. cum. 2	
Do.	12	4 p. m.	489.21	790	29.134	68	68.5	28.032	29.064	....	....	68.5	57	11.5	N.W. 1.	C. C. S. cum. 2	
Do.	12	5 p. m.	489.21	392	29.130	65.2	65	28.034	....	....	....	65	56	9	N.E. 2.	C. C. S. cum. 6	
Do.	12	5 p. m.	489.21	790	29.134	65	65	28.039	29.063	....	....	65	56	9	N.E. 2.	C. C. S. cum. 6	
Do.	12	6 p. m.	489.21	392	29.120	61.4	61.5	28.035	....	....	....	61.5	55	6.5	N.E. 2.	C. C. S. cum. 6	
Do.	12	6 p. m.	489.21	790	29.126	61	61.5	28.042	29.068	....	....	61.5	55	6.5	N.E. 2.	C. C. S. cum. 6	
Do.	14	8 a. m.	489 21	392	29.180	62.9	60	28.092	....	....	....	60	53	7	N.E. 2.	C. C. S. cum. 1	
Do.	14	8 a. m.	489.21	790	29.186	61	......	28.102	29.134	....	....	60	53	7	N.E. 2.	C. C. S. cum. 1	
Do.	14	9 a. m.	489.21	392	29.183	66.6	65	29.085	....	....	....	65	54.5	10.5	N.E. 2.	C. C. S. cum 1	
Do.	14	9 a. m.	489.21	790	29.190	64	65	29.098	29.125	....	....	65	54.5	10.5	N.E. 2.	C. C. S. cum. 1	
Do.	14	10 a. m.	489.21	392	29.189	71	69	29.079	....	....	....	69	56	13	N.E. 2.	C. C. S. cum. 1	
Do.	14	10 a. m	489.21	790	29.196	68	69	29.09.	29.126	....	....	69	56	13	N.E. 2.	C. C. S. cum. 1	
Do.	14	11 a. m.	489.21	392	29.190	73 5	71.5	29.074	....	....	....	71.5	57	14.5	N.E. 2.	C. C. S. cum. 1	
Do.	14	11 a. m.	489.21	790	29.198	71	71.5	29.088	29.134	....	....	71.5	57	14.5	N.E. 2.	C. C. S. cum. 1	
Do.	14	12 m.	489.21	392	29.190	75.5	73.5	29.069	....	....	....	73.5	57.5	16	N.E. 2.	C. C. S. cum. 1	
Do.	14	12 m.	489.21	790	29.196	73	73.5	29.081	29.152	....	....	73.5	57.5	16	N.E. 2.	C. C. S. cum. 1	
Do.	14	1 p. m.	489.21	392	29.170	78	75	29.042	....	....	....	75	59	16	E. 1.	C. C. S. cum. 4	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 41	April 14	1 p. m.	489.21	790	29.176	75.5	75	29.055	29.149			75	59	16	E. 1	C. C. S. cum. 4.	
Do	14	2 p. m.	489.21	392	29.166	77	76	29.040				76	59.5	16.5	E. 1	C. C. S. cum. 5.	
Do	14	2 p. m.	489.21	790	29.168	75	76	29.048	29.151			76	59.5	16.5	E. 1	C. C. S. cum. 5.	
Do	14	3 p. m.	489.21	392	29.140	71.5	69	29.029				69	56	13	E. 2	C. C. S. cum. 5.	
Do	14	3 p. m.	489.21	790	29.144	70.5	69	29.034	29.144			69	56	13	E. 2	C. C. S. cum. 5.	
Do	14	4 p. m.	489.21	392	29.125	68.5	68	29.022				68	57.5	10.5	E. 1	C. C. S. cum. 4.	
Do	14	4 p. m.	489.21	790	29.130	68	68	29.028	29.147			68	57.5	10.5	E. 1	C. C. S. cum. 4.	
Do	14	5 p. m.	489.21	392	29.110	68	67	29.008				67	57	10	S.W. 1	C. C. S. cum. 2.	
Do	14	5 p. m.	489.21	790	29.120	68	67	29.018	29.135			67	57	10	S.W. 1	C. C. S. cum. 2.	
Do	14	6 p. m.	489.21	392	29.108	63	62.6	29.029				62.6	55	7.6	S.W. 1	C. C. S. cum. 2.	
Do	14	6 p. m.	489.21	790	29.116	55	55	29.047	29.172	29.138	834	62.6	55	7.6	S.W. 1	C. C. S. cum. 2.	
Camp No. 42, near Jarupa	20	5 a. m.	480.21	392	29.255	42.5	43	29.219				43	42	1	S.W. 1	Cum. C. S. 3	
Do	20	5 a. m.	480.21	790	29.260	42.5	43	29.224	29.170			43	42	1	S.W. 1	Cum. C. S. 3	
Do	20	6 a. m.	480.21	392	29.268	43	43.5	29.230				43.5	42	1.5	S.W. 1	Cum. C. S. 5	
Do	20	6 a. m.	480.21	790	29.276	42.9	43.5	29.238	29.190			43.5	42	1.5	S.W. 1	Cum. C. S. 5	
Do	20	7 a. m.	480.21	392	29.285	53	53.5	29.221				53.5	50.5	3	S.W. 1	Cum. C. S. 3	
Do	20	7 a. m.	480.21	790	29 292	52.8	53.5	29.229	29.151			53.5	50.5	3	S.W. 1	Cum. C. S. 3	
Do	20	8 a. m.	480.21	392	29.310	62	62.5	29.223				62	55	7	S.W. 1	C. C. S. 1	
Do	20	8 a. m.	480.21	790	29.316	61.8	62.5	29.230	29.154			62	55	7	S.W. 1	C. C. S. 1	
Do	20	9 a. m.	480.21	392	29.320	68.5	69	29.217				69	58.5	10.5	W. 5	C. C. S. 1	
Do	20	9 a. m.	480.21	790	29.328	66.5	69	29.230	29.147			69	58 5	10.5	W. 5	C. C. S. 1	
Do	20	10 a. m.	480.21	392	29.328	76	74.4	29.205				74.4	60	14.4	W. 5	C. C. S. 1	
Do	20	10 a. m.	480.21	790	29.338	76	74.4	29.215	29.141			74.4	60	14.4	W. 5	C. C. S. 1	
Do	20	11 a. m.	480.21	392	29.330	80.2	79	29.196				79	61.9	17.1	W. 5	C. C. S. 1	
Do	20	11 a. m.	480.21	790	29.338	79	79	29.207	29.149			79	61.9	17.1	W. 5	C. C. S. 1	
Do	20	12 m.	480.21	392	29.326	83.9	82	29.182				82	62	20	W. 5	C. C. S. 2	
Do	20	12 m	480.21	790	29.336	82.5	82	29.197	29.168			82	62	20	W. 5	C. C. S. 2	
Do	20	1 p. m.	480.21	392	29.320	84	82	29.176				82	62.5	19.5	W. 5	C. C. S. 2	
Do	20	1 p. m.	480.21	790	29.330	82.5	82	29.190	29.191			82	62.5	19.5	W. 5	C. C. S. 2	
Do	20	2 p. m.	480.21	392	29.310	84.8	83	29.164				83	64	19	W. 1	C. C. S. 4	
Do	20	2 p. m.	480.21	790	29.318	82.9		29.177	29.193			83	64	19	W. 1	C. C. S. 4	
Do	20	3 p. m.	480 21	392	29.280	82.5	80.9	29.141				80.9	64.8	16.1	W. 1	C. C. S. 3	
Do	20	3 p. m.	480.21	790	29.288	81.4	80.9	29.151	29.181			80.9	64.8	16.1	W. 1	C. C. S. 3	
Do	20	4 p. m.	480.21	392	29.262	76.3	76	29.138				76	62.5	13.5	W. 1	C. C. S. 2	
Do	20	4 p. m.	480.21	790	29.272	75.4	76	29.151	29.186			76	62.5	13.5	W. 1	C. C. S. 2	

Do		20	5 p. m	480.21	392	29.255	75.7	75	29.133				75	61	14	W. 1	C. C. S. 1	
Do		20	5 p. m	480.21	790	29.264	74.9	75	29.141	29.175			75	61	14	W. 1	C. C. S. 1	
Do		20	6 p. m	480.21	392	29.255	70.5	70	29.146				70	58	12	W. 1	C. C. S. 1	
Do		20	6 p. m	480.21	790	29.264	69.9	70	29.156	29.192			70	58	12	W. 1	C. C. S. 1	
Do		20	7 p. m	480.21	392	29.250	65.5	66	29.154				66	59	7	W. 1	C. C. S. 1	Hazy.
Do		20	7 p. m	480.21	790	29.258	65	66	29.163	29.185			66	59	7	W. 1	C. C. S. 1	
Do		20	8 p. m	480.21	392	29.260	61.5	63	29.155				63	59	4	W. 1	C. C. S. 1	
Do		20	8 p. m	480.21	790	29.270	61.5	63	29.185	29.201			63	59	4	W. 1	C. C. S. 1	
Do		20	9 p. m	480.21	392	29.265	55.5	57	29.195				57	55	2	W. 1	C. C. S. 1	
Do		20	9 p. m	480.21	790	29.276	55	57	29.207	29.215			57	55	2	W. 1	C. C. S. 1	
Do		20	10 p. m	480.21	392	29.260	51.5	52	29.201				52	51	1	W. 1	C. C. S. 1	
Do		20	10 p. m	480.21	790	29.266	51.5	52	29.207	29.211			52	51	1	W. 1	C. C. S. 1	
Do		20	11 p. m	480.21	392	29.255	49.5	51	29.201				51	50	1	W. 1	C. C. S. 1	
Do		20	11 p. m	480.21	790	29.264	49.5	51	29.210	29.222			51	50	1	W. 1	C. C. S. 1	
Do		20	12 p. m	480.21	392	29.240	46.5	48	29.194				48	47	1	W. 1	C. C. S. 1	
Do		20	12 p. m	480.21	790	29.250	46.5	48	29.204	29.234			48	47	1	W. 1	C. C. S. 1	
Do		21	1 a. m	489.21	392	29.237	47	48	29 189				48	47	1	W. 1	C. C. S. 1	
Do		21	1 a. m	480.21	790	29.244	47	48	29.196	29.239			48	47	1	W. 1	C. C. S. 1	
Do		21	2 a. m	480.21	392	29.210	44.5	45	29.168				45	44.5	0.5	W. 1	C. C. S. 1	
Do		21	2 a. m	480.21	790	29.218	44.5	45	29.176	29.224			45	44.5	0.5	W. 1	C. C. S. 1	
Do		21	3 a. m	480.21	392	29.210	43.5	44	29.171				44	44		W. 1	C. C. S. 1	Heavy dew falling.
Do		21	3 a. m	480.21	790	29.218	43.5	44	29.179	29.228			44	44		W. 1	C. C. S. 1	
Do		21	4 a. m	480.21	392	29.210	42	42.5	29.175				42	42		W. 1	C. C. S. 1	
Do		21	4 a. m	480.21	790	29.218	42	42.5	29.183	29.219			42	42		W. 1	C. C. S. 1	
Do		21	5 a. m	480.21	392	29.200	42.5	43	29.164				43	42.5	0.5	W. 1	C. C. S. 1	
Do		21	5 a. m	480.21	790	29.208	42.5	43	29.172	29.218			43	42.5	0.5	W. 1	C. C. S. 1	
Do		21	9 a. m	480.21	392	29.285	73	72.1	29.170				72.1	62.5	9.6	W. 1	C. C. S. 1	
Do		21	9 a. m	480.21	790	29.290	71.6	72.1	29.179	29.186			72.1	62.5	9.6	W. 1	C. C. S. 1	
Do		21	12 m	480.21	392	29.290	84.2	82.8	29.145				82.8	64.5	18.3	W. 1	C. C. S. 2	
Do		21	12 m	480.21	790	29.300	83	82.8	29.159	29.200			82.8	64.5	18.3	W. 1	C. C. S. 2	
Do		21	3 p. m	480.21	392	29.275	83.8	82	29.132				82	67.5	14.5	W. 1	C. C. S. 3	
Do		21	3 p. m	480.21	790	29.280	82.5	82	29.141	29.231	29.192	783.4	82	67.5	14.5	W. 1	C. C. S. 3	
Camp No. 43		23	5 p. m	487.61	392	28.495	66	65	28.399	28.462						W. 2	C. C. S. 3	
Do		23	5.30 p. m	487.61	392	28.485	65	64.5	28 392			*1487				W. 2	C. C. S. 3	* Approximate.
Camp 44 lies on Temecla creek.				520 61														
Camp No. 45, S. Luis Rey river		25	5 p. m	536.63	392	29.815	66.9	66	29.714	29.777						W. 1	C. C. S. 3	
Do		25	5.30 p. m	536.63	392	29.810	61.7	64.9	29.709			†226				W. 1	C. C. S. 3	† Approximate.
Camp No. 48, Cañada de los Yeguas, near San Diego	May	7	9 a. m	598.77	392	29.938	65.5	63	29.839					55.5		E. 2	C. S. cum. 9	
Do		7	9 a. m	598.77	790	29.944	64.5	63	29.845	29.833				55.5		E. 2	C. S. cum. 9	
Do		7	10 a. m	598.77	392	29.950	66.8	64	29.848				64	56	8	E. 2	C. S. cum. 7	
Do		7	10 a. m	598.77	790	29.960	65.4	64	29.861	29.848			64	56	8	E. 2	C. S. cum. 7	
Do		7	11 a. m	598.77	392	29.955	68.5	64.5	29.848				64.5	57	7.5	E. 1	C. S. cum. 5	
Do		7	11 a. m	598.77	790	29.964	66.9	64.5	29.861	29.858			64.5	57	7.5	E. 1	C. S. cum. 5	
Do		7	12 m	598.77	392	29.942	67	64.9	29.839				64.9	58	6.9	E. 1	C. S. cum. 4	
Do		7	12 m	598.77	790	29.950	65.8	64.9	29.850	29.870			64.9	58	6.9	E. 1	C. S. cum. 4	
Do		7	1 p. m	598.77	392	29.940	68.5	66.5	29.833				66.5	58.5	8	E. 1	C. S. cum. 5	
Do		7	1 p. m	598.77	790	29.950	67.2	66.5	29.846	29.888			66.5	58.5	8	E. 1	C. S. cum. 5	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San José.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 48	May 7	2 p. m.	598.77	392	29.935	68	66.2	29.829				66.2	59	7.2	E. 2.	C. S. cum. 6	
Do	7	2 p. m.	598.77	790	29.914	66.5	66.2	29.842	29.898			66.2	59	7.2	E. 2.	C. S. cum. 6	
Do	7	3 p. m.	598.77	392	29.935	68.5	66.8	29.828				66.8	58.5	8.3	E. 1.	C. S. cum. 7	
Do	7	3 p. m.	598.77	790	29.944	67	*66.8	29.841	29.899			66.8	58.5	8.3	E. 1.	C. S cum. 7	
Do	7	4 p. m.	598.77	392	29.924	66.5	63.2	29.822				63.2	56	8.2	E. 2.	Cir. C. S. cum. 7	
Do	7	4 p. m.	598.77	790	29.932	64.8	63.2	29.835	29.895			63.2	56	7.2	E. 2.	Cir C. S. cum. 7	
Do	7	5 p. m.	598.77	392	29.900	60.5	59.9	29.814				59.9	56	3.9	E 2.	C. C.S.cum.nim.9	Slight fall of rain.
Do	7	5 p. m.	598.77	790	29.906	59.9	59.9	29.821	29.876	29.874	*130	59.9	56	3.9	E. 2.	C. C.S.cum.nim.9	*Approximate.
Do	7	6 p. m.	598.77	392	29.895	59.5	59.5	29.811				59.5	56	3.5	E. 2.	C. C S.cum.nim.9	
Do	7	6 p. m.	598.77	790	29.900	59	59.5	29.818				59.5	56	3.5	E. 2.	C. C.S.cum.nim.9	
San Diego			601.77														
			Dis. from S. Diego.														
Crossing of Rio Colorado, (Ankrim's Ferry,) 1¼ miles below Fort Yuma	June 9	6 a. m.	206.75	392	29.815	76.5	76	29.687	29.694						E. 2.	C. C.S.cum.nim.9	
Do	9	6 a. m.	206.75	790	29.822	75.9	76	29.696	29.694						E. 2.	C. C S.cum.nim.9	
Do	9	6.30 a. m.	206.75	392	29.834	83	81.9	29.688	29.693						E. 2.	C. C.S cum.nim.9	
Do	9	6.30 a. m	206.75	790	29.836	81.5	81.9	29.694	29.690						E. 2.	C. C.S.cum.nim.9	
Do	9	7 a. m.	206.75	392	29.860	86.2	85.9	29.705	29.708						E. 2.	C. C.S.cum.nim.9	
Do	9	7 a. m.	206 75	790	29.864	85.2	85.9	29.712	29.706						E. 2.	C. C.S.cum.nim.9	
Do	9	7.30 a. m.	206.75	392	29.865	90	90	29.701	29.699						E. 2.	C. S C.cum.nim.9	
Do	9	7.30 a. m.	206.75	790	29.870	89	90	29.708	29.697	29.747	260.7				E. 2.	C.C.S.cum nim.9	
Camp No. 60, near Fort Yuma	11	5 a. m.	215.25	392	29.642	63.5	64.3	29.550							E. 2.	C. cum. 2	
Do	11	5 a. m.	215.25	790	29.646	62.9	64.3	29.556	29.684						E. 2.	C. cum. 2	
Do	11	6 a. m.	215.25	392	29.675	72.8	74.2	29.559				73	64	9	E. 2.	C. cum. 1	
Do	11	6 a. m.	215.25	790	29.680	72	74.2	29.563	29.683			73	64	9	E. 2.	C. cum. 1	
Do	11	7 a. m.	215.25	392	29.695	79.8	80.8	29.557				80	68.5	11.5	E. 2.	C. cum. C. S. 1	
Do	11	7 a. m.	215.25	790	29.700	78.9	80.8	29.565	29.709			80	68.5	11.5	E. 2.	C. cum. C. S. 1	
Do	11	8 a. m.	215.25	392	29.725	89.8	90	29.561				89.9	70.5	18.4	E. 2.	C. cum. C. S. 1	
Do	11	8 a. m.	215.25	790	29.728	88.5	90	29.568	29.702			89.9	70.5	18.4	E. 2.	C. cum. C. S. 1	
Do	11	9 a. m.	215.25	392	29.750	94.5	94.8	29.574				94.8	73.5	21.3	E. 2.	C. cum. C. S. 1	
Do	11	9 a. m.	215 25	790	29.756	93.5	94.8	29.584	29.703			94.8	73.5	21.3	E. 2.	C. cum. C. S. 1	
Do	11	10 a. m.	215.25	790	29.768	98.8		29.580	29.702						E. 2.	C. cum. C. S. 1	
Do	11	11 a. m.	215 25	392	29.765	102.5	102	29.568				102	75.9	27.9	S.E. 5.	C. cum. C. S. 1	
Do	11	11 a. m.	215.25	790	29.768	101.5	102	29.573	29.695			102	75.9	27.9	S.E. 5.	C. cum. C. S. 1	

Do.	11	12 m.	215.25	392	29.755	105	103.5	29.550	....	....	....	104	73.5	30.5	S.W. 1..	C. cum. C. S. 1
Do.	11	12 m.	215.25	790	29.758	104	103.5	29.558	29.693	....	....	......	......	......	S.W. 1..	C. cum. C. S. 1
Do.	11	1 p. m.	215.25	392	29.738	106.9	105.7	29.528	....	....	....	105.7	75.8	29.9	S.W. 1..	C. cum. C. S. 1
Do.	11	1 p. m.	215.25	790	29.742	105.8	105.7	29.534	29.687	....	....	105.7	75.8	29.9	S.W. 1..	C. cum. C. S. 1
Do.	11	2 p. m.	215.25	392	29.720	107.4	106	29.508	....	....	....	106	75.5	30.5	S.W. 2..	C. cum. C. S. 1
Do.	11	2 p. m.	215.25	790	29.722	106.5	106	29.513	29.693	....	....	106	75.5	30.5	S.W. 2..	C. cum. C. S. 1
Do.	11	3 p. m.	215.25	392	29.698	106.5	106.2	29.489	....	....	....	107	73.5	33.5	S.W. 1..	C. cum. C. S. 1
Do.	11	3 p. m.	215.25	790	29.700	105.9	106.2	29.492	29.691	....	....	107	73.5	33.5	S.W. 1..	C. cum. C. S. 1
Do.	11	4 p. m.	215.25	392	29.684	106	105.6	29.476	....	....	....	106	71.5	34.5	S.W. 1..	C. cum. C. S. 1
Do.	11	4 p. m.	215.25	790	29.688	105	105.6	29.483	29.694	....	....	106	71.5	34.5	S.W. 1..	C. cum. C. S. 1
Do.	11	5 p. m.	215.25	392	29.660	103	102.8	29.460	....	....	....	103	69	34	S.W. 2..	C. cum. C. S. 1
Do.	11	5 p. m.	215.25	790	29.666	102.2	102.8	29.469	29.689	....	....	103	69	34	S.W. 2..	C. cum. C. S. 1
Do.	11	6 p. m.	215.25	392	29.655	101	100.5	29.460	....	....	....	101	67.5	33.5	S.W. 1..	C. cum. C. S. 1
Do.	11	6 p. m.	215.25	790	29.660	100.5	100.5	29.470	20.681	....	....	101	67.5	33.5	S.W. 1..	C. qum. C. S. 1
Do.	11	7 p. m.	215.25	392	29.665	97.5	97.5	29.481	....	....	....	98.5	67	31.5	S.W. 1..	C. cum. C. S. 1
Do.	11	7 p. m.	215.25	790	29.690	97	97.5	29.507	29.692	....	....	98 5	67	31.5	S.W. 1..	C. cum. C. S. 1
Do.	12	5 a. m.	215.25	392	29.680	61.9	63.2	29.590	....	....	....	62.5	56	6.5	S.W. 1..	C. C. S. 1.....
Do.	12	5 a. m.	215.25	790	29.680	61.5	63.2	29.592	29.732	....	....	62.5	56	6.5	S.W. 1..	C. C. S. 1.....
Do.	12	6 a. m.	215.25	392	29.725	72	73.6	29.608	....	....	....	72.5	63.5	9	S.W. 1..	C. C. S. .05....
Do.	12	6 a. m.	215.25	790	29.728	71.5	73.6	29.613	29.743	....	....	72.5	63 5	9	S.W. 1..	C. C. S. .05....
Do.	12	7 a. m.	215.25	392	29.765	81.8	82.5	29.622	....	....	....	83	67.5	14.5	S.W. 1..	C. C. S. .05....
Do.	12	7 a. m.	215.25	790	29.766	81	82.5	29.625	29.752	....	....	82	67.5	14.5	S.W. 1..	C. C. S. .05....
Do.	12	8 a. m.	215.25	392	20.802	86.2	87.6	29.648	....	....	....	86.5	66	20.5	S.W. 1..	C. C. S. .05....
Do.	12	8 a. m.	215 25	790	29.808	85.7	87.6	29.655	29.764	....	....	86.5	66	20.5	S.W. 1..	C. C. S. .05....
Do.	12	9 a. m.	215.25	392	29.825	91.3	91	29.658	....	....	....	91	67	24	W. .05..	C. C. S. .05....
Do.	12	9 a. m.	215.25	790	29.828	90.5	91	29.663	29.755	....	....	91	67	24	W. .05..	C. C. S. .05....
Do.	12	10 a. m.	215.25	392	29.840	95.5	94.2	29.661	....	....	....	94.5	67.2	27.3	W. .05..	C. C. S. .05....
Do.	12	10 a. m.	215.25	790	29.844	94.5	94.2	29.668	29.756	....	....	94.5	67.2	27.3	W. .05..	C. C. S. .05 ...
Do.	12	11 a. m.	215.25	392	29.842	100.1	98.8	29.651	....	....	....	99	70.2	28.8	W. .05..	C. C. S. .05....
Do.	12	11 a. m.	215.25	790	29.848	98	98.8	29.662	29.751	....	....	99	70.2	28.8	W. .05..	C. C. S. .05....
Do.	12	12 m	215.25	392	29.838	101.9	101.8	29.641	....	....	....	102	73	29	W. .05..	C. C. S. .05....
Do.	12	12 m	215 25	790	29.844	100	101.8	29.653	29.746	....	....	102	73	29	W. .05..	C. C. S. .05....
Do.	12	1 p. m.	215.25	392	29.830	101.9	99.3	29.633	....	....	....	99.9	70	29.9	S.W. 1...	C. C. S. .05....
Do.	12	1 p. m.	215.25	790	29.834	100.5	99.3	29.641	29.743	....	....	99.9	70	29.9	S.W. 1...	C. C. S. .05....
Do.	12	2 p. m.	215.25	392	29.800	101.8	101.4	29 603	....	....	....	101.4	72	29.4	S.W. 1...	C. C. S. .05....
Do.	12	2 p. m.	215.25	790	29.806	100.2	101.4	29.615	29.731	....	....	101.4	72	29.4	S.W. 1...	C. C. S. .05....
Do.	12	3 p. m.	215.25	392	29.782	100.2	100.5	29.591	....	....	....	101	71.5	29.5	S.W. 1...	C. C. S. .05....
Do.	12	3 p. m.	215.25	790	29.788	99.5	100.5	29.596	29.724	....	....	101	71.5	29.5	S.W. 1...	C. C. S. .05....
Do.	12	4 p. m.	215.25	392	29.768	100.2	100.3	29.577	....	....	....	100.8	71	29.8	S.W. 1...	C. C. S. .05...
Do.	12	4 p. m.	215.25	790	29.772	99.8	100.3	29.582	29.724	....	....	100.8	71	29.8	S.W. 1...	C. C. S. .05...
Do.	12	5 p. m.	215.25	392	29.750	98	98	29.564	....	....	....	98 5	70	28.5	S.W. 1...	C. C. S. .05....
Do.	12	5 p. m.	215.25	790	29.756	97.2	98	29.573	29.713	....	....	98.5	70	28.5	S.W. 1..	C. C. S. 1.....
Do.	12	6 p. m.	215.25	392	29.748	94	94.5	29.573	....	....	....	95	69	26	S.W. 1..	C. C. S. 1.....
Do.	12	6 p. m.	215.25	790	29.754	93.5	94.5	29.581	29.712	....	....	95	69	26	S.W. 1..	C. C. S. 1.....
Do.	12	7 p. m.	215.25	392	29.748	90.5	91	29.583	....	....	....	91.5	65.2	26.3	S.W. 5..	C. C. S. 1.....
Do.	12	7 p. m.	215.25	790	29.754	90.5	91	29.589	29 699	....	....	91.5	65.2	26.3	S.W. 5..	C. C. S. 1.....
Do.	13	4.50 a. m.	215.25	392	29.728	55	56.2	29.657	....	....	....	56	50	6	S.W. 5..	C. C. S. 1.....
Do.	13	4.50 a. m.	215.25	790	29.722	54.8	56.2	29.652	29.628	....	....	56	50	6	S.W. 5..	C. C. S. 1.....

