U. S. GEOGRAPHICAL SURVEYS WEST OF 100TH. MERIDIAN

WHEELER.

ANNUAL REPORT

1878

ANNUAL REPORT

UPON THE

GEOGRAPHICAL SURVEYS OF THE TERRITORY OF THE UNITED STATES WEST OF THE 100TH MERIDIAN, IN THE STATES AND TERRITORIES OF CALIFORNIA, COLORADO, KANSAS, NEBRASKA, NEVADA, OREGON, TEXAS, ARIZONA, IDAHO, MONTANA, NEW MEXICO, UTAH, WASHINGTON, AND WYOMING,

BY

GEORGE M. WHEELER,

FIRST LIEUTENANT CORPS OF ENGINEERS, U. S. ARMY;

BEING

APPENDIX N N

OF THE

ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1878.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1878.

NOTE.

Ten topographical atlas sheets, issued during the fiscal year ending June 30, 1878, accompany the copies of Appendix NN of the Annual Report of the Chief of Engineers for 1878, being Annual Report of Lieut. George M. Wheeler, Corps of Engineers, in charge of United States Geographical Surveys, herewith, and are in continuation of the series, ninety-five in number, embracing the territory west of the 100th meridian, which are being prepared as the results of these surveys. Several of the above maps indicate by colors, upon the topographical sheets as bases, the classification into agricultural, non-agricultural, mineral, &c., of the lands represented. (See progress map herewith, and for list of maps see end of report.)

[EXTRACT FROM THE ANNUAL REPORT OF THE SECRETARY OF WAR.]

WAR DEPARTMENT, *November* 19, 1878.

* * * * * * *

The systematic survey of the territory west of the one hundredth meridian, which has been for several years prosecuted under the direction of the Chief of Engineers, by the officers of the Corps of Engineers and other officers of the Army, has been carried on during the last fiscal year in California, Oregon, Nevada, Utah, Colorado, New Mexico, and Texas. The area surveyed and mapped since its commencement has aggregated more than 300,000 square miles.

The topographical maps, which are the most important and useful results of this survey, are regularly published and become at once available for the uses of the War Department and the other branches of the government service, for the settlers of our public lands, and for incorporation into school atlases and other maps for popular use published by private enterprise. Its organization is complete and in excellent condition for carrying on its work rapidly and economically, and it is hoped that the full amount of appropriation asked for by the Chief of Engineers for the next fiscal year will be granted by Congress.

* * * * * * *

A consideration of actual methods and expenses of all surveys of a scientific character under the War and Interior Departments, and the surveys of the Land Office, was referred at the last session of Congress (in the act providing for the sundry civil expenses of the government, approved June 20, 1878) to the National Academy of Sciences, with directions to report to Congress a plan for surveying and mapping the Territories of the United States on such general system as will secure the best results at the least possible cost. Subsequently, and at the request of the acting president of the National Academy of Sciences, I furnished to the academy a statement of the plans and wishes of the War Department in respect to these surveys, which was prepared by my direction by the Chief of Engineers, and will be found in the report of that officer.*

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[EXTRACT FROM THE ANNUAL REPORT OF THE CHIEF OF ENGINE TO THE SECRETARY OF WAR.]

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 19, 1878.

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GEOGRAPHICAL SURVEYS OF THE TERRITORY OF THE UNITED STATES WEST OF THE ONE-HUNDREDTH MERIDIAN.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engineers