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San Diego.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 60	April 13	9 a. m.	215.25	392	29.848	90.1	90.2	29.684				90.5	69	21.5	S.W. 5.	C. C. S. 1.	
Do.	13	9 a. m.	215.25	790	29.854	88.5	90.2	29.695	29.614			90.5	69	21.5	S.W. 5.	C. C. S. 1.	
Do.	13	12 m.	215.25	392	29.845	102.6	100	29.645				101.5	70.2	31.3	S.S.W. 5.	C. C. S. 1.	
Do.	13	12 m.	215.25	790	29.850	101	101	29.655	29.599			101.5	70.2	31.3	S.S.W. 5.	C. C. S. 1.	
Do.	13	3 p. m.	215.25	392	29.780	99	99.6	29.594				100	71	29	S.W. 1.	C. C. S. 1.	
Do.	13	3 p. m.	215.25	790	29.784	98.2	99.6	29.598	29.656			100	71	29	S.W. 1.	C. C. S. 1.	
Do.	13	6.55 p. m.	215.25	392	29.702	77	78.5	29.572				79	71	8	S.W. 1.	C. C. S. 1.	
Do.	13	6.55 p. m.	215.25	790	29.708	76.9	78.5	29.578	29.634			79	71	8	S.W. 1.	C. C. S. 1.	
Do.	14	4.35 a. m.	215.25	392	29.645	52.5	53.8	29.581				53	47.8	5.2	S.W. 1.	C. C. S. 1.	
Do.	14	4.35 a. m.	215.25	790	29.650	52.5	53.8	29.586	29.601			53	47.8	5.2	S.W. 1.	C. C. S. 1.	
Do.	14	9 a. m.	215.25	392	29.765	91.6	92.2	29.599				92	69.5	22.5	S.W. 1.	C. C. S. 1.	
Do.	14	9 a. m.	215.25	790	29.772	90.5	92.2	29.609	29.598			92	69.5	22.5	S.W. 1.	C. C. S. 1.	
Do.	14	12 m.	215.25	392	29.780	105.9	105.2	29.572				104.9	71	33.9	S.W. 1.	C. C. S. 1.	
Do.	14	12 m.	215.25	790	29.784	104	105.2	29.582	29.616			104.9	71	33.9	S.W. 1.	C. C. S. 1.	
Do.	14	3 p. m.	215.25	392	29.720	101.7	101.5	29.523				102	67.5	34.5	S.W. 5.	C. C. S. 1.	
Do.	14	3 p. m.	215.25	790	29.720	101	101.5	29.525	29.634			102	67.5	34.5	S.W. 5.	C. C. S. 1.	
Do.	14	6.55 p. m.	215.25	392	29.640	81.8	81.5	29.497				82	68	14	S.W. 5.	C. C. S. 1.	
Do.	14	6.55 p. m.	215.25	790	29.642	81.5	81.5	29.501	29.617			82	68	14	S.W. 5.	C. C. S. 1.	
Do.	15	4.50 a. m.	215.25	392	29.582	51.8	53.2	29.519				53			S.W. 5.	C. C. S. 1.	
Do.	15	4.50 a. m.	215.25	790	29.588	51.5	53.2	29.528	29.637			53			S.W. 5.	C. C. S. 1.	
Do.	15	9 a. m.	215.25	392	29.715	90	90.2	29.551				90.5			S.W. 5.	C. C. S. 1.	
Do.	15	9 a. m.	215.25	790	29.720	88.9	90.2	29.558	29.659			90.5			S.W. 5.	C. C. S. 1.	
Do.	15	12 m.	215.25	392	29.722	102	100.8	29.525				100	69	31	S.W. 5.	C. C. S. 1.	
Do.	15	12 m.	215.25	790	29.724	100.3	100.8	29.533	29.678			100	69	31	S.W. 5.	C. C. S. 1.	
Do.	15	3 p. m.	215.25	392	29.650	97.8	97.6	29.464				98	66	32	S.W. 5.	C. C. S. 1.	
Do.	15	3 p. m.	215.25	790	29.654	97	97.6	29.471	29.678			98	66	32	S.W. 5.	C. C. S. 1.	
Do.	16	4.35 a. m.	215.25	392	29.555	47	48.5	29.505				48	42	6	S.W. 5.	C. C. S. 1.	
Do.	16	4.35 a. m.	215.25	790	29.558	45.5	48.5	29.513	29.696			48	42	6	S.W. 5.	C. C. S. 1.	
Do.	16	9 a. m.	215.25	392	29.715	86.5	86.5	29.560				86	65	21	S.W. 5.	C. C. S. 1.	
Do.	16	9 a. m.	215.25	790	29.730	85.2	86.5	29.568	29.708			86	65	21	S.W. 5.	C. C. S. 1.	
Do.	16	12 m.	215.25	392	29.722	98.5	95	29.535				95	65.9	29.1	S.W. 5.	C. C. S. 1.	
Do.	16	12 m.	215.25	790	29.726	97	95	29.543	29.698			95	65.9	29.1	S.W. 5.	C. C. S. 1.	
Do.	16	3 p. m.	215.25	392	29.660	95.5	95.5	29.481				95.8	65.5	30.3	S.W. 1.	C. C. S. 1.	
Do.	16	3 p. m.	215.25	790	29.666	94.9	95.5	29.496	29.699			95.8	65.5	30.3	S.W. 1.	C. C. S. 1.	
Do.	16	7 p. m.	215.25	392	29.625	88.2	88.5	29.466				89	63	26	S.W. 5.	C. C. S. 1.	

Do		16	7 p. m.	215.25	790	29.630	87.5	88.5	29.472	29.667			89	63	26	S.W. 5.	C. C. S. 1.
Do		17	4.35 a. m.	215.25	392	29.638	48.8	50.5	29.583				49.5	45	4.5	S.W. 5.	C. C. S. 1.
Do		17	4.35 a. m.	215.25	790	29.642	48.5	50.5	29.587	29.732			49.5	45	4.5	S.W. 5.	C. C. S. 1.
Do		17	9 a. m.	215.25	392	29.770	86.7	86.7	29.613				86.2	65	21.2	S.W. 5.	C. C. S. 1.
Do		17	9 a. m.	215.25	790	29.774	85.5	86.7	29.622	29.732			86.2	65	21.2	S.W. 5.	C. C. S. 1.
Do		17	12 m.	215.25	392	29.800	101.9	100.6	29.603				100	72	28	S.W. 5.	C. C. S. 1.
Do		17	12 m.	215.25	790	29.802	100.2	100.6	29.610	29.736	29.691	296.6	100	72	28	S.W. 5.	C. C. S. 1.
Camp No. 68, below Maricopas villages	June	28	4 p. m.	385.16	392	28.728	100	98.8	28.547				98	67	31	S.W. 2.	Cum. 2
Do		28	4 p. m.	385.16	790	28.724	99.9	98.8	28.540	28.609			98	67	31	S.W. 2.	Cum. 2.
Do		28	5 p. m.	385.16	392	28.720	99.4	97.3	28.560				96.7	67	29.7	S.W. 2.	Cum. 1.
Do		28	5 p. m.	385.16	790	28.718	98.5	97.3	28.538	28.505			96.7	67	29.7	S.W. 2.	Cum. 1.
Do		28	6 p. m.	385.16	392	28.718	94.2	94	28.551				93.5	65.5	28	S.W. 2.	Cum. 1.
Do		28	6 p. m.	385.16	790	28.714	94	94	28.540	28.612			93.5	65.5	28	S.W. 1.	Cum. 1.
Do		28	6.50 a. m.	385.16	392	28.710	89	89.5	28.554				89	67.2	21.8	S.W. 1.	Cum. 1.
Do		28	6.50 a. m.	385.16	790	28.708	89	89.5	28.552	28.605			89	67.2	21.8	S.W. 1.	Cum. 1.
Do		29	6 a. m.	385.16	392	28.845	71	72.2	28.735				71.2	64	7.2	S.W. 1.	Cum. 1.
Do		29	6 a. m.	385.16	790	28.850	70	72.2	28.742	28.732			71.2	64	7.2	S.W. 1.	Cum. 1.
Do		29	7 a. m.	385.16	392	28.875	81	81.6	28.739				79.5	66.2	13.3	S.W. 1.	Cum. 1.
Do		29	7 a. m.	385.16	790	28.878	80.5	81.6	28.744	28.731			79.5	66.2	13.3	S.W. 1.	Cum. 1.
Do		29	8 a. m.	385.16	392	28.912	90.2	89.5	28.753				88	72.5	15.5	S.W. 1.	Cum. 1.
Do		29	8 a. m.	385.16	790	28.918	88.9	89.5	28.762	28.736			88	72.5	15.5	S.W. 1.	Cum. 1.
Do		29	9 a. m.	385.16	392	28.935	93	96.2	28.768				95	75.5	19.5	S.W. 1.	Cum. 1.
Do		29	9 a. m.	385.16	790	28.938	91.9	96.2	28.774	28.737			95	75.5	19.5	S.W. 1.	Cum. 1
Do		29	11 a. m.	385.16	790	28.934	98.9	100.5	28.749	28.729			99	74	25	S.W. 1.	Cum. 1.
Do		29	12 m.	385.16	790	28.920	101	103.5	28.732	28.727			101.5	75	26.5	S.W. 1.	Cum. 1.
Do		29	1 p. m.	385.16	790	28.906	101	102.5	28.718	28.730			101	73	27	S.W. 1.	Cum. .05
Do		29	2 p. m.	385.16	790	28.886	101.5	102.5	28.696	28.734			101	74.9	26.1	S.W. 1.	Cum. .05
Do		29	3 p. m.	385.16	790	28.872	101	101.4	28.684	28.740			100	72.5	27.5	S.W. 5.	Cum. .05
Do		29	4 p. m.	385.16	790	29.850	101	100	28.662	28.732			99.5	72.5	27	S.W. 5.	Cum. .05
Do		29	5 p. m.	385.16	790	28.840	99.8	100	28.657	28.737			99	76	23	S.W. 5.	Cum. .05
Do		29	6 p. m.	385.16	790	28.834	95	93	28.662	28.733			92	72.5	19.5	S.W. 5.	Cum. .05
Do		30	7 a. m.	385.16	790	28.928	81.9	83.3	28.790	28.784			82	64.5	17.5	S.W. 5.	Cum. .05
Do		30	10 a. m.	385.16	392	29.002	104	103.5	28.808				102	70.5	31.5	S.W. 5.	Cum. .05
Do		30	10 a. m.	385.16	790	28.982	102.9	103.5	28.788	28.766			102	70.5	31.5	S.W. 5.	Cum. .05
Do		30	12 m.	385.16	392	28.968	108.5	108	28.764				106	72	34	S.W. 5.	Cum. .05
Do		30	12 m.	385.16	790	28.950	107	108	28.746	28.746			106	72	34	S.W. 5.	Cum. .05
Do		30	1 p. m.	385.16	392	28.952	109.5	109.5	28.746				107	69.5	37.5	S.W. 5.	Cum. .05
Do		30	1 p. m.	385.16	790	28.936	108.6	109.5	28.727	28.744			107	69.5	37.5	S.W. 5.	Cum. .05
Do		30	2 p. m.	385.16	392	28.930	111.5	110.5	28.720				108	73.2	34.8	S.W. 5.	Cum. .05
Do		30	2 p. m.	385.16	790	28.914	109	110.5	28.705	28.746			108	73.2	34.8	S.W. 5.	Cum. .05
Do		30	3 p. m.	385.16	392	28.902	111	109	28.688				107.5	73.5	34	S.W. 5.	Cum. .05
Do		30	3 p. m.	385.16	790	28.892	109.4	109	28.683	28.737			107.5	73.5	34	S.W. 5.	Cum. .05
Do		30	4 p. m.	385.16	392	28.880	109	108	28.671				107	68	39	S.S.W. 5.	Cum. .05
Do		30	4 p. m.	385.16	790	28.870	108	108	28.663	28.733			107	68	39	S.S.W.5.	Cum. .05
Do		30	5 p. m.	385.16	392	28.870	108	105.4	28.663				105	71.2	33.8	S.S.W.5.	Cum. .05
Do		30	5 p. m.	385.16	790	28.856	106.5	105.4	28.652	28.733			105	71.2	33.8	S.S.W.5.	Cum. .05
Do		30	6 p. m.	385.16	392	28.860	103	99.5	28.662				99	73	26	S.S.W.5.	Cum. .05

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San Diego.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp No. 68	June 30	6 p. m.	385.16	790	28.844	101.9	99.5	28.673	28.734			99	73	26	S.S.W. 5	Cum. .05	
Do	30	7 p. m.	385.16	392	28.830	86.5	87	28.676				86.8	65	21.8	S.S.W. 5	Cum. .05	
Do	30	7 p. m.	385.16	790	28.814	86.5	87	28.664	28.720			86.8	65	21.8	S.S.W. 5	Cum. .05	
Do	July 1	7 a. m.	385.16	392	28.932	82.2	81.2	28.784				81	61	20	S.S.W. 5	Cum. .05	
Do	1	7 a. m.	385.16	790	28.912	81.7	81.2	28.775	28.769			81	61	20	S.S.W. 5	Cum. .05	
Do	1	8 a. m.	385.16	392	28.972	96	94	28.798				94	69	26	S.S.W. 5	Cum. .05	
Do	1	8 a. m.	385.16	790	28.954	94.8	94	28.782	28.769			94	69	26	S.S.W. 5	Cum. .05	
Do	1	9 a. m.	385.16	392	28.988	103	100.5	28.794				100.9	72.5	28.4	S.S.W. 5	Cum. .05	
Do	1	9 a. m.	385.16	790	28.970	101.5	100.5	28 780	28.753			100.9	72.5	28.4	S.S.W. 5	Cum. .05	
Do	1	11 a. m.	385.16	392	28.980	110.4	106	28.770				107.5	71.5	36	E. 5	Cum. in E. 1	
Do	1	11 a. m.	385.16	790	28.960	109	106	28.751	28.736			107.5	71.5	36	E. 5	Cum. in E. 1	
Do	1	12 m	385.16	392	28.965	113	110.5	28.748				110	74	36	E. 5	Cum. in E. 1	
Do	1	12 m	385.16	790	28.950	111.4	110.5	28.736	28.733			110	74	36	E. 5	Cum. in E. 1	
Do	1	1 p. m.	385.16	392	28.950	112.9	110.5	28.733				110	72.5	37.5	E. 5	Cum. in E. 1	
Do	1	1 p. m.	385.16	790	28.938	111	110.5	28.724	28.736			110	72.5	37.5	E. 5	Cum. in E. 1	
Do	1	2 p. m.	385.16	392	28.940	114.2	112.5	28.721				110.9	72	38.9	S.W. 5	Cum. in E. 1	
Do	1	2 p. m.	385.16	790	28.918	113	112.5	28.698	28.717	28.721	1,270.4	110.9	72	38.9	S.W. 5	Cum. in E. 1	
Camp No. 69, above Pimas villages	2	9 a. m.	404.38	790	28.800	106.5	105.5	28.600	28.570			106	70.5	35.5	W. 5	Cum. in E. 1	
Do	2	11 a. m.	404.38	392	28.800	110.5	105.5	28.587				110.5	73.5	37	S.W. 5	Cum. in E. 1	
Do	2	11 a. m.	404.38	790	28.796	111.5	109	28.581	28.560			110.5	73.5	37	S.W. 5	Cum. in E. 1	
Do	2	1 p. m.	404.38	392	28.780	114.5	111	28.563				112.5	74.5	38	S.W. 5	Cum. in E. 1	
Do	2	1 p. m.	404.38	790	28.756	114	111	28.534	28.556			112.5	74.5	38	S.W. 5	Cum. in E. 1	
Do	2	2 p. m.	404.38	392	28.755	115.8	111.5	28.534				112.5	73	39.5	S.W. 5	Cum. in E. 1	
Do	2	2 p. m	404.38	790	28.742	115	111.5	28.517	28.559			112.5	73	39.5	S.W. 5	Cum. in E. 1	
Do	2	3 p. m.	404.38	392	28.720	112.8	112	28.506				113	73	40	S.W. 5	Cum. in E. 1	
Do	2	3 p. m.	404.38	790	28.704	112	112	28.488	28.549			113	73	40	S.W. 5	Cum. in E. 1	
Do	2	4 p. m.	404.38	392	28.700	115	111	28.481				112	76	36	S.W. 5	Cum. in E. 1	
Do	2	4 p. m.	404.38	790	28.690	114	111	28.468	28.540			112	76	36	S.W. 5	Cum. in E. 1	
Do	2	5 p. m.	404.38	392	28.700	113.5	110	28.485				111	75	36	S.W. 5	Cum. in E. 1	
Do	2	5 p. m.	404.38	790	28.686	113	110	28.466	28.551			111	75	36	S.W. 5	Cum. in E. 1	
Do	2	6 p. m.	404.38	392	28.670	105.3	104.5	28.475				104.5	73.5	31	S.W. 5	Cum. in E. 1	
Do	2	6 p. m.	404.38	790	28.656	105	104.5	28.456	28.532	28.552	1,440.0	104.5					
Bivouac No. 3, left bank of Rio Gila	5	4.20 a. m.	448.38	790	28.176	67	66.5	28.080	28.095							C. S. & cum.	

Do	5	4.30 a. m.	448.38	790	28.184	67	66.9	28.094	28.107	28.101	1,899.6					C. S. & cum.	
Station (4 miles east of Camp 4) near mouth of cañon, on Gila	7	10.45 a. m.	448.38	790	28.068	104.9	104.9	28.876	27.852			104	72.5	31.5		Cir. stratus	
Do	7	12 m.	448.38	790	28.046	109.5	108	28.844	27.839			107.8	73	34.8		Cir. stratus	
Do	7	2 45 p. m.	448.38	790	27.992	113.5	112	28.780	27.830	27.840	2,167.1	111	71.5	39.5	W. 1	Cumuli	
Bivouac No. 5, left bank of Rio San Pedro, near its mouth	8	5.30 a. m.	467.38	790	27.916	69	69	27.815	27.818						W. 1	Cirrus	
Do	8	5.45 a. m.	467.38	790	27.930	72.5	72	27.820	27.821	27.819	2,188.7				W. 1	Cirrus	
Bivouac No. 6, right bank of San Pedro	9	6 a. m.	479.38	790	27.804	79	78	27.678	27.676						W. 1	Cirrus	
Do	9	6.15 a. m.	479.38	790	27.812	82.5	81	27.677	27.674						W. 1	Cirrus	
Do	9	6.15 p. m.	479.38	790	27.772	98.5	97	27.598	27.665						W. 1	Cumuli	
Do	9	6.55 p. m.	479.38	790	27.762	96.8	97	27.592	27.647	27.665	2,348.3				W. 1	Cumuli	

OBSERVATIONS MADE IN A RECONNAISSANCE NEAR MOUTH OF ARAVAYPA CREEK, FROM BIVOUAC No. 6.

Highest point of mesa	9	10.25 p. m.	479.38	790	27.135	103	100.5	26.956	26.931		3,122.0				S.W. 1	C. & cum.	
In Aravaypa creek, 5 miles from its mouth	10	8.40 a. m.	479.38	790	27.734	93	88	26.576	27.557		2,467.1				S.W. 1	C. & cum.	
Bivouac No. 7	12	6.45 a. m.	491.38	790	27.448	81.8	78.8	27.318	27.313			79.5	71	8.5		C. C. S.	Heavy rain last night.
Do	12	7 a. m.	491.38	790	27.450	82	80	27.319	27.313			80	71.5	8.5		C. C. S.	
Do	12	7.30 a. m.	491.38	790	27.450	82.9	81.5	27.316	27.305	27.310	2,708.4	81.9	71.5	10.4		C. C. S.	
Bivouac No. 8	13	6.30 a. m.	501.38	790	27.088	77	75.8	26.971	26.967			75.5	68	7.5	E. 1	C. C. S.	Had rain, accompanied with hail.
Do	13	6.45 a. m.	501.38	790	27.090	78	76.5	26.971	26.966			76.2	69	7.2	E. 1	C. C. S.	Do. do.
Do	13	7 a. m.	501.38	790	27.094	78.8	77.2	26.973	26.967			77	69	8	E. 1	C. C. S.	Do. do.
Do	13	7.15 a. m.	501.38	790	27.096	79.3	77.2	26.974	26.966	26.966	3,071.9	77.2	69.8	7.4	E. 1	C. C. S.	Do. do.
Bivouac No. 9	14	7.15 a. m.	517.88	790	26.726	75.5	75.5	26.615	26.605			75.9	67	8.9	S.E. 1	C. S.	Half of an inch rain fell yesterday afternoon, between 3.45 and 6 p. m.
Do	14	7.30 a. m.	517.88	790	26.728	76.7	77	26.614	26.603	26.604	3,459.1	76	67	9	S.E. 1	C. S.	
Bivouac No. 10, near lower crossing of San Pedro, right bank	14	5.15 p. m.	532.88	790	26.392	88	87	26.251	26.329						S.E. 1	C.C.S.cum.&nim.	
Do	14	5.45 p. m.	532.88	790	26.388	86.3	85	26.251	26.325						W. 1	C C.S.cum &nim.	
Do	14	6 p. m.	532.88	790	26.386	83.2	83	26.257	26 328						W. 1	C.S.C.cum &nim.	
Do	14	6.20 p. m.	532.88	790	26.386	81.9	82	26.261	26.326						W. 1	C S.C.cum.&nim.	
Do	15	5.40 a. m.	532.88	790	26.472	67.2	67	26.383	26.384			68	67	1	W. 1	C.S.C.cum.&nim.	Quarter of an inch of rain fell last night.
Do	15	6.25 a. m.	532.88	790	26.482	70.5	69	26.383	26.380			69.9	68	1.9		C.S C.cum.&nim.	
Do	15	6.45 a. m.	532.88	790	26.488	73.7	71	26.381	26.376			71	68	3		C.S C.cum.&nim.	
Do	15	7 a. m.	532.88	790	26.494	75.8	71.8	26.383	26.377	26.353	3,737.3	72.2	68	4.2		C S.C.cum.&nim.	
Bivouac No. 11, left bank of San Pedro, and opposite Quercus cañon	16	8 a. m.	540.38	790	26.446	79.5	78.1	26.326	26.309			78.1	69	9 1		C. C. S. cum.	
Do	16	9 a. m.	540.38	790	26.450	82.9	80	26.321	26.291			80.5	68.9	11.6		C. C. S. cum.	Light showers yesterday afternoon.
Do	16	10 a. m.	540.38	790	26.448	81.9	80	26.322	26.294			80	68	12		C. C. S. cum.	Showers off and on during the day, July 16.
Do	16	11 a. m.	540.38	790	26.450	82.5	80.5	26.323	26.303			81	68	13		C. C. S. cum.	
Do	16	12 m.	540.38	790	26.450	85.2	82	26.317	26.312			83	69	14		C. C. S. cum.	
Do	16	1 p. m.	540.38	790	26.440	87.6	85.5	26.301	26.313			85.5	70.5	15	S.W. 1	C. C. S. cum.	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San Diego.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Bivouac No. 11	July 16	2 p. m.	540.38	790	26.420	89.1	87	26.277	26.315	......	......	88	70.5	17.5	E. 1	C.C.S.cum.nim.	
Do	16	3 p. m.	540.38	790	26.396	85	83	26.273	26.329	26.308	3,786.0	82.5	70	12.5	E. 1	C.C.S.cum.nim.	
Camp No. 76, right bank of Rio San Pedro, Quercus cañon	18	8 a. m.	539.38	790	26.500	79.5	79.5	26.380	26.363	......	......	78.5	71.5	7	E. 1	C. C. S. cum. 6.	
Do	18	9 a. m.	539.38	392	26.520	84	......	26.389	......	......	......	......	......	......	E. 1	C C.S.cum.nim. 6	July 17, raining nearly all day.
Do	18	9 a. m.	539.38	790	26.504	83	82.2	26.375	26.348	......	......	80.2	70.5	9.7	E. 1	C.C.S.cum.nim. 6	
Do	18	10 a. m.	539.38	392	26.508	70	70.4	26.410	......	......	......	71	69	2	E. 1	C C.S.cum.nim. 8	Hard rain between 9.15 and 9.45.
Do	18	10 a. m.	539.38	790	26.492	70	70.4	26.394	26.370	......	......	71	69	2	E. 1	C.C S.cum nim. 8	
Do	18	11 a. m.	539.38	392	26.495	72.2	71.8	26.392	......	......	......	70.9	68.8	2.1	E. 1	C.C.S.cum.nim. 8	Raining slightly.
Do	18	11 a. m.	539.38	790	26.478	72	71.8	26.375	26.359	......	......	70.9	68.8	2.1	E. 1	C.C S.cum.nim. 8	
Do	18	12 m.	539.38	392	26.490	77.5	75.6	26.374	......	......	......	74.2	69	5.2	E. 1	C.C S.cum.nim. 7	
Do	18	12 m.	539.38	790	26.474	77	75.6	26.359	26.357	......	......	74.2	69	5.2	E. 1	C.C S.cum.nim. 7	
Do	18	1 p. m.	539.38	392	26.500	83.5	81	26.370	......	......	......	79	72.5	6.5	S.E. 5	C.C S.cum.nim. 8	
Do	18	1 p. m.	539.38	790	26.484	82.9	81	26.355	26.370	......	......	79	72.5	6.5	S.E. 5	C.C S.cum.nim. 8	
Do	18	2 p. m.	539.38	392	26.465	76	74.8	26.353	......	......	......	73.2	71	2.2	S.E. 5	C.C S.cum.nim. 9	
Do	18	2 p. m.	539.38	790	26.450	75.8	74.8	26.338	26.379	......	......	73.2	71	2.2	S.E. 5	C.C S.cum.nim. 9	
Do	18	3 p. m.	539.38	392	26.465	78.5	76.7	26.347	......	......	......	75.5	71	4.5	S.E. 5	C.C S.cum.nim. 9	
Do	18	3 p. m.	539.38	790	26.450	78	76.7	26.333	26.392	......	......	75.5	71	4.5	S.E. 5	C.C.S.cum.nim. 9	
Do	18	4 p. m.	539.38	392	26.462	80.2	78.7	26.340	......	......	......	77	71	6	S.E. 5	C.C S.cum.nim 9	
Do	18	4 p. m.	539.38	790	26.446	80	78.7	26.324	26.398	......	......	77	71	6	S.E. 5	C C S.cum.nim. 9	
Do	18	5 p. m.	539.38	392	26.450	75.5	75.6	26 339	......	......	......	75	68	7	S.E. 5	C.C.S.cum.nim. 9	
Do	18	5 p. m.	539.38	790	26.432	75.5	75.6	26.321	26.406	......	......	75	68	7	S.E. 5	C.C S cum.nim. 9	
Do	18	6 p. m.	539.38	392	26.450	73.5	74.4	26.344	......	......	......	74	67	7	E. 5	C C S cum.nim. 6	
Do	18	6 p. m.	539.38	790	26.432	73.5	74.4	26.326	26.402	......	......	74	67	7	E 5	C.C S.cum.nim. 6	
Do	18	6.30 p. m.	539.38	392	26.451	71.5	72	26.352	......	......	......	72	66	6	E. 5	C C.S.cum.nim. 6	
Do	18	6.30 p. m.	539.38	790	26.436	71.5	72	26.337	26.403	......	......	72	66	6	E. 5	C C S cum.nim. 6	
Do	19	7 a. m.	539.38	392	26.520	71	68.3	26.422	......	......	......	67.5	65.5	2	E. 5	C. S. cum. 5	2.64 inches [illegible] fell last night.
Do	19	7 a. m.	539.38	790	26.496	69.7	68.3	26.399	26.400	......	......	67.5	65.5	2	E 5	C. S. cum. 5	
Do	19	8 a. m.	539.38	392	26 525	77	68.3	29.410	......	......	......	73.5	67	6.5	E. 5	C. S. cum. 3	
Do	19	8 a. m.	539.38	790	26.500	76.2	75.4	26.387	26.377	......	......	73.5	67	6.5	E. 5	C. S. cum. 3	
Do	19	9 a. m.	539.38	392	26.538	80.2	79.4	26.416	26.373	......	......	78.8	69.8	9	E. 5	C. C. S. cum. 3.	
Do	19	10 a. m.	539.38	392	26.535	86.1	84.7	26 399	26.363	......	......	83	72	11	E. 5	C.C.S.cum. 3	
Do	19	11 a. m.	539.38	392	26.530	87.5	84.5	26.391	26.363	......	......	84	69	15	W. 1	C.C.S.cum. 4	
Do	19	12 m.	539.38	392	26.504	89.5	90	26.360	26.347	......	......	88.5	73.5	15	S.W. 2	C.C.S.cum.nim. 6	Wind in gust.
Do	19	1 p. m.	539.38	392	26.495	92.8	93.3	26.343	26.347	......	......	90.2	72.8	17.4	S.W. 2	C.C.S.cum.nim. 6	

Do.	19	2 p. m.	539.38	392	26.488	90.5	89.5	26.344	26.374	....	....	87	70.5	16.5	S.W. 1.	C.C.S.cum.nim. 7	
Do.	19	3 p. m.	539.38	392	26.465	91.7	90.9	26.316	26.364	....	....	88	70	18	W. 1	C.C.S cum.nim. 7	
Do.	19	4 p. m.	539.38	392	26.460	89	88	26.317	26.379	....	....	86	69	17	W. 1	C.C.S.cum.nim. 8	
Do.	19	5 p. m.	539.38	392	26.450	87.9	88.5	26.309	26.381	....	....	87.5	70	17.5	W. 1	C.C.S.cum.nim. 8	
Do.	19	6 p. m.	539.38	392	26.450	84.5	84.9	26.318	26.381	....	....	83.3	67	16.3	W. 1	C.C.S.cum.nim. 8	
Do.	20	6 a. m.	539.38	392	26.530	69.5	70.8	26.433	26.423	....	....	70	66.5	3.5	W. 1	C. C. S. 2	Heavy dew la
Do.	20	7 a. m.	539.38	392	26.548	76	76	26.436	26.422	....	....	75	68	7	W. 1	C. C. S. 2	
Do.	20	9 a. m.	539.38	392	26.550	85.5	85	26.416	26.378	....	....	84	70	14	S.W. 5	C. C. S. cum. 2	
Do.	20	10 a. m.	539.38	392	26.558	86.2	86.8	26.422	26.386	....	....	86	70.2	15 8	S.W. 5	C. C. S. cum. 2	
Do.	20	11 a. m.	539.38	392	26.560	90	89.5	26.415	26.387	....	....	89	70.2	8.8	N.W. 1	C. C. S. cum. 2	
Do.	20	12 m	539.38	392	26.545	92	91.5	26.395	26.382	....	....	91	71	20	N.W. 1	C. C. S. cum. 2	
Do.	20	1 p. m.	539.38	392	26.530	93.5	93	26.377	26.381	....	....	93	70.5	22.5	N.W. 1	C. C. S. cum. 3	
Do.	20	2 p. m.	539.38	392	26.510	88	86.2	26.339	26.399	....	....	85.5	67.2	18.3	N.W. 2	C. C. S. cum. 6	
Do.	20	3 p. m.	539.38	392	26.500	95	93.5	26 343	26.391	....	....	93.5	69.1	24.4	N.W. 1	C. C. S. cum. 6	
Do.	20	5 p. m.	539.38	392	26.490	95.5	94	26.332	26.404	....	....	94	69	25	N.W. 1	C. C. S. cum. 6	
Do.	20	6 p. m.	539.38	392	26.485	93	92.5	26.333	26.396	....	....	92.5	66	26.5	N.W. 1	C. C. S. cum. 5	
Do.	20	7 p. m.	539.38	392	26.480	82.5	83	26.353	26.399	....	....	82	64	18	N.W. 1	C. C. S. cum. 5	
Do.	21	7 a. m.	539.38	392	26.545	75	75.8	26.435	26.421	....	....	75.2	66	9.2	N.W. 1	C. C. S. cum. 5	
Do.	21	8 a. m.	539.38	392	26.550	80.2	80.5	26.427	26.402	....	....	79.8	67.9	1.9	N.W. 1	C. C. S. cum. 5	
Do.	21	9 a. m.	539.38	392	26.555	83.9	84.3	26.424	26.386	....	....	83	68.9	14.1	N.N.W. 5	C. C. S. cum. 5	
Do.	21	10 a. m.	539.38	392	26.550	87.5	86.9	26.411	26.375	....	....	86	69	17	N. 5	C. C. S. 1	
Do.	21	11 a. m.	539.38	392	26.548	91.9	91.5	26.398	26.370	....	....	91.2	70	21.2	N.W. 1	C. C.S. cum. .05	
Do.	21	12 m.	539.38	392	26.545	94.9	94	26.388	26.375	....	....	94	69	25	N.W. 1	C. C. S. cum. 1	
Do.	21	1 p. m.	539.38	392	26.538	96.5	96	26.377	26.381	....	....	95 5	68	27.5	N.W. 5	C. C. S. cum. 1	
Do.	21	2 p. m.	539.38	392	26.525	96.8	93.6	26.363	26.393	....	....	94	67	27	N.W. 1	C. C. S. cum. 3	
Do.	21	3 p. m	539.38	392	26.503	99.5	99.2	26.336	26.384	....	....	99.2	70	29.2	N.W. 1	C. C. S. cum. 4	
Do.	21	4 p. m.	539.38	392	26.495	99.5	99	26.328	26.390	....	....	99	70	29	N.W. 1	C. C. S. cum. 4	
Do.	21	5 p. m.	539.38	392	26.488	97.2	96	26.326	26.398	....	....	96	......	......	N.W. 1	C. C. S. cum. 4	
Do.	21	6 p. m.	539.38	392	26.480	92	91.8	26.330	26.393	....	....	92	69.5	22.5	N.W. 5	C. C. S. cum. 1	
Do.	21	7 p. m.	539.38	392	26.475	83.5	83.5	26.345	26.391	....	....	83.5	65	18.5	N.W. 5	C. C. S. cum. .05	
Do.	21	8 p. m.	539.38	392	26.460	78	79	26.343	26.384	....	....	79.5	62	17.5	N.W. 5	C. C. S. cum. .05	
Do.	21	9 p. m.	539.38	392	26.465	76	78	26.353	26.390	....	....	78	62	16	N.W. 5	C. C. S. cum. .05	
Do.	21	10 p. m.	539.38	392	26.458	65.5	65.5	26.371	26.406	....	....	66	61	5	N.W. 5	C. C. S. cum. .05	
Do.	21	11 p. m.	539.38	392	26.440	65	64.5	26.354	26.383	....	....	64.5	60.8	3.7	N W. 5	C. C. S. cum. .05	
Do.	21	12 midnight	539.38	392	26.450	65.5	67	26.363	26.384	....	....	66.5	59.5	7	N.W. 5	C. C. S. cum. .05	
Do.	22	1 a. m.	539.38	392	26.450	61.8	62	26.372	26.389	....	....	62	57	5	N.W. 5	C. C. S. cum. .05	
Do.	22	2 a. m.	539.38	392	26.455	59	59.8	26.383	26.396	....	....	59.5	57	2.5	N.W. 5	C. C. S. cum. .05	
Do.	22	3 a. m.	539.38	392	26.458	59	61	26.386	26.397	....	....	61	57.3	3.7	N.W. 5	C. C. S. cum. .05	
Do.	22	4 a. m.	539.38	392	26.462	60	61	26.387	26.392	....	....	60.5	57	3.5	N.W. 5	C. C. S. cum. .05	
Do.	22	5 a. m.	539.38	392	26.470	57	57.7	26.402	26.401	....	....	57.5	55.5	2	N.W. 5	C. C. S. cum. .05	
Do.	22	6 a. m.	539.38	392	26.500	66.5	66.7	26.410	26.400	....	....	66	60	6	E. 1	Cum. 1	
Do.	22	7 a. m.	539.38	392	26.525	73	72.4	26.420	26.406	....	....	71.5	62.5	9	E. 1	Cum. 1	
Do.	22	8 a. m.	539.38	392	26.530	79.5	79.5	26.410	26.385	....	....	78.5	63.2	15.3	E. 1	Cum. C. C. S. 2	
Do.	22	9 a. m.	539.38	392	26.540	87	86	26.402	26.364	....	....	84.5	67	17.5	E. 1	Cum. C. C. S. 4	
Do.	22	10 a. m.	539.38	392	26.540	90.9	89.7	26.392	26.356	....	....	89	65.5	23.5	N. 5	Cum. C. S ...1	
Do.	22	11 a. m.	539.38	392	26.545	93.2	93	26.393	26.365	....	....	92.5	68.5	24	N. 5	Cum. C. S. ...1	
Do.	22	12 m	539 58	392	26.540	97	96.8	26.378	26.365	....	....	97	71	26	N. 5	Cum. C. S. ...1	
Do.	22	1 p. m.	539 38	392	26.525	101.5	99.8	26.353	26.363	....	....	99	70.5	28.5	N W. 1	Cum. C. S. ..15	

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San Diego.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		*Miles.*		*Inches.*	°	°	*Inches.*	*Inches.*	*Inches.*	*Feet.*	°	°	°			
Camp No. 76	July 22	2 p. m.	539.38	392	26.500	100	97.5	26.331	26.361			97	69	28	N.W. 1	Cum. C. S. 3	Wind in gusts.
Do.	22	3 p. m.	539.38	392	26 500	100.5	99.9	26.330	26.378			100	70	30	N.W. 1	Cum. C. S. 3	Do.
Do.	22	4 p. m.	539.38	392	26.495	99	98.5	26.329	26.391			98.5	69.5	29	N.W. 1	Cumuli, 3	Do.
Do.	22	5 p. m.	539.38	392	26.480	99.5	99	26.313	26.385			99	71	28	W. 5	C. S. cum. .15	
Do.	22	6 p. m.	539.38	392	26.468	93	93	26.316	26.379			93	69	24	W. 5	C. S. cum. 5	
Do.	22	7 p. m.	539.38	392	26.450	81.8	82	26.324	26.370			81.8	67	14.8	W. 5	C. S. cum. 5	
Do	23	7 a. m.	539.38	392	26.570	70	71.4	26.472	26.458			70.5	62.9	7.6	E. 5	C. S. cum. 5	
Do.	23	9 a. m.	539.38	392	26.614	87.9	87.8	26.473	26.435			87	68	19	E. 5	C. S. cum. 5	
Do.	23	12 m.	539.38	392	26.642	97.8	95.6	26.478	26.465			95	69.5	25.5	E. 5	C. S. cum. 2	
Do.	23	3 p. m.	539.38	392	26.590	99.8	99	26.422	26.470			99	73	26	E. 5	C. S. cum. 2	
Do.	23	7 p. m.	539.38	392	26.530	87.4	87.4	26.391	26.437			87	66	21	E. 5	C. S. cum. 1	
Do.	24	7 a. m.	539.38	392	26.570	72	73.5	26.467	26.453			72.5	63	9.5	E. 5	C. S. 1	
Do.	24	9 a. m.	539.38	392	26.600	88.9	89.2	26.457	26.419			88	69.5	18.5	E. 5	Cir. .05	
Do.	24	12 m.	539.38	392	26.590	97.8	97.5	26.426	26.413			97.8	67.5	30.3	N.W. 5	Cum. .05	
Do.	24	3 p. m.	539.38	392	26.555	100	99.9	26.386	26.434			87	69.5	17.5	N.W. 5	Cum. .05	
Do.	24	7 p. m.	539.38	392	26.500	87.5	87.3	26.361	26.407			87	69.5	17.5	N.W. 5	Cum. .05	
Do.	25	7 a. m.	539.38	392	26.510	71.5	72.5	26.408	26.394			72	......	....	N.W. 5	Cum. .05	Light breeze from the east.
Do.	25	9 a. m.	539.38	392	26.565	88.9	88.3	26.422	26.384			88	67	21	N.W. 5	Cum. .05	Do. do west.
Do.	25	12 m.	539.38	392	26.550	98	98	26.386	26.373			98	69.5	28.5	N.W. 1	Cum. .05	
Do.	25	7 p. m.	539.38	392	26.475	87.5	87.3	26.336	26.382			87	68.5	18.5	N.W. 1	Cum. .05	
Do.	26	7 a. m.	539.38	392	26.530	70.5	70.9	26.431	26.417			70.8	63	7.8	N.W. 1	Cum. .05	
Do.	26	9 a. m.	539.38	392	26.560	89	89.2	26.417	26.379			88	68	20	N.W. 1	Cum. .05	
Do.	26	12 m.	539 38	392	26.580	102	101.9	26.406	26.393			100	71	29	N.W. 5	Cum. .05	
Do.	26	4 p. m.	539.38	392	26.520	105	103	26.339	26.401			103	72.5	30.5	N.W. 1	Cum. .05	
Do.	26	7 p. m.	539.38	392	26.482	86.2	86	26.346	26.392			86	68.5	17.5	N.W. 1	Cum. .05	
Do.	27	7 a. m.	539.38	392	26.500	69	70	26.404	26.390			69	58	11	E. .05	Cum. .05	
Do.	27	9 a. m.	539.38	392	26.542	90.5	90	26.396	26.358			88.5	66	22.5	E. .05	Cir. 2	
Do.	27	12 m.	539.38	392	26.560	101.5	101	26.388	26.375			99	69.8	29.2	S.E. 1	Cir. 2	
Do.	27	4 p. m.	539.38	392	26.583	105.5	105.5	26.403	26.465			102.5	72.9	29.6	N.W. 1	Cir. 2	
Do.	27	7 p. m.	539.38	392	26.460	86	85.6	26.324	26.370			85	68.5	16.5	N.W. 1	Cir. 2	
Do.	28	7 a. m.	539.38	392	26.520	69	70.5	26.424	26.410			......	......	......	N.W. 1	Cir. 2	
Do.	28	9 a. m.	539.38	392	26.570	89.2	89.6	26.427	26.389			88.5	68.5	20	N.W. 1	Cir. 2	
Do.	28	12 m.	539.38	392	26.575	101.5	101	26.403	26.390			99.5	69.5	30	N.W. 5	Cum. 1	
Do.	28	3 p. m.	539.38	392	26.545	106.2	105	26.361	26.409			103	69.5	33.5	N.W. 1	Cum. 2	
Do.	28	7 p. m.	539.38	392	26.482	86.5	86.5	26.345	....			86.5	68.9	17.6	N W. 1	Cum. C. S. 1	

Do		28	7 p. m.	539.38	790	26.464	86.7	86.5	26.397	26.421			86.5	68.9	17 6	N.W. 1	Cum. C. S. 1
Do		29	7 a. m.	539.38	392	26.575	77.5	78	26.459				77.5	66	11.5	N.W. 1	Cum. C. S. 1
Do		29	7 a. m.	539.38	790	26.582	77	78	26.467	26.453			77.5	66	11.5	N.W. 1	Cum. C. S. 1
Do		29	9 a. m.	539.38	790	26.606	88.2	88.5	26.465	26.445			87.5	69.5	18	N. 1	Cum. C. S. 1
Do		29	12 m.	539.38	392	26.599	98.5	98.7	26.434				97.5	71.5	26	N.W. 2	Cum. C. S. 2
Do		29	12 m.	539.38	790	26.604	97.5	98.7	26.441	26.428			97.5	71.5	26	N.W. 2	Cum. C. S. 2
Do		29	1 p. m.	539.38	392	26.580	100	100.2	26.471				98.5	72	26.5	N.W. 2	Cum. C. S. 2
Do		29	1 p. m.	539.38	790	26.588	99.5	100.2	26.421	26.451			98.5	72	26.5	N.W. 2	Cum. C. S. 2
Do		29	3 p. m.	539.38	392	26.545	101.5	101.5	26.373				99	71	28	N.W. 1	Cum. 2
Do		29	3 p. m.	539.38	790	26.550	100.5	101.5	26.380	26.428			99	71	28	N.W. 1	Cum. 2
Do		29	4 p. m.	539.38	392	26.535	101.5	101.5	26.363				99	71	28	N.W. 1	Cum. 1
Do		29	4 p. m.	539.38	790	26.540	100.5	101.5	26.370	26.432			99	71	28	N.W. 1	Cum. 1
Do		29	7 p. m.	539.38	392	26.490	88	88.5	26.349				88	66.5	21.5	N.W. 1	Cum. & C. S. 1
Do		29	7 p. m.	539.38	790	26.500	88	88.5	26.359	26.404	26.396	3,683.2	88	66.5	21.5	N.W. 1	Cum. & C S. 1
Camp No. 77, Croton springs, Playa de los Pimas		31	7.15 a. m.	570.14	790	25.900	67.2	66.4	25.811	25.802						S.E. 5	
Do		31	8 a. m.	570.14	790	25.934	73.5	72.5	25.831	25.814		4,279.6*				S.E. 5	
Station 1		31	0.20 p. m.	573.45	790	25.950	97.8	96.5	25.790	25.794		4,345.2				N.W. 5	
Between stations 2 and 3		31	3.10 p. m.	578.34	790	25.900	102	99	25.724	25.782		4,357.4				N. 1	
Camp No. 78, Railroad pass		31	6.30 p. m.	583.34	790	25.678	88	87.5	25.543	25.606						N.W. 1	Cirrus, 1
Do		31	7 p. m.	583.34	790	25.650	81.8	81.5	25.531	25.585	25.595	4,554.0				N.W. 1	Cirrus, 1
Station 1, Railroad pass	Aug.	1	4.40 a. m.	583.58	790	25.620	57	58.5	25.555	25.564		4,601.3				N.W. 1	Cirrus, 1
Station 4		1	8 a. m.	589.83	790	26.108	87.5	87.2	25.971	25.954						N.W. 1	Cirrus, 1
Do		1	8.15 a. m.	589.83	790	26.110	88.5	87.2	25.971	25.949	25.951	4,173.4				N.W. 1	Cirrus, 1
Station 5		1	10 a. m.	592.08	790	26.256	95	93.5	26.102	26.074		4,028.3				N.W. 1	Cirrus 1
Camp No. 79, Rio Sauz		1	6 p. m.	604.33	790	26.458	95.5	95	26.300	26.371						E. 1	C. cum
Do		1	6.50 p. m.	604.33	790	26.460	89 5	89.5	26.316	26.372							C. cum
Do		2	7 a. m.	604.33	790	26.566	73.4	74	26.456	26.452			72.9	60.9	12		
Do		2	8 a. m.	604.33	790	26.576	86.2	86.5	26.439	26.422			84.2	67	17.2		
Do		2	8.30 a. m.	604.33	790	26.600	87.5	88.5	26.460	26.412	26.406	3,674.8	86	68	18		
Camp No. 80, Rio Sauz		3	6.15 a. m.	615.31	790	26.475	66	66.5	26.386	26.383			66.5	62	4.5		C. cum. 2
Do		3	7 a. m.	615.31	790	26.487	71	72	26.386	26.380			71	64	7		C. cum. 1
Do		3	8 a. m.	615.31	790	26.506	81.5	81.5	26.381	26.364			81	66.5	14.5	S.E. 1	S. 1
Do		3	9.30 a. m.	615.31	790	26.536	86	85	26.400	26.391			84	67.5	16.5	E. 1	S. 1
Do		3	10.20 a. m.	615.31	790	26.544	90	91	26.399	26.377			90	74	16	E. 1	S. 1
Do		3	11 a. m.	615.31	790	26.543	92	93	26.393	26.373			91.5	71.5	20	E. 1	S. 1
Do		3	12 m.	615.31	790	26.526	92.5	93.2	26.375	26.370			91.5	71.5	20	E. 1	C. cum. nim. 2
Do		3	1 p. m.	615.31	790	26.506	95.5	96.5	26.355	26.373			95	72.5	22.5	E. 1	C. cum. nim. 3
Do		3	2 p. m.	615.31	790	26.484	97	98	26.322	26.360			96	73	23	E. 1	C. cum. nim. 4
Do		3	3 p. m.	615.31	790	26.464	98	98.5	26.300	26.356			97	72.5	24.5		C. cum. nim. 4
Do		3	4 p. m.	615.31	790	26.451	96	97	26.292	26.352			96	70	26		C. cum. nim. 4
Do		3	5 p. m.	615.31	790	26.437	95.5	95	26.279	26.359			94	70	24		C. cum. nim. 6
Do		3	6 p. m.	615.31	790	26.444	90	90	26.299	26.370			90	68	22		C. cum. nim. 8
Do		3	6.15 p. m.	615.31	790	26.453	86	86	26.319	26.377	26.370	3,713.1	86	68	18		C.S.cum.nim. 4
Station 1		4	5.45 a. m.	619.64	790	26.480	68	68.5	26.389	26.389		3,690.6					C S.cum.nim. 4
Between stations 1 and 2		4	7 a. m.	620.14	790	26.160	74	72.5	26.054	26.048		4,063.1					C.S.cum.nim. 3
Station 2		4	7.30 a. m.	621.30	790	26.000	76.8	75.5	26.890	26.879		4,250.5					C.S.cum nim. 3

* This elevation is the result of observations of July 27 and 28 combined with these two; vide pages 108-9.

APPENDIX E—Continued.

Station.	Date.	Hour.	Distance from San Diego.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.		Miles.		Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Between stations 2 and 3	Aug. 4	8.45 a. m.	624.15	790	25.598	81.5	79	26.467	25.441		4,706.3					C.S. cum. nim. 3	
Station 4	4	9.15 a. m.	624.44	790	25.408	82	79.5	26.324	25.254						E. 1	C.S. cum. nim. 3	
Do	4	9.30 a. m.	624.44	790	25.412	82.5	79.5	26.287	25.258	25.256	4,875.0				E. 1		
Camp No. 81, El Peloncillo	4	4 p. m.	627.09	790	25.550	91.5	91.2	25.404	25.474						E. 1	C. 7	
Do	4	5 p. m.	627.09	790	25.550	88	88	25.412	25.492			86	68.5	17.5	E. 1	C. 9	
Do	4	6 p. m.	627.09	790	25.550	78.6	79.6	25.437	25.508	25.491	4,654.9	78.5	66	12.5	E. 1	C. 9	Raining.
Summit readings south camp 81	4	0.50 p. m.	649.41	790	25.756	80	77.5	25.637								Cum. nim. 9	Heavy shower just passed over.
Do	4	0.55 p. m.	649.41	790	25.758	80	78.8	25.639								Cum. nim. 9	
Do	4	1 p. m.	649.41	790	25.755	80	78.8	25.636	25.624		4,481.3					Cum. nim. 9	
Between stations 1 and 2	5	5.50 a. m.	629.50	790	25.735	65.5	64.5	25.651	25.651		4,476.6				E. 1	C. C. S. 2	
Station 2	5	7.15 a. m.	632.99	790	26.022	75.9	75	25.914	25.906		4,194.6				E. 1	C. C. S. 2	
Between stations 2 and 3	5	8 a. m.	633.90	790	26.042	77.5	75.5	25.929	25.912		4,188.6					C. C. S. 2	
Station 3, near small hill on left.	5	9.15 a. m.	636.00	790	26.016	78.9	78.4	25.899	25.869		4,235.3					C. C. S. cum. 3	
Between stations 3 and 4	5	10.10 a. m.	637.25	790	26.022	82.5	80.4	25.897	25.870		4,234.3					C. C. S. cum. 3	
Summit, station 5	5	11.20 a. m.	640.94	790	25.917	90.5	89.5	25.775	25.765		4,350.3					Nim. C. C S. cum. 3	
Station 8, laguna	5	2.30 p. m.	648.71	790	25.930	95	93	25.776	25.823		4,286.6					Nim. C C. S cum. 3	
Between stations 8 and 9	5	3.10 p. m.	649.41	790	25.914	95.5	95.5	25.770	25.828		4,280.7				W. 1	Nim. C. C. S. cum. 3	
Camp No. 82, dry laguna	5	6 p. m.	651.37	790	25.800	83.4	83	25.673	25.744			83	66.5	16.5	N. 1	Nim. C. C S cum. 3	
Do	5	6.30 p. m.	651.37	790	25.790	81.2	81	25.670	25.732			79.5	65	14.5	N. 1	Nim C. C. S. cum. 3	
Do	5	7 p. m.	651.37	790	25.786	79.2	79.5	25.670	25.724	25.733	4,386.1	73.5	65	13.5	N. 1	Nim. C C S. cum. 3	
Station 1	6	5.15 a. m.	651.37	790	25.560	63.5	62.5	25.480	25.525		4,617.2				N. 1	Nim. C. C S. cum. 2	Sunrise observations south of wagon road.
Station 2	6	6.15 a. m.	651.37	790	25.416	[illegible]	71	25.319	25.316		4,851.4					Nim. C. C. S. cum. 2	
Station 3	6	9.45 a. m.	651.37	790	25.412	86.5	86.5	25.280	25.271		4,902.7					Nim. C. C S. cum. 2	
Station 4, Cook's road	6	10.30 a. m.	651.37	790	25.410	90	88.5	25.270	25.246		4,928.6					Nim C. C. S. cum. 3	
Station 5, junction of 2 roads	6	0.20 p. m.	651.37	790	25.172	93.5	91.5	25.024	25.025		5,181.1					Nim. C. C S. cum. 3	
Camp No. 83, Peñasquitas	7	9 a. m.	673.65	790	25.104	87.9	86	24.970	24.940		5,276.1					Cum. 1	
Station 1	7	0.10 p. m.	673.65	790	25.264	94.5	93	25.114	25.012		5,082.0					Cum. 2	
Station 2	7	1.45 p. m.	673.65	790	25.342	96.5	94	25.187	25.216		4,959.7					Nim. C. C. S. cum. 3	
Station 3	7	3.20 p. m.	673.65	790	25.288	94.5	93	25.142	25.203		4,973.0					C. C. S. cum. 4	
Camp No. 84, Ojo de la Vaca	7	6.30 p. m.	685.05	790	25.100	80.5	80.2	24.984	25.046							C. C. S. cum. 4	
Do	8	8.20 a. m.	685.05	790	25.200	85.8	85.8	25.073	25.052	25.049	5,151.7				W. 5	C. C. S. cum. 5	
Station 1	8	10.45 a. m.	685.05	790	25.416	92	89	25.275	25.253		4,921.4				W. 1	Nim. C. C. S. cum. 4	

Station 2	8	11.10 a. m.	685.05	790	25.336	90.5	88.5	25.198	25.180		4,997.0				S.W. 2	Nim.C.C.S.cum.4	
Station 3, 10 miles southeast of camp 84	8	0.50 p. m.	685.05	790	25.485	96.4	95	25.332	25.341		4,822.2				W. 1	Nim.C.C.S.cum.4	
Station 4	8	2.25 p. m.	685.05	790	25.578	98.5	96.2	25.419	25.464		4,684.7				S. 3	Nim.C.C.S.cum.4	
Station 5, 13 miles below crossing of river bank, Rio Mimbres	8	3.45 p. m.	685.05	790	25.560	83.2	82	25.435	25.501		4,643.5				N. 3	Nim.C.C.S.cum.8	
Camp No. 85, left bank of Rio Mimbres	9	10.20 a. m.	703.38	790	25.216	86.5	84	25.088	25.062							Nim.C.C.S.cum.6	
Do.	9	0.30 p. m.	703.38	790	25.218	87	84	25.088	25.091							Nim.C.C.S cum.9	
Do.	9	4 p. m.	703.38	790	25.124	90.2	87	24.987	25.057						E. 5	Nim.C.C.S.cum.6	Sultry; appearance of rain.
Do.	9	5 p. m.	703.38	790	25.120	87.8	85	24.989	25.069							Nim.C.C.S.cum.6	
Do.	9	6 p. m.	703.38	790	25.116	82.9	81.5	24.995	25.083	25.072	5,127.0					Nim.C.C.S.cum.8	
Station 1	10	0.15 p. m.	703.38	790	25.426	95	93	25.275	25.274		4,862.9					C. C. S. cum. 6.	
Station 2	10	1.15 p. m.	703.38	790	25.512	96.5	94	25.358	25.377		4,782.7					C. C. S. cum. 5.	
Station 3	10	2.10 p. m.	703.38	790	25.542	95	92.5	25.391	25.432		4,720.5					C. C. S. cum. 4.	
Station 4	10	3.10 p. m.	703.38	790	25.604	100	96	25.442	25.500		4,642 5					C. C. S. cum. 4.	
Camp No. 86, Cook's spring	11	7.30 a. m.	723.38	790	25.194	74.2	73.5	25.091	25.080						W. 2	C. C. S. cum. 9.	A strong W. wind blowing all night.
Do.	11	8 a. m.	723.38	790	25.196	75.4	74	25.091	25.074						W. 2	C. C. S. cum. 9.	
Do.	11	8.30 a. m.	723.38	790	25.200	79.5	77	25.089	25.066						W. 1	C. C. S. cum. 9.	
Do.	11	9 a. m.	723.38	790	25.206	81	77.5	25.089	25.059						W. 1	C. C. S. cum. 9.	
Do.	11	9.30 a. m.	723.38	790	25.220	83	79.1	25.099	25.070						W. 5	C. C. S. cum. 9	
Do.	11	10 a. m.	723.38	790	25.224	85.8	80	25.097	25.069	25.069	5,130.8				W. 5	C. C. S. cum. 9.	
Station 1	12	11.45 a. m.	723.38	790	25.700	77.5	75.5	25.591	25.582		4,553.9				N.E. 5	C.C.S.cum.nim.8	
Camp No. 86, station 2, foot of mesa	12	1.15 p. m.	723.38	790	25.900	74	71.5	25.798	25.817		4,293.0				N.E. 5	C.C.S.cum.nim.9	
Station 3	12	1.50 p. m.	723.38	790	25.910	82	77	25.791	25.822		4,287.3				N.E. 5	C.C.S.cum.nim.8	
Station 4	12	2.25 p. m.	723.38	790	26.210	86.5	80	26.081	26.126		3,952.4				S. 1	C.C.S.cum.nim.8	A hard rain during the day.
Camp No. 87, Mesilla valley, near Rio Grande	12	4 p. m.	773.69	790	26.182	73.9	73.2	26.078	26.147			73.2	69.8	3.4	S. 1	C.C.S cum.nim.7	
Do.	12	4.30 p. m.	773.69	790	26.182	73.5	72.5	26.078	26.151			72.5	69.5	3	S. 5	C.C.S.cum.nim.7	
Do.	12	5.15 p. m.	773.69	790	26.170	73	71.9	26.067	26.145			71.9	69	2.9	S. 5	C.C.S.cum.nim.7	
Do.	12	6 p. m.	773.69	790	26.170	72.5	72	26.068	26.139			72	68.5	3.5	S. 5.	C.C.S.cum.nim.6	
Do.	12	6.15 p. m.	773.69	790	26.174	70.5	71	26.077	26.144	26.145	3,933.4	71	68.5	2.5	S. 5	C.C.S.cum.nim.6	
Crossing of Rio Grande	12	10.15 a. m.	779.50	790	26.362	83	82.5	26.236	26.214		3,858.8						
Camp No. 89, near Fort Fillmore, New Mexico	21	6 a. m.	783.5	790	26.316	66	67	26.229	26.232			67	64	3	S. 5	C.C.S.cum.nim.8	
Do.	21	7 a. m.	783.5	790	26.328	71.2	70	26.229	26.228			70	64	6	S. 5.	C.C.S.cum.nim.5	
Do.	21	8 a. m.	783.5	790	26.356	73.9	73	26.250	26.236			73	66	7	S. 5	C.C.S.cum.nim.2	
Do.	21	9 a. m.	783.5	790	26.364	75.4	74	26.255	26.228			74	67	7		C.C.S.cum.nim.3	Light breeze from the east
Do.	21	10 a. m.	783.5	790	26.374	78.5	77	26.258	26.234			77	68	9	N. 5	C.C.S.cum.nim.3	
Do.	21	11 a. m.	783.5	790	26.370	82	80	26.246	26.231			80	68.5	11.5	N. 5	C.C.S.cum.nim.5	
Do.	21	12 m.	783.5	790	26.364	86.2	83	26.231	26.230			83	71	12	N. 5	C.C.S.cum.nim.7	
Do.	21	1 p. m.	783.5	790	26.350	81.4	80	26.227	26.241			80	68	12			
Do.	21	2 p. m.	783.5	790	26.325	76.8	74	26.211	26.249			74	69	5	N. 1	C.C.S.cum.nim.3	
Do.	21	3 p. m.	783.5	790	26.300	80.5	80	26.177	26.236			80	67	13			
Do.	21	4 p. m.	783.5	790	26.304	80	79.5	26.182	26.251			79.5	67	2.5			
Do.	21	5 p. m.	783.5	790	26.304	81.05	81	26.180	26.152	26.237	3,833.5	81	67	14			

APPENDIX E—Continued.

SUPPLEMENTARY TABLE OF OBSERVATIONS TAKEN ON SIDE RECONNAISSANCES.

OBSERVATIONS MADE FROM CAMP 76, RIO SAN PEDRO, THROUGH NUGENT'S PASS TO PLAYA DE LOS PIMAS, BY LIEUTENANT J. G. PARKE.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.			*Inches.*	°	°	*Inches.*	*Inches.*	*Inches.*	*Feet.*	°	°	°			
Nugent's Trail, station 1, three quarters of a mile from Rio San Pedro	July 30	8.30 a. m.	790	26.600	83.5	82.5	26.470	26.495		3,576.7				S.		
Station 2, 7 miles from Rio San Pedro	30	10.55 a. m.	790	26.166	88.5	88.5	26.027	26.052		4,059.1				S. 5.		
Station 3, 12 miles from Rio San Pedro (divide)	30	0.35 p. m.	790	25.838	91.2	90	25.693	26.718		4,431.2				N.W. 1.		
Station 4, 13 miles from Rio San Pedro (divide?)	30	1.15 p. m.	790	25.848	96	94	25.692	26.717		4,432.2				N.W. 1.		
Station 5, 17 miles from Rio San Pedro	30	4 p. m.	790	25.448	94	93.5	25.296	25.321		4,880.8				N.W. 5.		

OBSERVATIONS ON THE SAN PEDRO AND ARAVAYPA CREEK, FROM JULY 21 TO JULY 28, BY A. H. CAMPBELL.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
Bivouac 2, on San Pedro river.	July 21	6.15 a. m.	790	26.928	68	71	26.833	26.830		3,212.5					Cum. strat. 1.	
Station 8	21	10.15 a. m.	790	26.700	[illegible]	87	26.557	26.531		3,491.3					Cum. strat. 1.	
Bivouac 3, Prospect cañon	21	5.15 p. m.	790	26.420	83	83	26.291	26.371							Cum. strat. 4.	
Do.	22	2 p. m.	790	26.442	88	87	26.301	26.339						E. 1.	Cum. strat. 4.	
Do.	22	6 p. m.	790	26.428	83.5	83	26.298	26.367	26.360	3,718.0				E. 1.	Cum. strat. 4.	
Station 9	23	10.45 a. m.	790	26.238	93	89	26.086	26.064		4,040.0				W. 5.	Cum. strat. 4.	
Bivouac 4, Chameleon spring	23	5.15 p. m.	790	26.296	85	78	26.163	26.243		3,855.0				W. 5.	Cum. strat. 4.	
Sta. (summit) Pheasant pass	24	10 a. m.	790	24.736	83.5	81	26.606	24.578		5,712.0				W. 3.	Cum. strat. 4.	
Station 2, Bear springs	26	9.30 a. m.	790	26.045	93	91	26.896	25.921		4,264.0				W. 1.	Cum. strat. 4.	
Station 4, foot of mesa	26	11.30 a. m.	790	25.824	96	98	26.668	25.655		4,499.5				W. 2.	Cum. strat. 4.	
Station 5, top of mesa	26	0.15 p. m.	790	25.738	104	96.5	26.563	25.560		4,601.1				W. 2.	Cum. strat. 4.	
Station 6, on plain	26	2 p. m.	790	25.794	97	96	26.635	25.673		4,480.3				W. 2.	Cum. strat. 4.	
Sta. 1, 60 miles east from Biv. 7	27	8.10 a. m.	790	25.876	92	88	26.729	25.710		4,548.0				W. 1.	C. S. 2.	
Sta. 2, ½ mile from Biv. 7	27	11 a. m.	790	25.976	98	99	26.815	25.095		4,340.0						This station is nearly due west from Railroad pass.
Bivouac 8 and camp 77, Croton springs	27	2.35 p. m.	790	25.978	96.5	95	26.821	25.846						W. 2.	Cum. 1.	Clear.

Do.	27	3 p. m.	790	25.972	96.5	97	26.815	25.871						W. 2	Cum. 1	Temperature of Croton springs 63°.
Do.	27	4.40 p. m.	790	25.950	93.5	93	26.800	25.876						W. 2	Cum. 1	
Do.	27	Sunset	790	25.920	77	75	26.808	25.862						W. 2	Cum. 1	
Do.	28	Sunrise	790	25.914	48	48	26.869	25.876						W. 2	Cum. 1	
Do.	28	½ hour after sunset	790	25.918	56	55	26.854	25.857						W. 2	Cum. 1	
Do.	28	1½ do.	790	25.938	63	62.5	26.858	25.854						Light wind	Cum. 1	
Observations of camp 77 added									25 853	4,279.6						

TRIP TO SAN JOSÉ AND HEAD OF SALINAS RIVER.

	1854.															
Station 5	Dec. 12	0.30 p. m.	978	28.440	66	61	28.344	28.213							Clear and calm.	
Do.	12	0.45 p. m.	978	28.434	63.5	61	28.345	28.217		1,738.6						
Bivouac 1, San José	12	4 p. m.	978	28.772	69	71	28.669	28.580								
Do.	12	4.45 p. m.	978	28.742	55	54	28.674	28.582								Sunset.
Do.	13	Sunrise	978	28.720	26	27	28.726	28.596		1,357.5						
Station 4	13	10.20 a. m.	978	28.718	56	52	28.648	28.503								
Do.	13	10.30 a. m.	978	28.708	54	52.5	28.743	28.598		1,393.4						
Station 5	13	0.10 p. m.	978	28.500	67	64	28.402	28.266		1,690.4						
Station 6	13	1.30 p. m.	978	28.288	73	70.5	28.177	28.022		1,919.1						
Station 7	13	2 p. m.	978	28.248	74	71	28.134	27.964		2,046.9						
Bivouac 2, Macho cañon	13	3.30 p. m.	978	28.660	64	62	28.570	28.383								
Do.	14	6.30 a. m.	978	28.614	26.5	28	28.619	28.497								
Do.	14	7.20 a. m.	978	28.620	26	28	28.626	28.501								
Do.	14	7.45 a. m.	978	28.620	27	29	28.624	28.498		1,450.1						
Station 2	14	9.05 a. m.	978	28.332	52	50	28.272	28.116		1,815.6						
Station 3, (summit)	14	9.35 a. m.	978	28.039	63	63	27.943	27.787								
Do.	14	9.40 a. m.	978	28.042	65	64.5	27.951	27.795		2,164.4						
Station 3, + 1,000 feet	14	9.50 a. m.	978	28.170	55	62	27.104	27.949		2,049.9						
Bivouac 3, Rio S. Maria	14	2.10 p. m.	978	29.028	59.5	76.5	28.948	28.803							Clear	
Do.	14	4 p. m.	978	28.988	62.5	61	28.900	28.757						E.	Light fleecy cl'ds	
Do.	14	4.35 p. m.	978	28.980	54	53.5	28.914	28.778								Sunset.
Do.	15	6.30 a. m.	978	28.966	43	45	28.928	28.853						Strong S.E. wind.	Cum. & C. S. 6.	
Do.	15	7 a. m.	978	28.972	44	45	28.932	28.855						do.	Cum. & C. S. 6.	
Do.	15	7.30 a. m.	978	28.974	45	45	28.931	28.884		1,137.7					Light C. S.	
Station 5, about 100 feet above river bed	15	0.20 p. m.	978	29.378	81	79	29.242	29.176		819.3					Light C. S.	
Bivouac 4, cañon S. Maria and Macho	15	3.30 p. m.	978	29.470	76	76	29.347	29.326							Light C. S.	
Bivouac 4	15	4 p. m.	978	29.470	74.5	73.5	29.351	29.331							Light C. S.	
Do.	15	4.30 p. m.	978	29.452	67	66.5	29.352	29.329							Light C. S.	
Do.	15	5 p. m.	978	29.442	63	63.5	29.351	29.324							Light C. S.	
Do.	16	7 a. m.	978	29.388	33	34	29.376	29.338							Light C. S.	
Do.	16	7.30 a. m.	978	29.392	34	34	29.378	29.342								
Do.	16	7.50 a. m.	978	29.390	33.5	34.5	29.377	29.340		650.6						
Station 5	16	1 p. m.	978	29.168	72	71.5	29.058	29.091		895 6						
Bivouac 5, Macho cañon	16	2 p. m.	978	29.148	65	65	29.053	29.099								
Do.	16	3 p. m.	978	29.128	63	62	29.039	29.095								

APPENDIX E—Continued.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.			Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Bivouac 5, Macho cañon	Dec. 16	4 p. m.	978	29.122	57.5	57	29.047	29.108						S.E.	C. S.	
Do.	16	4.40 p. m.	978	29.111	52	52	29.050	29.108								Sunset.
Do.	17	6.35 a. m.	978	29.150	38	38.5	29.125	29.107								
Do.	17	7.25 a. m.	978	29.150	37	37.5	29.128	29.106								
Do.	17	7.40 a. m.	978	29.150	36.5	37.5	29.129	29.105		863.3					Clear	
Station 7, of Dec. 13	17	1.30 p. m.	978	28.110	75.5	67	27.993	27.992		1,996.9				S.W.		
Bivouac 6, bet'n stations 4 and 5, of Dec. 13, head of Salinas.	17	3.50 p. m.	978	28.306	53.5	51.5	28.238	28.243							Clear and calm.	
Do.	17	4 p. m.	978	28.294	50	49.5	28.240	28.245							Clear and calm.	
Do.	17	4.30 p. m.	978	28.292	47	46.5	28.246	28.249							Clear and calm.	
Do.	18	6.30 p. m.	978	28.374	30	32	28.370	28.236		1,692.9						Foggy.
TRIP TO PANZA, CARRIZO, AND QUATE DOMINGO, VIA SAN JOSÉ, BY A. H. CAMPBELL.																
Luna's house, (San José rancho,) bivouac 1	20	4 p. m.	798	28.561	63	62.2	28.473	28.404							Clear sky	
Do.	20	4.30 p. m.	798	28.552	58.5	59	28.477	28.408							Clear sky	Sunset.
Do.	21	6.40 a. m.	798	28.494	25	25	28.503	28.418							Clear sky	
Do.	21	7 a. m.	798	28.496	24	24.5	28.498	28.410							Clear sky	
Do.	21	7.12 a. m.	798	28.500	24	25	28.512	28.423							Clear sky	
Do.	21	7.35 a. m.	798	28.500	24.2	26.2	28.512	28.421		1,504.4					Clear sky	
Station 1	21	11 a. m.	798	26.964	54.5	53	26.900	26.805		3,027.2					C. S. 2	
Station 6, (Panza,) bivouac 2	21	3.30 p. m.	978	28.531	63.5	59.8	28.442	28.409						N.	C. S. 3	Doubtful.
Do.	21	4 p. m.	978	28.509	56.5	55.5	28.438	28.406							Clear sky	
Do.	21	4.30 p. m.	978	28.500	51.5	50	28.442	28.408							Clear sky	Sunset.
Do.	21	5 p. m.	978	28.500	44	43.5	28.460	28.420							Clear sky	
Do.	21	5.30 p. m.	978	28.484	39.5	40	28.456	28.433							Clear sky	
Do.	22	6.30 a. m.	978	28.486	20.5	22	28.506	28.435							Clear sky	
Do.	22	7 a. m.	978	28.486	19.7	21	28.509	28.437							Clear sky	Sunrise.
Do.	22	7.15 a. m.	978	28.490	21.8	23	28.508	28.437							Clear sky	
Do.	22	7.30 a. m.	978	28.500	22.5	24	28.516	28.445							Clear sky	
Do.	22	8 a. m.	978	28.520	30	30.5	28.456	28.389		1,497.0					Clear sky	
Station 2	22	9.43 a. m.	978	28.484	49.5	46.5	28.431	28.350		1,578.5					Clear sky	
Between stations 8 and 9	22	0.35 p. m.	978	28.010	65	60.5	27.919	27.875		2,072.5				Light S.E.	C. S.	Hazy in north.
Bivouac 3, head of Estrella river	22	4.40 p. m.	978	27.675	51	49	27.620	27.588						Calm	Clear sky	Sunset.
Do.	22	5.15 p. m.	978	27.674	53	53	27.614	27.575						Calm	Clear sky	

Do.	23	6.30 a. m.	978	27.700	31.8	32	27.694	27.591						Calm	Clear sky	
Do.	23	7 a. m.	978	27.702	30.5	30.5	27.697	27.589						Calm	Clear sky	
Do.	23	7.30 a. m.	978	27.706	32.5	34	27.696	27.585						Calm	Clear sky	
Do.	23	7.45 a. m.	978	27.719	39.5	39	27.692	27.579						Calm	Clear sky	
Do.	23	8 a. m.	978	27.730	41.6	41.6	27.698	27.584		2,315.7				Calm	Clear sky	
Station 2	23	8.50 a. m.	978	27.571	60	55.2	27.494	27.369		2,573.2				Calm	Clear sky	
Station 5	23	9.50 a. m.	978	28.076	64.5	60.5	27.986	27.860						Calm	Clear sky	
Do.	23	9.55 a. m.	978	28.070	64	61	27.981	27.855						Calm	Clear sky	
Do.	23	10 a. m.	978	28.069	63.5	61	27.982	27.857		2,109.4				Calm	Clear sky	
Station 8	23	0.30 p. m.	978	28.628	72	69	27.517	27.421						Calm	Clear sky	
Do.	23	0.45 p. m.	978	28.624	72	69.2	27.513	27.441						Calm	Clear sky	
Do.	23	1 p. m.	978	28.624	72	70	27.513	27.443		1,536.9						
Bivouac 4, Santa Maria river, Cuyama plain	23	4 p. m.	978	28.501	73.5	70	27.387	27.338								
Do.	23	4.15 p. m.	978	28.500	70	68.8	27.394	27.314								
Do.	23	4.30 p. m.	978	28.492	65.2	62	28.398	28.347							Clear sky	Sunset.
Do.	23	5 p. m.	978	28.487	57	57	28.414	28.361							Clear sky	
Do.	24	6.50 a. m.	978	28.498	26	28	28.504	28.368							Clear sky	
Do.	24	7 a. m.	978	28.500	26.5	28.5	28.505	28.367							Clear sky	Sunrise.
Do.	24	7.30 a. m.	978	28.507	28	29.2	28.508	28.367							Clear sky	
Do.	24	8 a. m.	978	28.510	30	31.5	28.446	28.302		1,589.6					Clear sky	
Station 2	24	10 a. m.	978	28.720	61	58	28.637	28.485		1,466.9					Clear sky	
Station 3	24	11 a. m.	978	28.748	70.5	64	28.641	28.503		1,459.4					Clear sky	
Station 3, 30 feet above river	24	11.10 a. m.	978	28.732	68	63	28.631	28.496		1,464.3					Clear sky	
Station 5	24	0.40 p. m.	978	28.166	83	72	28.030								Clear sky	
Do.	24	0.45 p. m.	978	28.156	80	72	28.027	27.928		2,039.9					Clear sky	
Station 8	24	1.45 p. m.	978	28.525	77	73.5	27.406	27.322		2,667.4					Clear sky	
Station 8 (summit)	24	2 p. m.	978	28.522	77	73.6	27.403	27.322							Clear sky	
Do.	24	2.15 p. m.	978	28.515	73.5	72	27.405	27.326		2,664.2					Clear sky	
Bivouacs 5 and 3	24	3.15 p. m.	978	28.774	72	67	27.667	27.593							Clear sky	
Do.	24	3.45 p. m.	978	28.765	65.8	64.5	27.674	27.601							Clear sky	
Do.	24	4 p. m.	978	28.758	63.5	64	27.672	27.600							Clear sky	
Do.	24	4.30 p. m.	978	28.747	57	56	27.677	27.601							Clear sky	Sunset.
Do.	24	5 p. m.	978	28.740	52	54	27.682	27.602							Clear sky	
Do.	25	6.30 a. m.	978	28.712	36	37	27.693	27.601							C. S. 2	
Do.	25	7 a. m.	978	28.715	38.5	38	27.691	27.596							C. S. 2	
Do.	25	7.30 a. m.	978	28.720	38.5	40	27.696	27.600							C. S. 2	
Do.	25	8 a. m.	978	28.742	51	46	27.687	27.590		2,330.7					C. S. 2	
Station 1	25	9.15 a. m.	978	28.164	60	55	28.085	27.974							C. S. 2	
Do.	25	9.30 a. m.	978	28.158	58	57	28.084	27.973		1,991.4					C. S. 2	
Station 3	25	11 a. m.	978	28.363	64	61	28.274	28.172		1,772.3					C. S. 2	
Bivouacs 6 and 2	25	3 p. m.	978	28.600	72	66	28.489	28.435							C. S. 2	Doubtful.
Do.	25	4 p. m.	978	28.558	60	59	28.478	28.426							C. S. 4	
Do.	25	4.30 p. m.	978	28.550	55	55	28.482	28.426							C. S. 4	
Do.	26	7 a. m.	978	28.503	27	28	28.507	28.382							C. S. 4	
Do.	26	7.30 a. m.	978	28.503	28	28.8	28.504	28.378							C. S. 4	
Do.	26	8 a. m.	978	28.546	32	33	28.537	28.310		1,536.5					C. S. & cum. 9.	

APPENDIX E—Continued.

OBSERVATIONS MADE ON LINE OF SURVEY FROM HEAD OF SALINAS RIVER TO SANTA MARIA.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1854.			Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Bivouac 4, (on Santa Maria)	Dec. 31	7.30 a. m.	978	28.841	42.5	43	28.805	28.749							Cum. & S. 7	
Do.	31	7.45 a. m.	978	28.846	43.5	44	28.807	28.751		1,189.6					Cum. & S. 7	
Biv. 5, Quate Domingo springs	31	1 p. m.	978	28.524	65	64	28.431	28.461						S.W.	Nim. 9	
Do.	31	2 p. m.	978	28.516	64.5	64.5	28.425	28.464						S.W.	Nim. 9	
Do.	31	3 p. m.	978	28.522	63	64	28.434	28.520		1,380.7				Strong	Nim. 9	Rained continuously until dark of January 1, 1855. Wind in gusts; heavy rain; showers during night of Jan. 1.
Bivouac 5, (on tree, C.'s station 8, of Dec. 23)	1855. Jan. 2	10 a. m.	978	28.569	43.5	43.5	28.531	28.483						L't W. b'ze	Cum. 2	
Do.	2	11 a. m.	978	28.583	49	49	28.531	28.499						Light E.	Cum. 2	From northeast.
Do.	2	12 m	978	28.576	49	49	28.524	28.501						S.E.	Cum. 2	Scattering.
Do.	2	1 p. m.	978	28.550	48	47	28.500	28.497						N.	Cum. 1	
Do.	2	2 p. m.	978	28.550	48.5	48.2	28.499	28.501								
Do.	2	3 p. m.	978	28.551	48.5	48.2	28.500	28.506								
Do.	2	4 p. m.	978	28.564	45.5	44.5	28.521	28.529						N.	Cum. 1	
Do.	2	4.40 p. m.	978	28.558	40.5	40	28.528	28.531		1,425.5				N.	Clear	
Station 1, (H.'s 231 C.'s)	3	10.10 a. m.	978	28.692	41	38	28.660	28.639		1,288.5				S.W.	Nim. 7	Calm; upper cirrus.
Station 2, (C.'s)	3	11.30 a. m.	978	28.096	51	46	28.040	28.041		1,877.8				S.W.	Nim. 9	Do.
Station 3, (H.'s 275)	3	0.10 p. m.	978	27.855	50	46	27.801	27.852		2,010.1				S.W.	Clouds	Threatening rain.
Station 3, (H.'s 287, summit 4, Deer pass)	3	1.25 p. m.	978	27.627	46	45	27.621	27.692						S.E.	Cum. 1, nim. 9.	Raining on mountains to south.
Do.	3	1.40 p. m.	978	27.612	45	45.5	27.571	27.664						S.E.	Cum. 1, nim. 9.	
Do.	3	1.50 p. m.	978	27.610	45.5	45.5	27.568	27.674						S.E.	Cum. 1, nim. 9.	
Do.	3	2 p. m.	978	27.610	45.5	45.5	27.568	27.665						S.E.	Cum. 1, nim. 9.	
Do.	3	2.25 p. m.	978	27.604	45	46	27.563	27.664		2,439.7				S.E.	Cum. 1, nim. 9.	Raining until evening of January 4.
Bivouac 7, near Carrizo	5	7.10 a. m.	978	28.077	29	30	28.076	28.166							Clear and calm.	Sunrise.
Do.	5	8 a. m.	798	28.088	30.5	31	28.083	28.159							Clear and calm.	
Station (H.'s 346)	5	8.45 a. m.	798	28.076	36	35	28.057	28.113		1,755.8					Clear and calm.	
Bivouac 7	5	4.30 a. m.	798	28.144	39	39.5	28.118	28.212						Light N.W.	C. & cum. 2	
Do.	5	4.45 a. m.	798	28.140	37.5	38	28.118	28.210						Light N.W.	C. & cum. 2	
Do.	6	7 a. m.	798	28.335	28	30	28.336	28.208							Cum. 1	In N.
Do.	6	8 a. m.	798	28.360	31.5	32.8	28.353	28.219						Calm	Cum. 1	
Do.	6	9 a. m.	798	28.396	36	37.5	28.377	28.230						Calm	C. S. 1	
Do.	6	10 a. m.	789	28.409	39.5	39.5	28.381	28.233						Light E.	C. S. 1	
Do.	6	11 a. m.	798	28.408	41.5	41.5	28.375	28.233						Light E.	C. S. 1	

Do.	6	11.30 a. m.	798	28.404	43	43	28.367	28.234						Light E.	C. S. 1	
Do.	6	12 m.	798	28.398	43	43	28.362	28.239		1,697.2				Light E.	C. S. 1	
Bivouac 8, Panza	6	3.30 p. m.	798	28.666	48	44	28.616	28.532						Light E.	C. S. 5	
Do.	6	4 p. m.	798	28.659	47	46.2	28.612	28.538						Calm	C. S. 3	
Do.	6	4.40 p. m.	798	28.650	39.5	39	28.622	28.532						Calm	C. S. 3	Sunset.
Do.	6	5 p. m.	798	28.644	35	36	28.627	28.530						Calm	C. S. 2, cum. 1.	
Do.	7	7 a. m.	798	28.616	22	21	28.633	28.478						Clear	C. S. 2, cum. 1.	
Do.	7	7.12 a. m.	798	28.618	23	25.5	28.632	28.477						Clear	C. S. 2, cum. 1.	
Do.	7	8 a. m.	798	28.627	27.5	29.5	28.631	28.474						Clear		Doubtful as to time.
Do.	7	8.30 a. m.	798	28.642	31	32.8	28.636	28.474		1,413.8				Clear		

OBSERVATIONS MADE AT STATIONS FROM CAMP 16.

Station 1, at foot of Serpentine hill, near San Luis.	15	10 a. m.	392	29.780	56.2	53.5	29.703	29.510						Clear	C. C. S. 8
Do.	15	10.10 a. m.	392	29.769	56	54.2	29.696	29.504		475.5				Clear	C. C. S. 8
Station 2, San Luis	15	10.50 a. m.	392	30.020	58	57	29.941	29.756						Clear	C. C. S. 8
Do.	15	11.30 a. m.	392	30.025	61	60.9	29.938	29.766		236.4				Clear	C. C. S. 3
Station 3, Rancho de la Cuesta, (house)	15	0.20 p. m.	392	29.782	67	64	29.680	29.517						Clear	C. C. S. 3
Do.	15	0.30 p. m.	392	29 769	67	64	29.667	29.503		477.9				Clear	C. C. S. 3
Station 4, on divide, connecting Serpentine ridge with main mountain	15	1.50 p. m.	392	29.019	70	68	28.911	28.780						Clear	
Do.	15	2.03 p. m.	392	29.010	68	65	28.908	28.779						Clear	
Do.	15	2.13 p.m.	392	29.009	68	65	28.907	28.779		1,180.4				Clear	
Station 5, mouth of cañon, east end of Serpentine ridge	15	4.25 p. m.	392	29.671	62	59.5	29.583	29.460						Clear	C. S. & cum. 5.
Do.	15	4.35 p. m.	392	29.678	58	56	29.600	29.470		511.9					C. S. & cum. 5.
On beach near mouth of Corral de Piedras creek	17	11.30 a. m.	392	30.188	65.5	60	30.088	*30.013							C. & C. S. 6
Mag. Bg. to Pt. San Luis, west.	17	11.50 a. m.	392	30.182	63	60	30.089	*30.023							C. & C. S. 6
On beach at St. Luis port	17	2.05 p. m.	392	30.145	66.5	61.5	30.043	*30.027							C. & C. S. 8
5 feet below line of high tides	17	2.10 p. m.	392	30.141	65.5	62.5	30.041	*30.025							C. & C. S. 8
Do.	17	2.15 p. m.	392	30.138	64.5	62	30.042	*30.028							C. & C. S. 8
On San Luis creek, at junction of Davenport's creek	17	3.50 p. m.	322	30.068	68	66.5	29 962	30.903						N.	C. & C. S. 7
Do.	17	4 p. m.	392	30.066	67.5	66	29.962	30.995						N.	C. & C. S. 7

OBSERVATIONS MADE FROM CAMP 17 TO 17′, ON JANUARY 18, 1855.

On Trout creek, near base of Oak knob, H's station, between 0 and 1.	18	0.15 p. m.	392	29.742	69	68.7	29.635	29.562						Strong E.	Clear
Do.	18	0.25 p. m.	392	29.740	69	68.7	29.633	29.559		443.0				Strong E.	Clear
Camp 17′, head of Corral de Piedras creek	18	1 p. m.	392	29.635	72.9	71	29.518	29.470						N.W. 1.	Clear
Do.	18	1.20 p. m.	392	29.630	72.9	71	29.513	29.468						N.W. 1.	Clear

*These observations are combined with those of January 24, on beach.

APPENDIX E—Continued.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.			Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Camp 17′, head of Corral de Piedras creek	Jan. 18	1.40 p. m.	392	29.619	73	71	29.502	29.460						N.W. 1	Clear	
Do	18	2 p. m.	392	29 615	73.6	71.8	29.496	29.457							Clear	
Do	18	2.20 p. m.	392	29.612	73.6	71.8	29 493	29.456							Clear	
Do	18	2.40 p. m.	392	29.610	73	71	29.493	29.458							Clear	
Do	18	3 p. m.	392	29.610	72.5	70	29.494	29.462		538.8				Light N.W.	Clear	
Summit on the middle road, No. 2	20	10.35 a. m.	392	29.620	56	54.5	29.547	29.385						Strong S.E	Clear	
Do	20	10.45 a. m.	392	29.600	55	54	29.530	29.368						Strong S.E.	Clear	
Do	20	11 a. m.	392	29.592	56.2	55	29.519	29.359		614.5				Strong S E	Clear	
Summit No. 1	20	11.20 a. m.	392	29.592	57.5	55	29.516	29.362						Strong S.E.	Clear	
On road from Corral de Piedras to Arroyo Grande, near Capt. Williams'	20	11.30 a. m.	392	29.589	56.5	55	29.515	29.354		627.0				Strong S.E.	Clear	

OBSERVATIONS MADE ON BEACH NEAR PRICE'S, JANUARY 24.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
On beach, high tide	24	1.20 p. m.	392	30.140	62.5	61.5	30.049	*30.069						Sea breeze 1.	C. C. S. 2	
Do	24	1.45 p. m.	392	30.100	64.5	64	30.004	30.034						Calm	C. C. S. 2	
Do	24	2 p. m.	392	30.095	65.5	64.3	29.996	30.027						Calm	C. C. S. 2	
Do	24	2.15 p. m.	392	30.095	65.5	65	29.996	30.031						Calm	C. C. S. 2	
Do	24	2.30 p. m.	392	30.095	65.5	65	29.996	30.035						Calm	C. C. S. 2	
Do	24	2.45 p. m.	392	30.095	67.5	66	29.991	30.039						Calm	C. C. S. 2	
Do	24	3 p. m.	392	30.095	67.5	66	29.991	30.041						Calm	C. C. S. 2	
Do	24	3.15 p. m.	392	30.095	67	65	29.992	30.040	†30.030	Sea level				Calm	C. C. S. 2	

OBSERVATIONS MADE ON SIDE TRIP TO PURISSIMA AND TIDOS SANTOS MISSION.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
La Purissima to Bivouac No. 1	28	5.15 p. m.	392	29.862	54	53	29.794	29.826						N.W.	C. C. S. 2	
Do	29	6.30 a. m.	392	29.755	44	54.4	29.714	29.745						S.E.	C. C. S. 5	
Do	29	6.45 a. m.	392	29.752	44.5	46	29.710	29.740						N.E.	C. C. S. 5	
Do	29	7 a. m.	392	29.752	44	44	29.711	29.744						Calm	C. C. S. 5	Sunrise.
Do	29	7.15 a. m.	392	29.754	47	48	29.705	29.740						Calm	C. C. S. 5	
Do	29	7.30 a. m.	392	29.760	52.5	52.5	29.697	29.734						Light E. breeze.	C. C. S. 5	

Do.		29	7.45 a. m.	392	29.766	56.5	54.5	29.692	29.730		379.4				do.	C. C. S. 5	
Sta. 1, where trail leaves valley.		29	9.10 a. m.	392	29.505	68	62	29.401	29.441						do.	C. C. S. 1	
Do.		29	9.15 a. m.	392	29.503	66	61	29.404	29.445		550.4				do.	C. C. S. 1	
Station 2, summit.		29	10.15 a. m.	392	29.815	70	69	29.706	29.746		1,218.3				E.	C. C. S. 1	
Station 3, Tidos Santos summit		29	1.30 p. m.	392	29.362	67	65	29.262	29.354		637.2				Strong S.E.	C. C. S. 4	
Do.		29	2 p. m.	392	29.342	62	61	29.255	29.352		637.2				Strong S E.	C. C. S. 4	
Bivouac 2, Tidos Santos ranch.		29	3.35 p. m.	392	29.605	64	61	29.513	29.618						Strong S.E	C. C. S. 8	
Do.		29	4.10 p. m.	392	29.600	60	60	29.517	29.622						Strong S.E.	C. C. S. 8	
Do.		29	5 p. m.	392	29.598	58.5	59	29.519	29.617						Strong S.E.	C. C. S. 9	
Do.		30	6.45 a. m.	392	29.684	57	58	29.609	29.632						Strong S.E.	Overcast; C. S. cum. nim.	
Do.		30	7.15 a. m.	392	29.690	58	58	29.612	29.643						Strong S.E.	do.	
Do.		30	7.45 a. m.	392	29.690	58	58.5	29.612	29.641						Strong S.E.	do.	
Do.		30	8 a. m.	392	29.690	59	59	29.610	29.634		374.6				Strong S.E.	do.	
Station 1, Jesus Maria.		30	11.30 a. m.	392	29.965	71	70	29.851	29.875						Str'g S.S.E.	do.	
Do.		30	11.35 a. m.	392	29.965	71	69.5	29.851	29.874		146.4				Str'g S.S.E.	do.	
Station 1, on mesa.		30	12 m.	392	29.645	70	68	29.531	29.561		441.0				Str'g S.S.E.	do.	

OBSERVATIONS MADE FROM CAMP 22 ON LINE OF SURVEY, FEBRUARY 3, 1855.

Station 1, (H.'s sta. 16, +200 ft.)	Feb.	3	10 a. m.	392	29.505	63.5	63	29.413	29.307		674.7					Clear	
Summit, (wagon road)		3	10.25 a. m.	392	29.233	63.5	63	29.141	29.035		933.8					Clear	
Summit, (H.'s station 26)		3	10.40 a. m.	392	29.262	65	64	29.166	29.061		910.9					Clear	
Station, foot of hill, (H.'s station 29, wagon road)		3	11 a. m.	392	29.510	71	68	29.398	29.292		691.6					Clear	
Naheeze (½ mile from last sta.)		3	11.40 a. m.	392	29.660	71	69	29.548	29.450		541.3					Clear	
Station No. 6 (Naheeze)		3	0.30 p. m.	392	29.738	74	72.5	29.618	29.517		480.2					Clear	

OBSERVATIONS MADE ON SIDE TRIP FROM CAMP 31.

Bivouac No. 1, (Peru cañon,) on trail to Tejon.	Mar.	1	3.30 p. m.	978	28.100	62	61	28.016	27.982						Calm.	Nim. 1	
Do.		1	4 p. m.	978	28.094	61	60	28.013	27.978						Calm.		
Do.		1	5 p. m.	978	28.096	58.5	58.5	28.022	27.975						Calm.		
Do.		1	5.40 p. m.	978	28.096	54	54	28.032	27.979		1,939.9				Calm.	Overcast; sun setting clear.	
Bivouac 5, Sta. Maria, Cuyama		9	5.20 p. m.	978	26.590	54	54	26.530	26.658						N.N.W. 3	Cum. 8	
Do.		9	6 p. m.	978	26.590	52	52	26.534	26.658						N.N.W. 3	Cum. 8	
Do.		10	6.20 a. m.	978	26.550	42	42.5	26.517	26.637						N.W. 2.	Nim. 1	
Do.		10	7 a. m.	978	26.552	42	42.5	26.519	26 637		3,259.6				N.W. 2.	Nim. 1	
Station 1		10	12 m.	978	25.970	57	56	25.904	26.031						W. 1	C. S. 6	
Do.		10	12 m.	978	25.970	60	56	25.897	26.024		3,961.2				W. 1.	C. S. 6	
Bivouac 6, head of Santa Maria		10	4.30 p. m.	978	25.430	46	46	25.390	26.524						W. 3.	Nim. 1	
Do.		10	5.15 p. m.	978	25.434	44	44	25.398	26.527		4,427.5				W. 3.	Nim. 1	
Summit.		11	8.10 a. m.	978	26.636	45	39	24.598	24.650		5,374.1				W. 3.	Nim. 1	Snowing.
Station 2		11	9.15 a. m.	978	24.964	43	39	24.932	24.976		5,015.2						Raining.
Bivouac 7, Peru cañon.		11	5.30 p. m.	978	25.156	40	40	25.130	25.242						N.W. 1.	C. S. 8	
Do.		11	6 p. m.	978	25.156	39	39	25.132	25.246						N.W. 1.	C. S. 8	

* Rejected in computation.

† This is the mean of the above observations, combined with those taken at mouth of Corral de Piedras creek, and on beach of San Luis harbor.

APPENDIX E—Continued.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
	1855.			Inches.	°	°	Inches.	Inches.	Inches.	Feet.	°	°	°			
Bivouac 7, Peru cañon	Mar. 12	6.30 a. m.	978	25.196	41	43	25.168	25.277							C. S. 9	Misting.
Do	12	7.15 a. m.	978	25.202	46	46	25.163	25.270		4,724.2					C. S. 9	
Bivouac 8, Peru cañon	13	7.10 a. m.	978	26.196	51	53	26.144	26.299		3,661.3						Raining.
Station 1, where Tejon trail leaves cañon of serpentine	14	8.30 a. m.	978	27.610	52	52	27.554	27.675		2,247.2						Raining.

OBSERVATIONS MADE AT SEMI SUMMIT, SUNDAY, MARCH 25, 1855, BY H. CUSTER, ASSISTANT.

Station.	Date.	Hour.	Number of barometer.	Reading of barometer.	Attached thermometer.	Detached thermometer.	Corrected for temperature.	Final reduction.	Mean.	Height above sea.	Dry bulb.	Wet bulb.	Difference.	Winds.	Clouds.	Remarks.
Station 1, foot of pass, east	25	9 a. m.	392	29.145	76.5	71	29.021	29.020						N.W.	Clear	
Do	25	9.45 a. m.	392	29.106	75	74	28.986	28.986	29.003	975.0						
Summit	25	11.10 a. m.	392	28.517	78	76	28.391	28.396		1,577.2						
West foot of pass	25	0.15 p. m.	392	29.022	75	74	28.902	28.962		1,121.3						
Halfway between summit and Semi rancho	25	1.45 p. m.	392	29.160	78	76	29.032	29.126		859.3						
Bivouac No. 2	25	5.45 p. m.	392	29.027	62.5	60.5	28.939	28.999								
Do	26	5.55 a. m.	392	28.937	37.5	38	28.914	28.993								Sunrise.
Do	26	6.35 a. m.	392	28.952	43	46	28.914	28.990	28.994	959.3						
Second summit	26	7.50 a. m.	392	28.393	67.5	65	28.296	28.371		1,582.7						
Do	26	8.20 a. m.	392	29.035	68.5	65	28.933	29.005		966.2						
Station No. 1, head of Guadalupe Largo	Jan. 30	9.30 a. m.	392	28.413	61	59	28.330	29.374		1,578.7				S.E. 3	C. nim. cum	Head of Mission creek, Santa Inez.
Station No. 2	30	10.45 a. m.	392	28.480	63	62.5	28.392	29.434		1,577.6				S.E. 3	C. nim. cum	Head of branch of Santa Maria river.
Right fork of Arroyo Grande	Jan. 23	0.30 p. m.	392	29.595	69.5	70	29.489	29.466								
Base of Custer's hill	23	4.10 p. m.	392	29.644	75	74.2	29.524	29.534								

CONCLUSION

OF THE

OFFICIAL REVIEW OF THE REPORTS

UPON THE

EXPLORATIONS AND SURVEYS FOR RAILROAD ROUTES

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WASHINGTON, D. C
1855-7.

CONTENTS.

PREFATORY NOTE.

Subjoined are extracts from the Annual Reports of the Secretary of War, transmitted to Congress in December, 1855 and 1856, and also the accompanying yearly reports of Captain A. A. Humphreys, Topographical Engineers, in charge of the office of Pacific Railroad Explorations and Surveys. These extracts and reports furnish, up to their respective dates, information in regard to the condition and progress of the several War Department explorations, and present the leading facts and results determined by each. They form, therefore, a proper conclusion to the series of special reports upon the different lines of survey.

An annexed table, similar to that contained in the Report of the Secretary of War, in Vol. I, exhibits the comparative lengths, cost, &c., of the various railroad routes, according to the latest corrections and revisions. Explanations are given of some of the more important modifications of the previously reported results.

No. 1.

EXTRACT

FROM THE

ANNUAL REPORT OF THE SECRETARY OF WAR.

DECEMBER, 1855.

The reports of the officers employed under the appropriations made for explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean, were submitted to Congress on the 27th of February last, with a report from this department, giving a general sketch of the country over which they extended, a recapitulation of their results, and a comparison of their distinguishing characteristics; from which it was concluded that of the routes examined, the most practicable and economical was that of the thirty-second parallel. A report is herewith submitted from the officer in this department charged with the revision of the work of the several parties, and I refer to it for additional information derived from materials collected, on a further examination of them by himself, and the several officers who made the particular surveys, as well as for the results of explorations carried on during the past year.

When the report was made, in February last, many of the maps, drawings, and scientific papers, intended to form part of the report, and which could only be prepared after an elaborate examination of the materials collected, had not been completed for want of time, and it became necessary to substitute hastily prepared drawings and preliminary reports. This was particularly the case with regard to the work on the route of the thirty-fifth parallel. A minute examination of the material collected in that survey has resulted in showing the route more practicable than it was at first represented to be, and in reducing to nearly one-half the original estimates of the officer in charge of the survey, which, indeed, seemed, when they were submitted, to be extravagant, and were noted in the report from this department as probably excessive.

Another feature of interest developed in the course of the further examination of the work on the route of the thirty-second parallel is, that the Colorado desert, which is traversed by the route for a distance of 133 miles, and which, in the report referred to, was noted as consisting of a soil that needed only water to render it highly productive, is, in fact, the delta of the Colorado river, and, according to barometric levels, is so much lower than that stream as to be easily irrigated from it. Thus, there is every reason to believe 4,500 square miles of soil of great fertility, of which nearly one-half is in our territory, may be brought into cultivation in one unbroken tract along the route.

Under the appropriation made at the last session for the continuation of these surveys and other purposes, three parties have been in the field during the past season.

One of these was directed to make examinations connected with the routes of the 32d and 35th parallels. This survey has greatly improved the aspect of the former route by changing the line for nearly half the distance between the Rio Grande and the Pimas villages on the Gila river from barren ground to cultivable valleys, and entirely avoiding a *jornada* of eighty miles, which occurs in that section; also by the discovery of an eminently practicable route through cultivable country from the plains of Los Angeles, along the coast and through the Salinas valley, to San Francisco. The connexion originally proposed between these points was by way of the valley of San Joaquin and the Great Basin.

The attention of this party was also directed to an examination into the practicability of procuring water along certain parts of the route where it is now deficient. The report shows that it may be obtained by common wells at distances of about twenty miles.

From the result of this exploration, moreover, it appears practicable to obtain, at a small expense, a good wagon road, supplied with water by common wells, from the Rio Grande down the San Pedro and Gila and across the Colorado desert. Such a road would be of great advantage in military operations, would facilitate the transportation of the mail across that country, and relieve emigrants pursuing that route from much of the difficulty and suffering which they now encounter.

A second party was charged with the duty of testing the practicability of procuring water by artesian wells on the Llano Estacado, an arid plain, which has been heretofore described as a desert. The experiment has so far demonstrated its practicability as to leave little doubt of its final success; it will be continued, however, until the problem shall have been fully solved.

The examinations into the feasibility of causing subterranean streams to flow upon the surface from artesian wells, though undertaken in connexion with the practicability of a railroad, if they should prove entirely successful, will have a value beyond their connexion with that object in the reclamation of a region which is now a waste, and its adaptation to the pastoral, and, perhaps, the agricultural uses of man.

The third party was directed to conduct an exploration from the Sacramento to the Columbia river, with a view to ascertain the practicability of a route to connect the valleys of those rivers. The officer in charge has reported the successful completion of the duty, but has not given details. The same officer has been directed to make a reconnaissance of the Sierra Nevada in the vicinity of the head branches of Carson river.

The prosecution of instrumental surveys, accompanied by an investigation into many branches of physical science simultaneously over lines of such length, and embracing such an extent of latitude, is a work of greater magnitude than any of the kind hitherto undertaken by any nation; and its results have not only proved commensurate with the amount of work done, but possess a value peculiar to the scale on which it has been conducted, as affording a basis for the determination of some questions of science which no number of smaller and detached explorations could have furnished. Should means be granted pursuant to the estimate in the report referred to, for continuing these explorations, I have every confidence that the expenditure will be well repaid by these contributions to our knowledge of the interior of the country.

The facts developed by these surveys, added to other information which we possess, suggest some considerations of great interest with regard to our territory on the Pacific. They exhibit it as a narrow slope of an average width of less than one hundred and fifty miles of cultivable land, skirting the ocean for a distance of one thousand miles; rich in those mineral productions which are tempting even beyond their value, and which would be most readily turned to the use of an invader; drained by two rivers of wide-spread branches, and with seaports lying so directly upon the ocean that a hostile fleet could commence an attack upon any one of them within a few hours after being descried from land; or, if fortified against attack, so few in number that comparatively few ships would suffice to blockade them.

This territory is not more remote from the principal European States than from those parts of our own country whence it would derive its military supplies, and some of those States have colonies and possessions on the Pacific which would greatly facilitate their operations against it. With these advantages, and those which the attacking force always has of choice of time and place, an enemy possessing a considerable military marine could, with comparatively little cost to himself, subject us to enormous expenses, in giving to our Pacific frontier that protection which it is the duty of the general government to afford.

In the first years of a war with any great maritime power, the communication by sea could not be relied upon for the transportation of supplies from the Atlantic to the Pacific States. Our naval peace establishment would not furnish adequate convoys for the number of storeships which it would be necessary to employ, and storeships alone laden with supplies could not undertake a voyage of twenty thousand miles, passing numerous neutral ports, where an enemy's armed vessels, even of the smallest size, might lie in wait to intercept them.

The only line of communication, then, would be overland; and by this it would be impracticable, with any means heretofore used, to furnish the amount of supplies required for the defence of the Pacific frontier. At the present prices over the best part of this route the expense of land transportation alone for the annual supplies of provisions, clothing, camp equipage, and ammunition for such an army as it would be necessary to maintain there, would exceed $20,000,000; and to maintain troops and carry on defensive operations under those circumstances, the expense per man would be six times greater than it is now; the land transportation of each field twelve-pounder, with a due supply of ammunition for one year, would cost $2,500; of each 24-pounder and ammunition, $9,000; and of a seacoast gun and ammunition, $12,000. The transportation of ammunition for a year for 1,000 seacoast guns would cost $10,000,000. But the expense of transportation would be vastly increased by a war; and at the rates that were paid on the northern frontier during the last war with Great Britain, the above estimates would be trebled. The time required for the overland journey would be from four to six months. In point of fact, however, supplies for such an army could not be transported across the continent. On the arid and barren belts to be crossed, the limited quantities of water and grass would soon be exhausted by the numerous draught animals required for heavy trains, and over such distances forage could not be carried for their subsistence.

On the other hand, the enemy would send out his supplies at from one-seventh to one-twentieth the above rates, and in less time—perhaps in one-fourth the time—if he should obtain command of the isthmus routes.

Any reliance, therefore, upon furnishing that part of our frontier with means of defence from the Atlantic and interior States, after the commencement of hostilities, would be vain, and the next resource would be to accumulate there such amount of stores and supplies as would suffice during the continuance of the contest, or until we could obtain command of the sea. Assigning but a moderate limit to this period, the expense would yet be enormous. The fortifications, depots, and storehouses, would necessarily be on the largest scale, and the cost of placing supplies there for five years would amount to nearly one hundred millions of dollars.

In many respects, the cost during peace would be equivalent to that during war. The perishable character of many articles would render it perhaps impracticable to put provisions in depot for such a length of time; and in any case, there would be deterioration amounting to some millions of dollars per year.

These considerations, and others of a strictly military character, cause the Department to examine with interest all projects promising the accomplishment of a railroad communication between the navigable waters of the Mississippi and those of the Pacific ocean. As military operations depend in a greater degree upon rapidity and certainty of movement than upon any other circumstance, the introduction of railway transportation has greatly improved the means of defending our Atlantic and inland frontiers; and to give us a sense of security from attack upon the most exposed portion of our territory, it is requisite that the facility of railroad transportation should be extended to the Pacific coast. Were such a road completed, our Pacific coast, instead of being further removed in time, and less accessible to us than to an enemy, would be brought within a few days of easy communication, and the cost of supplying an army there, instead of being many times greater to us than to him, would be about equal. We would be relieved of the necessity of accumulating large supplies on that coast, to waste, perhaps, through long years of peace; and we could feel entire confidence that, let war come when and with whom it may, before a hostile expedition could reach that exposed frontier, an ample force could be placed there to repel any attempt at invasion.

From the results of the surveys authorized by Congress, we derive at least the assurance that the work is practicable; and may dismiss the apprehensions which, previously, we could not but entertain as to the possibility of defending our Pacific territory through a long war with a powerful maritime enemy.

The judgment which may be formed as to the prospect of its completion must control our future plans for the military defence of that frontier; and any plan for the purpose which should leave that consideration out of view, would be as imperfect as if it should disregard all those other resources with which commerce and art aid the operations of armies.

Whether we shall depend on private capital and enterprise alone for the early establishment of railroad communication, or shall promote its construction by such aid as the general government may constitutionally give; whether we shall rely on the continuance of peace until the increase of the population and resources of the Pacific States shall render them independent of aid from those of the Atlantic slope and Mississippi valley, or whether we shall adopt the extensive system of defence above referred to, are questions of public policy which belong to Congress to decide.

Beyond the direct employment of such a road for military purposes, it has other relations to all the great interests of our confederacy, political, commercial, and social, the prosperity of which essentially contributes to the common defence. Of these it is not my purpose to treat, further than to point to the additional resources which it would develop, and the increase of population which must attend upon giving such facility of communication to a country so tempting to enterprise, much of which having most valuable products, is beyond reach of market.

No. 2.

REPORT

UPON THE

PROGRESS OF THE PACIFIC RAILROAD EXPLORATIONS AND SURVEYS.

NOVEMBER, 1855.

BY CAPTAIN A. A. HUMPHREYS, CORPS OF TOPOGRAPHICAL ENGINEERS.

WAR DEPARTMENT,
Office Pacific Railroad Explorations and Surveys,
Washington, November 29, 1855.

SIR: Since my report to you of February 5, 1855, the general map of the territories of the United States lying between the Mississippi river and the Pacific ocean has been completed as far as the materials collected admit, and is in the hands of the engraver. The labors of the parties organized for continuing explorations will afford data for still further additions.

Many of the maps, drawings, and scientific papers intended to form part of the reports submitted to you by the first exploring parties, soon after their return from the field, could only be prepared after an elaborate use of the materials collected. In some instances hastily prepared drawings and preliminary reports were temporarily substituted for the more elaborate results, which are now, for the most part, complete.

The results of the investigations in the various branches of physical science in connexion with the expeditions are of great practical value, and full of scientific interest. The geological and meteorological reports are eminently so in many points of view. By the former it will be perceived that the sources and quality of building materials at various remote and important localities have been determined, and rich deposits of gypsum and limestone have been marked out. On the routes of the 35th and the 32d parallels, the structure of desert areas has been minutely studied with special reference to the practicability of obtaining water by wells or by boring, and generally with the most satisfactory results. From the report of Mr. W. P. Blake, the geologist of the expedition in charge of Lieutenant R. S. Williamson, it appears that the structure of the Colorado desert, between Fort Yuma and the Coast mountains is very favorable to the success of artesian borings, and it is considered probable that an abundant supply of water would be obtained by boring to a moderate depth. Such a result would be of extreme importance, not only by facilitating communication between Fort Yuma and the coast for government trains, but as a relief to the emigrant parties which are constantly crossing to California through New Mexico and Sonora. The general nature and composition of the soils and sub-soils over the region explored has been determined, and analyses of the most desirable have been made. An analysis of the soil of the alluvial portion of the Colorado desert, which covers an area of 4,500 square miles, and is four times greater in extent than the land under cultivation on the Mississippi river, between the mouth of Red river and the Balize, shows that it has all the elements of great fertility, and, but for the adverse climatic conditions, would rival in its productions the best lands of the delta of the Mississippi. According to the barometrical levellings of Lieutenant Williamson, the alluvial portion of this plain is lower than the surface of the Colorado river; and should this be confirmed by more accurate modes of levelling, as there is every reason to believe it would be, an extensive system of irrigation would entirely change the character of its surface by the introduction of water, the only element required for great productiveness. About one half of the Colorado desert is within our territory.

Valuable ores of several metals have been brought in and examined, and their localities visited and described. A specimen from the collection of Captain Pope proves to be a mass of carbonate of lead, nearly pure, and containing seventy-two per cent. of metal. Another specimen of earth, from the bed of Delaware creek, contains over eighteen per cent. of free sulphur. In California two veins of copper ore, one of iron, and one of antimony, of great extent and richness, have been found and reported upon; worth alone the whole cost of Lieutenant Williamson's expedition. The character and extent of large deposits of bitumen asphalt near Los Angeles has also been made known. The examination of a collection of salty and alkaline incrustations from the soil and dry lakes of California, shows that they consist principally of salt, sulphate of magnesia, and carbonate of soda. Nitre was not found in any quantity.

Along the 35th parallel the carboniferous limestone has been found as far west as the San Francisco mountain, in longitude 112°. The discovery of these rocks so far west renders it possible that deposits of true coal will be found in that region, although, the observations having been very limited, none has yet been seen. The probable existence of coal in other new and important localities has been indicated, which more thorough examinations may develop. Much additional geological exploration is required to throw light on this important subject.

The character of the sand-hills of the Colorado desert has been carefully considered by Mr. Blake, who has shown that they are confined in position to a bank or terrace, and, contrary to the opinion previously entertained, do not constitute a formidable obstacle to the construction and working of a railroad.

Among the results of special scientific interest is the determination of the geological age of mountain chains. It has been ascertained that the coast mountains, in the vicinity of San Francisco, and further south, have upraised within or since the Eocene division of the Tertiary period. The strata about San Francisco, Benicia, Monterey, and other localities, have been shown to be of Tertiary age, and the foldings and contortions to which they have been subjected reveal the violent disturbances and mighty changes of that part of the continent within recent geological times. Tertiary marine shells and sharks' teeth have been brought from the tops of hills, at the base of the Sierra Nevada, over 1,500 feet above the ocean.

Of similar interest are the examination and description of volcanoes, the exhibition of the nature of the rocks and soils along the several routes, by large collections of rocks, minerals, and fossils, and the comparison of the ages of mountains, and the strata on their flanks. These additions to our knowledge of the geological structure of the country have been of great assistance in determining its general features and topography.

The results of the investigations into the zoology and botany of the country west of the Mississippi have proved interesting and important. The existence and geographical distribution of many species, useful in an economical point of view, or interesting to science, have been determined.

The precise range of the buffalo, the antelope, the prairie dog, the various species of deer, and of other animals, with that of numerous valuable trees and herbaceous plants, has been satisfactorily ascertained. Several forms of animal and vegetable life, noticed by earlier travellers, especially by Lewis and Clark, but unknown since their time, have been re-discovered.

The labors of the naturalists and the collectors attached to the several parties have resulted in a collection illustrating the natural resources of our country west of the Mississippi, more complete than will be found in all the museums of the United States and Europe combined.

Lieutenant Williamson's report shows a remarkable coincidence of the elevations deduced from barometrical observations with those obtained at the same time by the spirit level. The profiles of the Tejon pass and the Cañada de las Uvas, delineated from the spirit level altitudes, differ so slightly from the barometrical profiles, that the barometer may be regarded as sufficiently accurate for the purpose of railroad reconnaissance in that climate.

The report of Captain Whipple, topographical engineers, upon the manner in which the elevations for the elaborated profile of his route have been deduced, indicates means by which great accuracy can be obtained in barometrical levelling over extensive regions, without the delay consequent upon the mode of eliminating those errors arising from irregular changes of atmospheric pressure, by simultaneous observations at near points. Between the Mississippi and the Pacific, these errors are in some instances equal to 1,000 feet. The investigation made by Captain Whipple leads to the following conclusions, regarding these irregular movements of the barometer:

1st. They are of great magnitude, and if not taken into account may produce an error in the deduced altitude of many hundreds of feet.

2d. They are but slightly affected by local storms.

3d. They *may* occur almost simultaneously over the whole interior portion of the continent.

4th. They are actually identical within certain areas of great extent.

These conclusions will be regarded with great interest by scientific explorers and those engaged in studying and observing meteorological phenomena.

It has been suggested, in connexion with this, to make series of barometrical observations at military posts on lines crossing our territories from east to west, in order to determine the areas over which these irregular (abnormal) movements occur simultaneously. These having been ascertained, it will be merely necessary, in future explorations, to have corresponding observations made at one point in each of the barometrical areas, or regions, traversed by an expedition. The plan of observations proposed could be carried into effect at the cost of a few thousand dollars; and, incidentally, would make important additions to meteorological knowledge.

As a kindred subject, I beg leave to ask your attention to a proposed arrangement for improving the means of computing the observations for longitude of exploring parties. The best mode of determining longitudes by these parties, is that of observations upon moon culminating stars. One night's observations by a good observer will give a resulting longitude—the error of which will not exceed two miles, provided there are corresponding observations at some well determined point; but without these corresponding observations, errors, three or four times as great, may be introduced by the use of tables of the computed positions of the moon. Thus it appears that the field observations are more accurate than the means of computing used in the office. This source of error could be obviated by a preconcerted arrangement with an observatory for observations, at certain times during the continuance of exploring parties in the field.

Upon reviewing his barometrical work for the correction of errors due to abnormal changes, Captain Whipple has included a mass of altitude observations, not reduced before for want of time, which gives a remarkably detailed and accurate profile of the ground; and in connexion with the equally minute topographical notes, now for the first time used, has greatly improved the character of his route as a railroad line.

Among the most important changes that the revision has introduced, Capt. Whipple reports the reduction of the length of the route, which from Fort Smith to San Pedro is now 1,760 miles, and from Fort Smith to San Francisco, direct from the Mojave river by the Tay-ee-chay-pah pass, avoiding the tunnel of the Cajon pass, it is 2,025 miles. In the preliminary report the distances were measured upon the wagon trail; those now given are along the plotted railroad line. Many of the difficulties of construction previously reported may, in the judgment of Capt. Whipple, be obviated; and, in his opinion, there is strong probability of improving the route still further, by shortening distance and avoiding costly construction. A scrutiny of the barometrical observations through Campbell's pass of the Sierra Madre, about twenty miles north of the Camino del Obispo, shows that that mountain chain may be crossed without a tunnel or excavation at the summit, with a maximum grade of 40 feet to the mile, at an elevation of 6,952 feet above the sea. By the Camino del Obispo, the old route, elevation 8,250 feet, a tunnel three-quarters of a mile long, at an elevation of 8,000 feet, was required.

The elevations of several of the passes have been materially reduced; and Captain Whipple reports that the data are now provided for an actual computation of the excavation, embankment, and cost of construction of the proposed route.

As this computation necessarily involves much tedious labor, it has not yet been made, and for the present Captain Whipple submits an estimate made in a manner similar to those of the other routes, in order to exhibit more correctly the comparative practicability of this, than was done in the preliminary report. He has based it upon the facts developed by a careful study of the observations made and the material collected in the field, and it is believed by him that the amount will be much diminished when the results of the computation are arrived at. The cost of construction, as given in the preliminary report, was greatly exaggerated, the estimates having been formed without reference to the field notes. In the examination which, by your direction, I made of that report, the estimates were thought by me to be largely in excess. They were—

From Fort Smith to San Pedro, distance 1,892 miles	$169,210,265 00
From Fort Smith to San Francisco, the road leaving the Mojave river 34 miles from the east entrance of Cajon pass, and crossing the Tay-ee-chay-pah pass, (the estimate from the Mojave river to San Francisco, a distance of 406 miles, having been made by me) distance 2,174 miles	175,877,265 00
These, according to Captain Whipple, are now—	
From Fort Smith to San Pedro, distance 1,760 miles	86,130,000 00
From Fort Smith to San Francisco, crossing direct from the Mojave river to the Tay-ee-chay-pah pass, distance 2,025 miles	94,720,000 00

Under the appropriation for continuing explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean, three parties were organized by your directions.

The first, under the command of Lieutenant John G. Parke, topographical engineers, was instructed by the letter of the Department of October 2, 1854, to determine the practicability of constructing a railroad from the waters of the bay of San Francisco to the plain of Los Angeles, by the Salinas river valley, and through the spurs of the Coast Range, which extend to the sea coast near Point Concepcion, or, if that was found to be impracticable, by the coast route; to make certain explorations in the Great Basin, in connexion with the route of the 35th parallel, and between the Pimas villages on the Gila and the Rio Grande; the attention of the party being particularly directed to such examinations in the latter region as would show the degree of practicability of constructing artesian and common wells. These duties have been thoroughly and satisfactorily executed, and the party has just returned to Washington from the field. A rough reduction of portions of the field-work, at the most difficult points, shows that a railroad route from the headwaters of the Salinas, through the spurs of the Coast Range, direct to the plains of Los Angeles, is not practicable; whilst that along the coast route is eminently so. With equal length, it has the advantage over the route by New (Williamson's) and Tay-ee-chay-pah passes, of a less sum of ascents and descents, less elevation, (the greatest attained being only 1,350 feet above the sea,) less cost of construction, and of passing continuously through a settled and cultivated country. The grades are favorable, the greatest required being, with a cut of 60 feet at the summit, 125 feet per mile for the space of 15 miles, (ascending and descending;) and this, it is believed, can be reduced to 100 feet per mile, by a tunnel 1,000 feet long.

The labors of the party will develop the topography of a district that was before unknown, or the nature of which was greatly misconceived; and will show a practicable railroad route, with easy grades, connecting the valley of Salinas river with the head of Tulare valley, by the Estrella, a tributary of the Salinas, and the Estero, a plain lying within the Coast Range, and connected with the Tulare valley, near the Cañada de las Uvas. The exploration in the Great Basin was successfully executed, demonstrating that the Mojave river is a stream of the Great Basin, and does not flow into the Colorado at any time; an elevated ridge separating the basins of the two rivers.

The topographical examinations between the Pimas villages on the Gila and Doña Ana, or El Paso, on the Rio Grande, have resulted in many important improvements upon the line of survey of last year. They have established the practicability of constructing a railroad between those points, by the Gila river, to the mouth of the San Pedro, and up that stream to the vicinity of the line of 1854; a route possessing great advantages over all others in this region, since, from the Pimas villages to the point of departure from the San Pedro, a distance of 166 miles, it passes along the cultivable valleys of those streams, instead of over bare jornadas. The ridge of mountains east of the San Pedro is crossed by a more direct route than that of the old line, and the Puerto del Dado of the Chiricahui mountains is avoided, that range being turned on the north by a gap or break lying between it and Mount Graham. The length and the cost of construction of this route will be about the same as of that examined by Lieutenant Parke, in 1854; the summits to be overcome will be fewer in number, the elevations less, the grades more gentle, and the supply of water greater; these, with the great advantage first mentioned, constitute this the best route yet made known in that region. The results of the examinations with reference to the supplies of water make it probable, from the form and geological structure of the basins and plains, that ordinary wells, at distances not exceeding twenty miles, would furnish abundant supplies, distances not too great for the economical working of passenger trains. They also indicate the feasibility of artesian wells in some localities, which might be resorted to if needed.

Upon the arrival of Lieutenant Parke at Fort Fillmore, after the completion of this duty, a report was made by him to this office of the principal results bearing upon the question of supply of water, of the points where it was desirable to have borings made, indicated in the order most suitable for trial, together with all the information necessary for the party directed to make the borings. A copy of this was furnished by Lieutenant Parke to Captain Pope, then engaged in the construction of an artesian well near the Pecos, who had been previously instructed to make the requisite borings west of the Rio Grande, upon the successful completion of the first duty assigned him.

By the construction, at no great cost, of a series of eight common wells between the Rio Grande and the San Pedro, and a series of four or six across the plain known as the Colorado Desert, and the expenditure of a few thousand dollars in making the route along the San Pedro and the Gila, to the Pimas villages, practicable for wagons, an excellent emigrant and mail route for coaches will be had, and great suffering be saved to those crossing the continent in this latitude. This route will be much shortened, and its value still further increased, by constructing a series of artesian wells, not exceeding five in number, across the Llano Estacado. The party of Lieutenant Parke is now engaged in the reduction of the field-work and preparation of the reports, maps, &c.

The duty assigned to the second party organized under the direction of Brevet Captain John Pope, topographical engineers, by the instructions of the Department of January 5, 1855, was that of testing the practicability of procuring water by artesian wells on the arid plains of the interior.

The point selected for the first trial was upon the Llano Estacado, near latitude 32°, about fourteen miles east of the Pecos, at the mouth of Delaware creek, where water for the use of the party could be conveniently obtained from the river. The party arrived at this point in the latter part of May, and commenced the operation of boring. At the depth of three hundred and sixty feet water was reached, which rose immediately seventy feet in the well, and remained at that height—the level of Delaware spring. It was found that the various strata of sandstone passed through in boring did not possess the degree of hardness reported by Mr. Marcou, the geologist, who examined the geological collection made by Captain Pope when crossing the Llano the preceding year; and in consequence, after some delays from the caving in of the sides of the well, it was found necessary to line it with tubing throughout. From the reported character of the formation, five hundred feet of tubing was considered sufficient for all the experiments the party was directed to make, less than half of which would be required for the well of the Llano Estacado; but the unexpected softness of the strata made it necessary to use all the tubing in the first five hundred feet. About the middle of September, at the depth of six hundred and forty feet, a second supply of water, pressed up through sandstone, was attained, which rose three hundred and ninety feet in a few minutes, and was still rapidly rising, when the caving in of the marly clay below the tubing filled in the well to the height of seventy feet, and effectually cut off the communication of the subterranean reservoir or stream with the surface. An attempt was made to remove this accumulation with the mud pumps, but, after a continuous labor of twelve days and nights without making any impression upon it, the attempt was discontinued, as without additional pipe the well could not be finished; and, in the opinion of Captain Pope, the practicability of constructing artesian wells on the Llano Estacado had been fully established. The party then proceeded to the execution of the second duty assigned to it.

This result having been reported to the Department, by your directions, measures were taken to supply additional tubing to Captain Pope, who has been instructed to resume the work on the Llano.

In the opinion of the officer charged with the operation they had, at the depth of six hundred and forty feet, closely approached coal measures, and he was convinced that a clear stream or reservoir would have been found twenty feet lower. From his report and accompanying diagram it appears that, at five hundred and seventy feet, a stratum of dark blue shale of the coal measures was pierced. It is highly probable that the water, which appeared at the depth of six hundred and forty feet, pressed up through the lower portion of the stratum of sandstone which they had been boring through for the last sixty feet, would have risen to the surface in large quantities. As the first supply of water rose to within two hundred and ninety feet of the surface, it might reasonably be concluded that, if another supply were attained three hundred feet below the source of the first supply, it would rise to the surface; the bottom of the boring was within twenty feet of this point when the second supply was pressed up through sandstone. The level attained by the first supply of water was that of Delaware spring. At Independence spring, which is west of Delaware spring, and six hundred feet above it, the upper carboniferous formation of the Guadalupe mountains begins. If the strata of sandstones, indurated clays and marls, found between these two springs, should extend under the Llano Estacado, parallel to each other and of equal thickness, it was probable that, at a depth of six hundred feet below the point at which the first supply of water was reached, (coming from the same level as Delaware spring,) the second supply would be had coming from the upper carboniferous strata and the level of Independence spring; but as the blue shale of the coal measures was reached at one-half this depth, it would appear that the strata are about three hundred feet apart at the point where the boring was made, instead of six hundred feet, as they are between Delaware and Independence springs. These conclusions are dependent upon the fact reported by Captain Pope, that the dip of the strata is very slight, being nearly coincident with the slope of the surface of the ground. Both supplies of water in the well were clear, pure, and palatable, free from any impurities appreciable by the tests at the command of the geologist, Dr. Shumard. An important result of this boring is the probable existence of coal in the carboniferous formation which appears upon the surface at the foot of the Guadalupe mountains.

The instructions of the Department required Captain Pope, after the successful completion of the well on the Llano Estacado, or the demonstration of its impracticability, to make borings at certain points west of the Rio Grande on the route to be examined by Lieutenant Parke's party, in order to determine the practicability of artesian wells there, and the depths at which water can be had (by ordinary wells) at the dryest season, and the thickness of the water-bearing strata. By the time this duty is completed, it is probable that he will have received the additional tubing necessary to the successful completion of the artesian well on the Llano Estacado, and will then be enabled to resume that work.

The importance of obtaining large supplies of water on the interior plains and basins, by the construction of artesian wells at moderate cost, is too apparent to need exposition.

The greater part of the rain and other precipitation in those arid regions falls upon the mountains, and percolating through the loose debris on their flanks, descends below the surface of the plains, appearing again, sometimes at great distances, in springs and streams—the sources of rivers.

On the plains and table lands of Asia, which so closely resemble those of North America that a description of one may be taken for the other, water for irrigation, where no streams are found, is obtained by a series of wells connected by subterranean conduits. This laborious process is extensively used, and converts waste barren land into productive fields.

If to a demonstration of the practicability of constructing artesian wells at moderate cost on the interior plains and table-lands be joined the discovery of coal beds, fertility, industry, and wealth may be made to take the place of sterility and solitude over extensive areas of those arid, naked, and treeless districts.

A third party, under the command of Lieutenant R. S. Williamson, topographical engineers, was organized, under instructions from the department of May 1, 1855, to explore, first, the region between the Sacramento and Columbia rivers, to ascertain the practicability of connecting them by railroad; second, to make examinations and surveys near the sources of Carson river, to ascertain the practicability of crossing the Sierra Nevada in that vicinity by railroad, provided the information obtained from the troops and others who had recently crossed the mountains by that route should indicate the probable existence there of a railroad route. By a report of this officer of the 19th of October, the first duty has been successfully executed.

In addition to the immediate practical value of these explorations in ascertaining the best routes suitable for rail and common roads; their importance from military considerations; their usefulness in making known shorter and better routes of travel to emigrants by which much suffering and loss is avoided; their value in indicating additional sources of national wealth and strength; in substituting exact knowledge for vague surmise and the entirely unknown; the large amount of valuable information collected by them respecting the physical features and condition of our country in topography, geography, and geology, meteorology, botany and zoology, render it highly desirable to continue them.

Many portions of the interior are entirely unknown; and for continuing their exploration during the following year an appropriation of one hundred and fifty thousand dollars could be well expended.

Very respectfully, your obedient servant.

A. A. HUMPHREYS,
Captain Top. Engineers in charge

Hon. JEFFERSON DAVIS,
Secretary of War.

No. 3.

EXTRACT FROM THE ANNUAL REPORT OF THE SECRETARY OF WAR, DECEMBER, 1856.

A report is herewith submitted from the office of this Department connected with the explorations made to ascertain the most practicable route for a railroad to the Pacific, to which I refer for a detailed account of the duties performed in that relation during the past year.

My last annual report contained a brief reference to the principal results of the explorations and surveys made during that year in connexion with the routes near the 35th and 32d parallels, and between the Gila and Rio Grande. The report of the officer charged with these duties shows the proposed railroad line between the bay of San Francisco and the plain of Los Angeles to be an eminently practicable route. It occupies the valley of the San José and Salinas rivers; crosses the Santa Lucia mountains near San Luis Obispo; traverses the rolling country adjacent to the coast as far as Tres Alamos river, and thence, to the mouth of the Gaviote creek, passes either along the valley of Santa Inez river and the Gaviote pass, or follows the coast, turning Point Concepcion; from the mouth of Gaviote creek it follows the shore line to San Buenaventura, and crosses the Santa Clara plain, the Semi pass, and San Fernando plain to Los Angeles.

The distance from San José, near the bay of San Francisco, to Los Angeles, by the shortest line, is 396 miles. Two tunnels are proposed, each three-fourths of a mile in length, one on the San Luis pass, through the Santa Lucia mountains, and the other in the Semi pass. The estimated cost of this route, including equipment, is $20,823,750, or about $52,600 per mile.

A favorable pass, leading from the valley of the Salinas river to the Tulare valley, was discovered by this party, forming a good connexion with the bay of San Francisco for the route of the 35th parallel.

The results of the survey, it was formerly stated, have greatly improved the aspect of the first route surveyed between the Pimas villages, on the Gila, and the Rio Grande, by changing the line for nearly half the distance from barren ground to cultivable valleys, and entirely avoiding a *jornada* of eighty miles which occurs in that section. The route now follows the valleys of the Gila and the San Pedro rivers to the mouth of the Aravaypa, a tributary of the San Pedro, discovered by this party; continues up that stream to its source; crosses between Mount Graham and Chiricahui mountains by a very favorable pass; proceeds in a direct course through the Peloncillo mountains, and joins the former line in the vicinity of Colonel Cooke's emigrant road. From this point to the Rio Grande the route lies in the lowest line of the depression which characterizes the plateau of the Sierra Madre in this latitude, the mean elevation of which is about 4,400 feet above the level of the sea, the summit being 4,600 feet above that level.

The maximum grade upon this route is 64.4 feet per mile. The route for two-thirds of the distance is represented as being most favorable for a railroad; the remaining one-third being nearly equally divided between ground of a rolling and mountainous character.

The examinations of this party, in reference to the practicability of procuring water, show that it may be obtained at suitable distances by common wells and conduits, supplied from permanent streams. In some localities artesian wells might probably be resorted to successfully.

The estimated cost of the whole distance, 345 miles, is $15,300,000, or about $44,000 per mile. The estimate, based upon a thorough re-examination of the ground, and a close study of the subject by the officers in charge of the survey, coincides very nearly with that made by the officer who presented the general revisory report upon the first explorations.

It is deemed proper to call especial attention to this coincidence, so strongly exhibiting the general reliability of these estimates, because a minority report made at the last session of Congress, from a committee of the House of Representatives, characterized the estimates, based on the reconnaissances of the topographical engineers, as unreliable, and adduced to sustain that disparaging reflection, the fact that on one of the lines explored, the preliminary estimate of the officer in charge greatly exceeded that which he presented after a further study of his observations in the field; this, too, being in disregard of the fact that the first estimate was hastily made by the explorer to meet a pressing demand for his report, and was at the time stated by him to have been prepared in anticipation of the future examination of the data he had collected. In the remarks of the revising officer which accompanied the reports it was also pointed out that this estimate was probably largely in excess.

Although the two lines between the Gila and Rio Grande, of which the estimated cost is so nearly alike, are over different routes, the features of the ground, so far as they would affect the cost of construction of a railroad, are nearly identical; the advantages of the new line depending upon other considerations already enumerated.

Similar remarks may be applied to the estimated cost of the two routes between the plains of Los Angeles and San Francisco, though the coincidence there is not so close, the character of the ground being such as would cause a difference of expense in the road bed formation.

In addition to his own results, the officer in command of this party has presented those of an instrumental survey from San Diego bay, through Warner's pass, to the Colorado desert, made under the auspices of the San Diego and Gila Railroad Company.

The engineer of this company estimates the cost of a railroad on this route from San Diego to Fort Yuma, distance 189.1 miles, at $7,571,500; one half of this distance being estimated at $14,615 per mile, and the other half at $65,085 per mile. These estimates are much less than those contained in the reports of the officers of this Department for routes passing over similar ground. Either standard of cost per mile applied to the routes from Fort Yuma to San Diego and from Fort Yuma to San Pedro, through the San Gorgonio pass, gives about the same total amount of cost for each route. The line to San Diego forms the shortest route to the Pacific, the distances being, from Fulton to San Diego, 1,548 miles; from Fulton to San Pedro, 1,618 miles. If the final terminus of a Pacific railroad is to be San Francisco, the route through the San Gorgonio pass to San Pedro is preferable to that to San Diego, since the former port is about 100 miles nearer to San Francisco.

The party directed to explore the country between the Sacramento and Columbia rivers, with a view to ascertain the practicability of connecting these valleys by a railroad, examined two routes—one east, the other west of the Cascade range.

The former accomplishes the passage of the western chain of the Sierra Nevada by following

Pit river. The route then traverses a sterile plateau, elevated from four to five thousand feet above the sea, to the head of the Des Chutes river. Serious obstacles to the construction of a railroad are encountered at the cañons of Pit river, and near upper Klamath lake. Wood and water are sufficiently abundant. The deep cañons in which the Des Chutes river and its tributaries flow render it impracticable for a railroad to follow its valley to the Columbia river. A practicable, although difficult, pass was examined through the Cascade range near Diamond Peak, by which the road can reach the Willamette valley; the route through which to the Columbia is very favorable to the construction of a railroad. The route west of the Cascade range is through the Willamette, Umpqua, Rogue River, and Shasta valleys. It proved to be more favorable than had been anticipated; and had not the smallness of the party and its inability to obtain an escort during the existence of Indian hostilities prevented lateral reconnaissances, it appears probable that a practicable line to Fort Reading would have been found, traversing for nearly the whole distance a fertile and inhabited region.

Between the Columbia river and Fort Lane in Rogue River valley, the Calapooya mountains, Umpqua mountains, and the Grave Creek hills are the chief obstacles to the construction of a railroad. An excellent pass through the first, and a difficult, but practicable, pass through the second, were surveyed. The Grave Creek hills, it is thought, can be turned.

Information respecting a pass from Rogue River valley to the plateau east of the Cascade mountains makes it probable that an easy connexion with the first route examined may be made, and this will be especially important should the obstacles encountered between Fort Lane and Fort Reading be shown by further examination to be insurmountable.

The pass examined through the Siskiyou mountains, which separate Rogue River and Shasta valleys, was very unfavorable to the construction of a railroad.

From Shasta valley to Fort Reading the route over the Scott and Trinity mountains is reported utterly impracticable. A feasible location between these places might be obtained by following the Sacramento valley.

The route east of the Cascade range may be considered practicable. The total distance by it from Benicia to Vancouver is about 800 miles, of which only 350 miles are in a fertile and settled region. The construction for about 250 miles would be very difficult and costly; for the remainder of the distance the work would be light.

The principal advantage of a route west of the Cascade Range would consist in its traversing a fertile and inhabited country. By the line surveyed the total distance from Benicia to Vancouver is 680 miles, of which 500 would be easy of construction, 100 difficult and costly, and 80 so difficult and expensive as to be considered impracticable.

Additional experiments have been made during the past year by the party previously engaged in testing the practicability of procuring water by means of artesian wells upon the Llano Estacado, and upon the table lands west of the Rio Grande. In the latter region the trial has not been prosecuted sufficiently far to admit of satisfactory conclusions. The work upon the Llano, which had been suspended until additional tubing could be procured, was resumed, and a well has been sunk to the depth of 861 feet. At the depths of 245 and 676 feet seams of pure and palatable water were laid open; the first rising in the well twenty-five feet, and the second to within 110 feet of the surface. As no water rose above this point it has not yet been practically demonstrated that, in this region, there are subterranean streams which can be made to flow upon the surface; but nothing has been developed to change the opinion, heretofore expressed, that the experiment will be attended with success, if prosecuted to the depth then contemplated by the Department.

More detailed information regarding the late operations will be found in the report from the office connected with these explorations.

The well has been left in such condition that the boring may be continued from the point where it ceased, should future appropriations admit the resumption of the work.

The important results that may attend the solution of this question, not only in connexion with the construction of a railroad, but also in the development of the resources which the country may contain, have been already noticed in previous reports from this Department.

The topographical surveys carried on in connexion with this work have improved the location of that portion of the railroad route near the thirty-second parallel east of the Rio Grande.

No. 4.

REPORT

UPON THE

PROGRESS OF THE PACIFIC RAILROAD EXPLORATIONS AND SURVEYS.

NOVEMBER, 1856.

BY CAPTAIN A. A. HUMPHREYS, UNITED STATES TOPOGRAPHICAL ENGINEERS.

War Department,
Office Pacific Railroad Explorations and Surveys,
Washington, November 29, 1856.

Sir: At the date of my last report, November 29, 1855, the party of Lieutenant John G. Parke, topographical engineers, had just returned to Washington from the field. Since then it has been occupied in preparing the reports and maps of the survey, which are now nearly completed.

By instructions from the department, of October 2, 1854, Lieutenant Parke was directed to make explorations to determine the practicability of constructing a railroad from the waters of the bay of San Francisco to the plain of Los Angeles, by the Salinas river valley, and through the spurs of the Coast range, which extend to the seacoast, near Point Concepcion; or, if that was found to be impracticable, by the coast route; to make certain explorations in the Great Basin, in connexion with the route of the 35th parallel, and to explore the country between the Pimas villages on the Gila and the Rio Grande; the attention of the party being particularly directed to such examinations in the latter region as would show the degree of practicability of constructing artesian and common wells.

The survey was commenced at San José, California. The route lay through the Santa Clara, or San José valley, to the Pajaro river; down the valley of this stream to near its debouche into the bay of Monterey; around the foot hills of the Gavilan range of mountains to the Salinas plains and the valley of the Salinas river, and up the Salinas river to Santa Margarita, at the base of the San Luis pass.

Thus far, no material obstacles were presented to the construction of a railroad; the Santa Clara valley and Salinas plains affording a peculiarly favorable location for it. A bridge across the Pajaro and some light earth work at the terminal spurs of Mount Gavilan, and in the valley of the Salinas, between the mouth of the San Lorenzo and Santa Margarita, constitute the heaviest portion of the work for this distance of one hundred and seventy-seven miles. The maximum grade required will be seventy feet per mile, for two miles.

A month was devoted to a thorough examination of the headwaters of the Salinas river. Reconnoitring parties were sent forward to examine the main stream and its largest tributary, the Estrella and the Cuyama plain, or valley of the Rio de Santa Maria, beyond, while a detailed survey of the San Luis pass was being made. The explorations about the heads of the Salinas and the Cuyama plain prove that a line through this country would be impracticable. An extensive basin was discovered—the Llano Estero—a tributary to the Tulare valley, which affords a very favorable pass from that valley to the bays of Monterey and San Francisco; the elevation of the summit being about 1,800 feet above the sea. The approach from the Tulare valley is over a plain for about forty miles. The distance from this pass to Kern lake is sixty-five miles.

The elevation of the lake above the sea, according to Lieutenant Williamson, is three hundred and ninety-eight feet. It is believed that a grade of sixty feet per mile will accomplish the descent from the summit, westward, to the Estrella. The average grade of Estrella creek to its mouth at San Miguel is about twenty feet per mile.

The route was continued across the Santa Lucia mountains, through the San Luis pass, to the seashore. A detailed survey of this pass was made. It is a sharp divide, composed of slightly metamorphosed sandstone and serpentine rock. The elevation of the summit was found to be 1,556 feet above the sea. It is proposed to tunnel this pass for three-fourths of a mile, commencing at a point about 200 feet below the summit. The maximum ascending grade would be 80 feet per mile. The San Luis creek heads on the seaward side of this pass, and descends rapidly to the plain through a wide valley, flanked on either side by rib-like spurs from the mountain. The descent of the stream is too great to admit the location of the road through or near San Luis Obispo; but, four and a half miles below its source, there is a lateral ravine, from the summit of which the line may be carried along the slopes of the mountains to the small divide between Corral de Piédras creek and Arroyo Grande, a stream running to the Pacific, whose slope, from the point where it is reached, admits of railroad location as far as its mouth. From the summit of the San Luis pass to the ocean, a grade of 100 feet per mile would be required for fourteen miles. This section constitutes the boldest feature of the route between San Francisco and Los Angeles. Lieutenant Parke is of opinion that for temporary purposes this pass can be surmounted without a tunnel, by resorting to a system of short curves and heavy grades—the greatest 200 feet per mile—similar to that adopted in the location of the Virginia Central Railroad across the Blue Ridge at Rockfish Gap, where the maximum grade is 275 feet per mile. The examinations in the vicinity of San Luis Obispo having been completed, the region lying between the ocean, the plains of Los Angeles, the western edge of the Great Basin, and the heads of the Tulare and Salinas valleys was thoroughly explored. The line adopted as most favorable commences at the Arroyo Grande; traverses the Guadalupe Largo; ascends the Todos Santos summit; descends to the Rio de Tres Alamos; crosses the spur between Rio de Tres Alamos and the Santa Inez river; passes to the summit of the Gaviote pass at Santa Cruz—elevation, 700 feet—and, through the lower portion of the Gaviote pass and creek, to the coast. The maximum grade upon this line is 100 feet per mile, for $5\frac{1}{2}$ miles, through the Gaviote cañon. From the summit of the Gaviote pass (at Santa Cruz) to the ocean, the location will be bold; requiring heavy work in earth and rock (sandstone) to keep up the grade. A lofty structure will be required across the Gaviote creek, and a heavy cut through a salient point at its mouth. The route around Points Purissima, Arguello, and Concepcion is 14 miles longer. It lies wholly on the terraced shore, and at no point is over 100 feet above the sea.

From Gaviote creek to San Buenaventura (60 miles) the character of the location will be the same as that of the route around Point Concepcion, being near the shore and on the terraces.

The most favorable route from San Buenaventura, or the Santa Clara river, follows the Semi plain and pass to the San Fernando plain. The Semi pass divides the San Fernando plain from the Santa Clara plain. A tunnel is proposed here, which will not exceed three-fourths of a mile in length, and, upon closer survey, may be materially shortened. The rock is sandstone of easy cleavage. The summit of this pass is 1,577 feet above the sea; the summit of the grade, 976 feet above that level. The ascending and descending grades are light. The San Fernando and Los Angeles plains are separated by a narrow valley. The route from San José, on the waters of the bay of San Francisco, to near Los Angeles, is divided into nine parts. The length of each division, the maximum grade, and approximate cost are presented by Lieutenant Parke, as follows:

Division.	Length.	Maximum grades, &c.	Cost per mile.	Total cost.
	Miles.			
1	39.25	18 feet per mile.	$30,000 00	$1,177,500 00
2	20.75	11 feet per mile.	55,000 00	1,141,250 00
3	45.50	6½ feet per mile.	30,000 00	1,365,000 00
4	71.50	70 feet per mile.	50,000 00	3,575,000 00
5	24.50	100 feet per mile.	117,142 00	2,870,000 00
6	32.50	63.2 feet per mile.	30,000 00	975,000 00
7	33.50	100 feet per mile.	80,000 00	*2,680,000 00
8	58.50	60 feet per mile.	60,000 00	3,510,000 00
9	70.00	63 feet per mile.	30,000 00	2,100,000 00
Total	396.00	Average cost per mile	49,163 00	19,468,750 00

* For the line via Point Concepcion, 13¾ miles longer, the maximum grade is 60 feet per mile; the average cost per mile $60,000. This makes the cost of the entire division $2,835,000, which exceeds the above $155,000 and increases the total cost to $19,623,750

The above estimates are exclusive of equipment. If we take a proportional amount for this distance of 400 miles of the entire amount estimated for the 32d parallel route, for first equipment, we shall have about $1,200,000 to add to the above, giving $20,823,750.

The examinations of the coast route having been completed, the Mojave river and basin were explored and found to have no connexion with the Colorado river and basin.

Proceeding to the Pimas villages, the initial point of the last reconnaissance, a division of the party was made; one half proceeding, via Tuscon, San Xavier, and the Cienega de los Pimas, to the river San Pedro, and the other up the Gila and San Pedro valleys. In his report of 1854, Lieutenant Parke suggested the probability of finding a feasible route from the Valle del Sauz to the Gila valley by passing between the Chiricahui mountains and Mount Graham, and continuing thence in a northwesterly direction, along the western base of Mount Graham to the Gila. His views in this respect were fully confirmed by the examinations of the division of the party retained under his own command. Following the Gila river to the mouth of the

San Pedro, a favorable route was found for nearly the entire distance. The valley of the San Pedro proved to be wide and open, presenting no impediment to a rail or wagon road. There was an abundance of water, grass, and excellent soil, but no growth suitable for timber, though sufficient for fuel. Twelve miles from the mouth a large tributary was encountered, coming in from the east, and a party was organized for its examination. This party, descending the San Pedro for 35 miles from the Quercus cañon, crossed the mountains on the right bank to the plains west of Mount Graham, and, pursuing a northwesterly course for 36 miles, found the head of the "Aravaypa," as the newly discovered stream was called. The springs mentioned by Nugent, in his notes of Hay's trip, were found in the Playa de los Pimas, and a reconnaissance was made of Nugent's pass. The main detachment passed through the Puerto del Dado and the smaller through the wide pass,* between the Chiricahui mountains and Mount Graham; the two uniting on the Rio Sauz, about 15 miles below the Cienega. Examinations made eastward, across the Peloncillo (Sugar Loaf) mountains, resulted in the discovery of an excellent pass for a railroad in a more direct line than that of the route of 1854. From this range of mountains an easterly course was pursued, and connexion made with the former survey about 15 miles west of the point where Colonel Cooke's emigrant road diverges to the southwest.

The route between the Rio Grande and the Pimas villages may be divided into three parts—from the Rio Grande to the Valle del Sauz; from the Valle del Sauz to the mouth of the San Pedro; and from the mouth of the San Pedro to the Maricopa wells.

First division. *From the Rio Grande to the Valle del Sauz.*—From the Rio Grande the line ascends the mesa on the right bank by a grade of 60 feet per mile, and pursues a nearly direct westerly course, passing north of Sierra Florida, and 12 miles south of Cooke's spring, crossing the Mimbres bed 21 miles below the sink of the water, and passing through the lowest points of the great depression which characterizes the plateau of the Sierra Madre upon this route. The summit of the plateau is crossed near Cooke's emigrant road. The line then proceeds due west to the Sauz valley, through a pass in the Peloncillo range, (Sugar Loaf,) about 4 miles south of the Sugar Loak Peak. The maximum grade upon this division is 64.4 feet per mile. The mean elevation of the plateau is about 4,400 feet above the sea. The summits of the Florida pass, of the Sierra Madre, and of the Peloncillo pass, are, respectively, 4,600, 4,600, and 4,481 feet above the sea. The maximum grade (64.4 feet) is from the Peloncillo summit to the Sauz valley.

Second Division. *From El Sauz to the mouth of the San Pedro.*—From the Sauz the line is projected through the Railroad pass—the wide opening between the Chiricahui and Pinaleño (Mount Graham) ranges—thence, northwesterly, along the Pinaleño plain to the Aravaypa valley; down this valley to the San Pedro and to the Gila. The summit of the Railroad pass is 4,600 feet above the sea—582 feet lower than the Puerto del Dado—and is without doubt several hundred feet lower than any other pass through this range of mountains, south of the Gila. The Pinaleño plain has a mean elevation of about 4,400 feet. The descent of the Aravaypa to the cañon through the Calitro mountains is about 40 feet per mile, for 31 miles; the grade through the cañon and the San Pedro is 60.3 feet per mile, and thence to the Gila 14.4 feet per mile.

Third Division. *From the mouth of the San Pedro to the Maricopa wells.*—This division passes along the valley of the Gila, and presents a favorable location, except at about four points where salient spurs obstruct the stream. These are thin, and can be easily removed by

* Railroad pass.

blasting. The maximum grade on this division is 15 feet per mile, and it may possibly be increased to 20 feet per mile, in a final location, for a short distance. The distance from the Rio Grande at Fort Fillmore to the Maricopa wells is 345.25 miles; being about 23 miles shorter than the line by the former survey. The highest elevation attained is 4,600 feet.

For the purpose of comparing this route with others, and to form an approximate estimate of its cost by an assimilation to roads already built, Lieutenant Parke has divided the country through which it passes into three characteristic portions, viz: prairie, rolling or hilly, and mountainous. The prairie section comprises that portion which will require but little more work than the adjustment of the sills for the reception of the rails; the hilly or rolling, that portion which will require light earth work and little or no rock cutting; and the mountainous, the bolder features of the line, where side locations and heavy earth and rock work will be necessary. The respective lengths of these divisions are:

Of prairie	230 miles.
Of rolling	65 "
Of mountainous	50 "
Total	345 miles.

The longest line of continuous prairie route is 130 miles, and the shortest 25 miles.

The longest line of rolling route is 30 miles, and the shortest 5 miles.

The longest line of mountainous route is 25 miles, and the shortest 5 miles.

The estimates for the final report are not yet completed. According to these estimates, so far as they have been made, the cost of the three sections will not exceed $30,000, $60,000, and $90,000 per mile, respectively, including equipment; making a total of $15,300,000, or an average cost per mile of the whole line of $44,000.

With reference to the supply of water between the Rio Grande and the Gila, Lieutenant Parke is of opinion that an abundance can be delivered on the line, at suitable distances, by conduits from the following localities: Cooke's spring, Rio Mimbres, Ojo de la Vaca, Agua Fria, Ojo de Inez, Cienega de Sauz, Croton springs, at the Playa de los Pimas, Antelope, Dove, and Castro springs, and Bear springs, at the head of the Aravaypa. The above localities are permanent watering-places, and have never been known to fail, notwithstanding the drains upon them by evaporation, by large herds of stock *en route* for the Pacific coast, and the frequent visits of the wandering Apaches. It is well known that while little rain is delivered upon the plains and valleys during the rainy season, the clouds are nearly always hovering over the mountains, dispensing copious showers, furnishing abundant supplies to the springs and streams enumerated. The longest distance between the points which can be supplied with certainty from permanent water is fifty-one miles. This occurs between Ojo de Inez and Cienega de Sauz; but there are two points in the Pyramid basin—one east and one west of the Pyramid range—where there is every reason to conclude that ample supplies of water can be procured by common or artesian wells. The distances between the water stations proposed along the line are as follows:

From Rio Grande to station 1, 31 miles.
From station 1 to station 2, 19 "
" " 2 " 3, 15 "
" " 3 " 4, 22 "

From	station	4	to station	5, 17	miles.
"	"	5	"	6, 10	"
"	"	6	"	7, 20	"
"	"	7	"	8, 21	"
"	"	8	"	9, 28	"
"	"	9	"	10, 29	"

The supply of timber along this route is scanty. Cedar and pine are found in the Copper-mine mountains and near the sources of the Mimbres. The valleys of the Santa Cruz and the Gila contain dense groves of mezquite, which, particularly in the former locality, will furnish a large number of excellent cross-ties. Cotton-wood in limited quantities is found in nearly all the valleys where water-courses exist. There is not timber enough along the line, within fifty miles each way, to supply its demands.

The improvements in the former route made by this survey may be stated in brief to be: a more direct railroad line between the Pimas villages and the Rio Grande, with lighter grades, fewer summits, less elevation, greater supply of water, avoidance of a long jornada, and the introduction of cultivable valleys. It is probable, from the form and geological structure of the basins and plains, that ordinary wells may be made to furnish abundant supplies of water at distances not too great for the economical working of passenger trains. It has been indicated that in some localities artesian wells may be resorted to if needed.

As a post-route, Lieutenant Parke is of opinion that the route of the thirty-second parallel presents many advantages. By the construction of water stations at suitable distances, and by providing relays at various points, the mails could be transmitted from the Mississippi to San Diego in less than thirty days.

In addition to the results of his own examinations near the thirty-second parallel, Lieutenant Parke presents those of a detailed instrumental survey from the bay of San Diego, through Warner's pass, to the Colorado desert, made by Charles Poole, Esq., civil engineer, under the direction of the San Diego and Gila Railroad Company, organized under the authority of the legislature of California. Beginning at San Diego, this line ascends the San Diego river to San Isabel; passes through the valley of San Isabel and San José to Warner's pass and to the Indian villages of San Felipe, and from this point, through a cañon, to the desert. The maximum grade—107 feet per mile—is at the approach to the San Isabel summit. The grades to the summit of Warner's pass are 102 and 106 feet per mile. The distance from San Diego to Fort Yuma is 189.1 miles. The whole line is divided into two portions, the prairie and mountainous. Assuming in his estimate that the two are equal in length—stating, however, that "the cheaper is largely in excess"—Mr. Poole says: "we have ten miles at the western, and eighty-five at the eastern section, to be estimated at the lower rate."

The probable average cost of a single mile of the cheaper portion, to put the road in running order, including equipment, he estimates to be	$14,615 00
And for ninety-five miles	1,388,425 00
And for the more expensive portion, the cost per mile	65,085 00
Which for ninety-five miles is	6,183,075 00
Making a total of	7,571.500 00

These estimates of cost per mile are very much less than those for similar ground in the report of Lieutenant Parke, and in other War Department reports.

Either standard applied to the two routes—the route to San Diego by Warner's pass, and that to San Pedro by the San Gorgonio pass—will give about the same total cost for each. If the object is to reach the bay of San Francisco, the route through the San Gorgonio pass is preferable, since, after reaching San Diego through Warner's pass, at a cost equal to that of the route through the San Gorgonio pass to San Pedro, there would remain the distance between San Diego and San Pedro—nearly 100 miles—over which it would be necessary to build the road.

In obedience to instructions from the War Department, dated May 1, 1855, a party was organized by Lieutenant R. S. Williamson, corps of Topographical Engineers, to examine the country lying between the Sacramento and Columbia rivers, with a view to ascertain the practicability of connecting their valleys by a railroad.

The first 200 miles of the route—from Benicia to Fort Reading, in the Sacramento valley—pass through a settled country. The average grade would not exceed five feet, and bridges would form the only expensive item in the construction of a railroad. Timber and water are abundant.

From Fort Reading, two routes to the Columbia river were examined—one east of the Cascade range, and the other between it and the Coast range. The former crosses the western branch of the Sierra Nevada by Noble's pass—a difficult location for a railroad, as there is an ascent, in a distance of 40 miles, of about 6,000 feet. A better line for crossing this range can be had by ascending Pit river along the route surveyed by Lieutenant Beckwith. A careful examination of the two cañons of this river developed results less favorable than those obtained by Lieutenant Beckwith, but nevertheless demonstrated the practicability of constructing a railroad near them.

The route beyond the upper cañon of this river lies for about 250 miles over a plateau—mostly sterile, though well supplied with water—elevated between 4,000 and 5,000 feet above the sea. This plateau extends from the western chain of the Sierra Nevada, northward, beyond the Columbia, gradually declining towards that river from the head of the Des Chutes valley.

Where timber is wanting in the immediate vicinity of the route, which rarely occurs, the mountains bordering it on the west will furnish an abundant supply.

For nearly the whole distance the average grade will be less than 25 feet, though in a few instances it rises to 100 feet, per mile. Difficult work will be found near Upper Klamath lake, and between it and Klamath marsh, where some heavy cutting and filling will be requisite. At the latter place it will be necessary to follow the cañon of Klamath river for about six miles. Near the head of the Des Chutes valley the party divided. Lieutenant Williamson, after a careful examination of the Cascade range in this vicinity, crossed it near Diamond Peak by a pass through which a wagon road has been made. Both the ascending and descending grades were found to be very abrupt. By the road, the ascending grades were for 2.5 miles 231 feet; for 4.7 miles 72 feet, and for 2 miles 42 feet per mile. The descending grades were for 5 miles 23 feet; for 3.7 miles 512 feet, and for 2.5 miles 311 feet per mile. Below this point they were all less than 125 feet per mile, and they continued to diminish rapidly. The above grades might be reduced by a side location to an ascending grade of 150 feet per mile for 7 miles, and a descending grade of 180 feet per mile for 16 miles, and perhaps even still further. There will be great difficulty in cutting through the dense forest. The summit of the pass is 5,600 feet above the sea.

After crossing the Cascade mountains, the Willamette valley was followed for 150 miles to the Columbia river, the route being favorable and the grades light. The total distance from Benicia to Fort Vancouver by this route is 760 miles.

Lieutenant Abbot, corps of Topographical Engineers, examined the Des Chutes valley to the Columbia river. The impracticability of constructing a railroad across or along the deep cañons cut in the plateau by that river and its western tributaries was fully demonstrated. Proceeding to Vancouver, the Cascade mountains were crossed a short distance south of Mount Hood, through a pass discovered by the party, which is practicable for a railroad, though probably inaccessible on the eastern side. Through this pass an ascending grade of 100 feet per mile would be required for 14 miles, and a descending grade of 123 feet per mile for 30 miles. The summit is 4,500 feet above the sea. For about 55 miles the construction would be difficult and expensive. The pass is a good one for a wagon road.

Lieutenant Williamson was compelled by the lateness of the season to return by water to San Francisco to prepare for a second survey in the Sierra Nevada, near the head of Carson river. Orders were left for Lieutenant Abbot to survey the route to Fort Reading lying between the Cascade and Coast ranges. After Lieutenant Williamson's departure, hostilities were commenced by the Indian tribes on this route, which rendered an escort for the small topographical party absolutely necessary. The exigencies of the public service in that region were such, however, as, in the opinion of the commanding officer at Fort Vancouver, to require him to attach the escort that had accompanied the party from California to his command, and it was therefore necessary either to abandon the duty or pass without an escort through a hostile Indian country. The latter course was adopted, and, although the absence of the escort rendered it impossible to make side explorations, the result of the survey proved the route to be more favorable than was anticipated. With the means to make side explorations, it is thought that a route might have been found through this fertile and settled country better adapted to a railroad than the line traversing the sterile region east of the Cascade range.

Through the Calapooya mountains, which separate the Willamette from the Umpqua valley, an excellent pass was found; giving, without difficult or expensive construction, an ascending grade of 31 feet per mile for 2 miles, and a descending grade of 66 feet per mile for 5 miles. The summit is 900 feet above the sea. In the Umpqua valley there are a few hills where the work would be difficult, but it is thought that these may be avoided and a good location obtained to the Umpqua cañon. This pass, a serious obstacle to the construction of a railroad, leads through the Umpqua mountains to Rogue river valley. Its summit is 2,000 feet above the sea. An ascending grade would be required of 207 feet per mile for 7 miles, with some heavy rock cutting, and a descending grade of 192 feet per mile for 2 miles. By side location the latter might be greatly reduced. It is possible that an examination of Cow creek cañon might have developed a more favorable route.

In Rogue river valley the Grave creek hills present the principal obstacle. By following Wolf creek to Rogue river they might probably be turned, but this examination could not be made. There is a pass from the valley to the great plateau east of the mountains, which, if as favorable as reported, would make a good connexion with the route surveyed by Lieutenant Williamson.

Through the Siskiyou mountains, which separate Rogue river and Shasta valleys, the construction of a railroad would be very difficult. The summit of the pass surveyed is 4,500 feet above the sea. An ascending grade of 130 feet per mile for ten miles, with a tunnel six miles long, and a descending grade of 106 feet per mile for 12 miles would be required. A better pass was reported, but again the want of an escort prevented the necessary examinations.

A recent survey made by a number of gentlemen from Shasta to determine the practicability of constructing a wagon road from Shasta valley to Fort Reading, by the valley of the Sacramento river, showed that project to be quite feasible. This route was not examined owing to the lateness of the season, there being no grass upon it at that time, and the animals being nearly broken down. The Trinity trail, which crosses Scott's mountains and Trinity mountains, was followed, and it proved utterly impracticable for a railroad.

By the return route the distance from Vancouver to Fort Reading is 470 miles.

Of the two routes surveyed from Benicia to the Columbia river, that east of the Cascade range may be considered practicable for a railroad. Three hundred and fifty miles of it lie through a fertile and settled region, where the construction would be easy. Two hundred miles are through an unsettled and barren country, but where no very heavy work would be required. The remainder of the route, which side locations would probably render 250 miles long, passes through a wilderness, and would require difficult and costly construction.

By the actually surveyed line west of the Cascade range, there are 500 miles where the construction would be easy, 100 miles that would be difficult and expensive, and 80 miles impracticable.

The field work terminated at Fort Reading, the season being too far advanced to admit of the intended exploration of the Sierra Nevada near the sources of Carson river.

Lieut. Williamson and party reached Washington in January, 1856, and have since been engaged in preparing the maps, drawings, and detailed reports of the survey. These are now in an advanced condition.

The party, under the direction of Captain John Pope, Topographical Engineers, organized by the instructions of the Department of January 5, 1855, to ascertain the practicability of constructing artesian wells upon the arid plains of Texas and New Mexico, has continued its labors during the past year. The region selected for the field of its first operations is described by Captain Pope as extending from the Rio Grande, east, to the headwaters of the Canadian, the Red river, the Brazos, and the Colorado, with their tributaries. It is included between the parallels of 30° and 36° N. latitude, and comprises an area of about 100,000 square miles. The river Pecos flows through it in a general S.S.E. direction, dividing it into two nearly equal parts. Three chains of mountains, generally parallel, averaging 3,000 feet above the plain and about fifty miles apart, lie to the west of the Pecos, the easterly range (called at the crossing of the 32d parallel the Guadalupe mountains) being fifty miles distant from that river. The strata of the valleys between these chains have been broken through by the upheaved mountains, and the ruptured edges lie along their sides at altitudes from 600 to 2,000 feet above the lowest lines of the basins between. From the notes accompanying the meteorological observations, it appears that the amount of precipitation for the year in rain and snow is from four to five times as great upon the mountains as it is upon the plains. Descending upon the summits, it is shed along the faces of the hard rock until it reaches the upturned edges of the broken and porous strata, through which it percolates. The water is thus intercepted from running over the country below, and forms reservoirs beneath the earth, which, if reached by boring at any point lower than the source, must rise and overflow the surface of the ground. The division of the region referred to lying east of the Pecos is a vast undulating prairie, called the Llano Estacado, or Staked Plain. It is a table land, about 3,500 feet above the level of the sea, with a dip towards the southeast. There is neither timber nor water upon its surface. It is subject to the same influences as the valleys above referred to, except that there is no mountain range at the east to correspond with the Guadalupe mountains, along the base of which the western edges of its strata outcrop.

The first point selected for boring was near the 32d parallel and about fifteen miles east of the Pecos. The party reached this position in the latter part of May, 1855, and the boring was commenced about the first of June. In three and a half months the well was sunk to a depth of 641 feet, through sandstone, marl, and clay. At a depth of 360 feet, pure and clear water was reached, which rose to within 290 feet of the surface of the ground. About 200 feet lower, water was again met with; and, at the lowest point attained, a third supply of water forced its way up through the sandstone in which the boring was being carried on. Here the rapid rising of the water so softened and undermined the beds of clay and marl that the well caved in, and it was found impossible to clear it. The details of these operations were given in my last annual report. It was mentioned in this report that the supply of tubing taken with the party, (500 feet,) which, from the character of the formation, had been deemed ample for all the trials to be made, had been found insufficient for this well, and that Captain Pope was obliged to suspend further boring upon the Staked Plain until he could receive additional tubing, and had in the meantime proceeded to the execution of the second duty assigned him—that of ascertaining the practicability of constructing artesian and other wells upon the route explored by Lieut. Parke between the Rio Grande and the Gila rivers.

The point selected for trial was ten miles distant from Fort Fillmore, on the plain west of the Rio Grande. The operations were begun here about the 1st November, and continued until the 15th February, at which time a depth of 293 feet had been bored through a porphyritic detrital deposit, slightly united by calcareous cement, with occasional beds of tenacious yellow and red clay. The boring, which was very difficult, had not passed through this formation when the party moved to the Pecos to meet the new supply of tubing, the arrival of which at that stream was expected to take place about the 1st of April. While the operation of boring was going on west of the Rio Grande, a reconnaissance was made to ascertain the practicability of boring artesian wells upon the Jornada del Muerto. The result, in the opinion of the geologist, made it probable that, to be successful, they must be carried to the depth of 1,500 feet, where the carboniferous strata would be found that outcrop on the mountains east and west of the jornada. From this opinion Captain Pope dissented, and gave reasons, connected with the thickness of the detrital deposits and the stratified rocks, composing in part these mountains, which induced him to think that it would not be necessary to carry the wells to more than half the depth assigned by the geologist.

The point west of the Rio Grande where the boring was made, lies in the continuation of the basin of the Jornada del Muerto; the thicknesses of the formations varying from those found in and near that jornada.

The party of Captain Pope arrived on the Pecos the second time about the last of March, 1856, and resumed the borings for an artesian well at a point five miles east of that where the work had been carried on the previous year. Commencing to bore on the 5th of April, the depth of 245 feet was reached by the 16th. Here water was encountered, which rose twenty-five feet in the well, and remained at the level to which the first water met with, on the preceding year, rose. The new supply of tubing was now needed, but it had not arrived. In my report to the Department of November 29, 1855, it was stated that, by your directions, measures had been taken to supply additional tubing to Captain Pope, in order that he might resume the work on the artesian well near the Pecos, in accordance with his instructions.

This tubing was prepared in Philadelphia, and, after being inspected by me, left there about the 20th January. It consisted of 1,200 feet of wrought iron tubes, three inches interior diameter, with a thickness a little exceeding $\frac{3}{16}$ of an inch, cut in lengths of nine feet, with screw joints. As a precaution, 400 feet of $1\frac{1}{4}$-inch wrought iron pipes, in lengths of nine feet, with screw joints, such as are used for boring rods, were sent with the tubing, as they would doubtless be of use for other purposes, if not wanted or not suitable for boring rods. The tubing and pipes reached New Orleans on the 5th February, and were shipped in the steamer for Indianola on the 7th of that month. Long delay occurred between Indianola and San Antonio, the roads being almost impassable, and the supply of tubes and pipes did not leave San Antonio until the 27th March, arriving at Captain Pope's camp on the Pecos on the 29th April. As before stated, on the 16th April the boring had been carried to the first water bearing stratum, 245 feet below the surface, beyond which it could not be sunk without the tubing. With the tubes a depth of 450 feet was soon attained, when the third piece of tube from the bottom gave way, spreading outside of and partly enveloping the piece below, and rendering it impracticable to continue the well further. As much of the tubing as could be got out was withdrawn, and the work again commenced at the surface on the 20th May. At the depth of 676 feet the lower stream, nearly approached the preceding year, was met with, the water rising to within 110 feet of the surface.

The supposition formed last year, upon piercing a stratum of dark blue shale, that the carboniferous strata of the Guadalupe mountains would be entered near this depth, proved to be unfounded. On the 20th July a depth of 809 feet was attained. The report upon the condition of the work at this date states that 1,200 feet of boring rods (wooden) had been taken originally with the party, but at that time they had been reduced by breakage, &c., to 860 feet. The hope was, however, expressed that, with the use of the ash tent poles of the party and command, (the country not affording supplies of suitable wood,) the depth of 1,000 feet would be attained by the close of August, if water was not sooner reached. This anticipation, however, was not realized. At the depth of 830 feet, the boring, after passing through strata of clays, marls, and soft sandstones, entered hard sandstone. On the 26th of August Captain Pope reported that the work had been brought to a close at the depth of 861 feet, as his boring rods had been exhausted and all the boring material in his possession consumed.

The tubing sunk during the boring was left in the well, which was so secured that the work may at any time be resumed. No new supply of water had been encountered below that met with at the depth of 676 feet.

It is to be regretted that the boring could not have been continued to the depth of about 1,000 feet, since there is great probability that a large supply of water, overflowing at the surface, would have been found at or near that depth, coming from the permeable carboniferous strata lying on the flank of the Guadalupe mountains. No information having reached this office of an anticipated deficiency of boring-rods or material other than tubing, no steps had been taken by me to supply them. Previous to the arrival of the tubing at the Pecos, some apprehension had been expressed that it would not admit of the use of the same drills that had been used for the first well; the diameter of the two sets of tubing proved, however, to be so nearly identical, that the drills for the first were adapted to the second without serious difficulty.

Geological and topographical surveys were made, in connexion with this work, on the lines traversed by Captain Pope's party. The route near the 32d parallel, between the Pecos and the Rio Grande, was re-surveyed, and the proposed railroad line modified and improved. The Guadalupe mountains were examined for 75 miles, from the southern high peak to the Lympia mountains, but no pass found so favorable as that now traversed by the road, (the Guadalupe pass.) A new examination of this pass has led Captain Pope to the conclusion that the maximum grade, in following it, may be reduced from 108 feet to less than 80 feet per mile. Water is to be found at intervals of less than two miles from this pass, nearly to Ojo del Cuerbo. Forests of pine line the summits of the range for 30 miles north of the pass, and are also found upon the adjacent mountain chains.

Between Ojo del Cuerbo and El Paso two new lines have been surveyed; the first passing the Waco mountains, with a maximum grade of 60 feet, and with a summit level 200 feet lower than that of the route pursued in 1854; the second line lengthening the route 10 miles, but reducing the maximum grade to 40 feet, and avoiding the Waco mountains.

It is reported by Captain Pope that an examination of the Llano Estacado has developed an unfailing source of fuel in the mezquite root which exists there in great abundance. The wood thus furnished is of a hard and compact structure, and varies in size from three to six inches in diameter, affording a superior charcoal. Specimens of the wood and charcoal have been brought in for examination.

A topographical as well as geological survey was made of the Jornada del Muerto and the country between the Rio Grande and the Mimbres, and the mines of the Organ mountains examined.

Astronomical positions were determined at different points along the routes traversed, and from data collected by many months' observations, a point was fixed in longitude near the intersection of the thirty-second parallel with the Pecos river, and a stone monument erected to mark its position.

Elaborate magnetic and meteorological observations were made during the time that the party was in the field. These observations embraced a period including the different seasons of the year, and extended over lines connecting the low lands near the Gulf of Mexico with the high table lands of the interior.

The party of Captain Pope has recently returned to Washington, and is now employed in preparing detailed reports of the operations that have been conducted under his direction.

The geological and other sub-reports which accompany the reports of the various surveys will form the subject of future notice. They contain material valuable in its bearing upon the construction and working of a railroad, and in a scientific point of view. They are merely referred to here; the object now being to present only those general topographical features which will be looked for with most interest, as chiefly solving the question of the comparative practicability of the different routes.

Certain maps, drawings, and scientific papers that were still in progress at the date of my communication of November 29, 1855, and which are intended to form part of the reports submitted by the first exploring parties, have been, with one exception, completed.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Captain Topographical Engineers,
In charge of Office of P. R. R. Exp. and Surveys.

Hon. JEFFERSON DAVIS,
Secretary of War.

No. 5.

TABLE EXHIBITING THE COMPARATIVE LENGTHS, COST, ETC., OF THE DIFFERENT ROUTES, WITH EXPLANATORY REMARKS.

BY CAPTAIN A. A. HUMPHREYS, CORPS TOPOGRAPHICAL ENGINEERS.

THE distances and estimates of cost of the route of the thirty-fifth parallel, given in the following table, are not those contained in Captain Whipple's revised report. The line from the Big Sandy river to the Colorado river, adopted by Captain Whipple, is 54 miles in length. It is nearly an air line, has never been passed over, and was not noted during the examination in the field as probably affording a practicable route, but was deemed practicable after a study in the office of the field notes. For these reasons, it can only be considered a line which future examinations may show to be practicable; and not one to be adopted, and the cost of a railroad along it elaborately estimated. Upon this principle, the reports upon the other routes have been revised. The corrected distance along the route examined between these two points is 160 miles, which is the length used in the following table. The shortest probable railroad route, from the Mojave river to the Tah-ee-chay-pah pass, is 73 miles in length. The measured distance through the Tah-ee-chay-pah pass is 42 miles. There are parts of the line where the reduction of length shown in Captain Whipple's report may be considered problematical.

However elaborate the field operations of an exploration of this character may be, the extent of ground passed over in a day is so great, that even detailed maps like those of Captain Whipple, though prepared with great care, must represent the ground less broken than it really is. Had, however, the location of the railroad line been made in the field, and notes taken, or rough computations made upon the spot of the excavation, embankments, &c., required, or had the portions of the line been assimilated at the time to lines of road already built, with which the engineer was personally familiar, the liability to error in the estimate of cost would have been less than by the method followed on the route of the thirty-fifth parallel. The location of th railroad line of that route was made on the maps in the office; it follows the actual line of survey for less than half the distance, in many places deviating widely from it, and in occasional cut-offs (one of which is over 50 miles in length) lying over ground that was not examined. The chances of error in the estimates of cost by this method are greater than by the other, and any computations of excavation and embankment are rendered liable to serious inaccuracies.

Captain Whipple's estimated cost of the first 706 miles is probably $5,000 per mile too small.

The estimated cost on the cut-off from the Big Sandy to the Colorado, where there is a descent of 3,400 feet in less than 40 miles, if the line be found practicable, will probably be doubled; but until the line has been examined, the route should be estimated along Bill Williams' fork. In the estimate contained in the following table, one-third of the distance to the mouth of that stream is taken at $45,000 per mile, one-third at $65,000, and one-third at $90,000 per mile along the Colorado at $45,000 per mile. With the exceptions indicated, the estimate in the table is that of Captain Whipple.

In the topographical description of the country, Captain Whipple states, in reference to the cut-off line from the Big Sandy to the Colorado, "the distance for a railroad by that line would be about 70 miles." Adopting this as the length of the cut-off, the length of the route of the thirty-fifth parallel, from Fort Smith to San Francisco, may possibly become 2,006 miles, with a cost under estimated at $100,000,000, and the distance from the Mississippi river to San Francisco 2,270 miles. So far as yet demonstrated, the length and cost of a railroad by the route of the thirty-fifth parallel, from Fort Smith to San Francisco, cannot be less than 2,096 miles, and $106,000,000; nor the distance from the Mississippi river to San Francisco, by the same route, be less than 2,360 miles.

The distance from Fort Smith to San Pedro, (route of thirty-fifth parallel,) so far as yet demonstrated, is at least 1,820 miles, the estimated cost not less than $92,000,000. The distance from the Mississippi river to San Pedro, by this route, 2,090 miles. Should the cut-off be found practicable, the first may become 1,730 miles, the cost not less than $86,000,000, and the second distance 2,000 miles.

The construction of the wagon road from Fort Defiance to the Colorado river will probably solve the question of the railroad practicability of the line from the Big Sandy to the Colorado.

Table showing the lengths, sums of ascents and descents, equated lengths, cost, &c., of the several routes explored for a railroad from the Mississippi to the Pacific.

	Distance by air line.	Distance by proposed railroad route.	Sums of ascents and descents.	Length of level route of equal working expense.	Comparative cost of different routes.	No. of miles of route through arable land.	No. of miles of route through land generally uncultivable, arable soil being found in small areas.	Number of miles at an elevation above the sea between—										Altitude above the sea of the highest point on the route.	
								0 and 1,000 feet.	1,000 and 2,000 feet.	2,000 and 3,000 feet.	3,000 and 4,000 feet.	4,000 and 5,000 feet.	5,000 and 6,000 feet.	6,000 and 7,000 feet.	7,000 and 8,000 feet.	8,000 and 9,000 feet.	9,000 and 10,000 feet.		
	Miles.	*Miles.*	*Feet.*	*Miles.*														*Feet.*	
Route near 47th and 49th parallels, from St. Paul to Seattle.	1,410	2,025	18,654	2,378	* $140,871,000	535	1,490	470	580	720	130	97	28	....	....	....	...	6,044	Tunnel at elevat'n of 5,219 feet.
Route near 47th and 49th parallels, from St. Paul to Vancouver.	1,455	1,864	17,654	2,198	* 130,781,000	374	1,490	309	580	720	130	97	28	....	....	....	....	6.044	Tunnel at elevat'n of 5,219 feet.
Route near 41st and 42d parallels, from Council Bluffs, via South pass, to Benicia.	1,410	2,032	29,120	2,583	116,095,000	632	1,400	220	170	210	160	590	285	270	107	20	....	8,373	
† Route near 38th and 39th parallels, from Westport, via Coo che-to-pa and Tah-ee-chay-pah passes, to San Francisco.	1,740	2,080	49,985	3,026	Impracticable	620	1,460	340	276	165	348	466	170	60	155	80	20	10,032	Tunnel at elevat'n of 9,540 feet.
Route near 38th and 39th parallels, from Westport, via Coo-che-to-pa and Madelin passes, to Benicia.	1,740	2,290	56,514	3,360	Impracticable	670	1,620	275	308	190	143	725	284	110	155	80	20	10,032	Tunnel at elevat'n of 9,540 feet.
Route near 35th parallel, from Fort Smith to San Francisco.	1,550	2,096	48,521	3,015	106,000,000	646	1,450	585	290	261	236	181	295	222	26	....	....	7,550	
Route near 35th parallel, from Fort Smith to San Pedro.	1,360	1,820	48,862	2,745	92,000,000	420	1,400	354	292	236	210	185	295	222	26	....	....	7,550	Tunnel at elevat'n of 4,179 feet.
Route near 32d parallel, from Fulton to San Francisco, by Coast route.	1,630	2,024	38,200	2,747	‡ 90,000,000	834	1,190	893	347	120	342	271	50	....	....	....	....	5,717	
Route near 32d parallel, from Fulton to San Pedro.	1,400	1,598	30,181	2,169	68,000,000	408	1,190	478	337	120	342	271	50	....	....	....	....	5,717	
Route near 32d parallel, from Fulton to San Diego.	1,360	1,533	33,454	2,167	§ 68,000,000	374	1,159	420	305	125	362	271	50	....	....	....	....	5,717	

* These are the estimates of the office, those of Gov. Stevens having been brought to the same standard of increased cost with the other routes, and his equipment reduced to that of the other routes. His estimates were $117,121,000 and $110,091,000.

† Supposing the route to be a straight line, with uniform descent, from the Un-kuk-oo-ap mountains (near Sevier river) to the entrance of the Tah-ee-chay-pah Pass—the most favorable supposition possible.

‡ The estimate of Lieut. Parke, for the construction of a railroad by this route from Fulton to San José, is $82,812,750. Adding $2,025,000, the office estimate for the route from San José to San Francisco, Lieut. Parke's total estimate from Fulton to San Francisco would be $84,837,750.

§ The estimate of Lieut. Parke for this route is $59,005,500.

The sum of the minor undulations (not included in the sum of ascents and descents here given) will probably be greater for the routes near the 47th and 49th parallels than for the other routes.

With the amount of work estimated for the roads in this report, the equated lengths, corresponding to the sums of ascents and descents, have but little practical value. With a full equipment and heavy freight business, the sum of ascents and descents becomes important.

ERRATA FOR VOLUME VII.

PART I.

Page 11, line 6—for "southeasters" read "southwesters."
26, line 1—prefix "The summit is."
33, line 1—for "plateaux" read "plateau."
40, last line—for "maxinum" read "maximum;" and for "miles" read "feet."
41, line 11—after the words "San Francisco" insert the word "bay."
42, line 11—for "was" read "were."

PART II.

Page 29, line 43—for "*Pachyderma*" read "*Pachydesma.*"
30, line 35—for "tertiary" read "middle tertiary."
36, line 31—for "Llomas" read "Lomas."
44, last line—
45, line 7— } for "asterodapsis" read "astrodapsis."
46, line 7—
50, line 5—for "Emilo" read "Emilio."
57, line 10—for "Quadre" read "Cuadre."
71, line 40—after "over" insert "which."
72, last line—for "asterodapsis" read "astrodapsis."
77, line 30—after "in this" insert "range."
81, line 10—for "come" read "comes."
95, line 6—for "asterodapsis" read "astrodapsis."
131, line 43—for "felsphatic" read "felspathic."
134, in note—for "salvadorite" read "labradorite."
163, line 7—for "*Ballous*" read "*Ballons.*"
168, line 26—for "hyrdocloric" read "hydrochloric."
174, line 21—for "monlifera" read "monilifera."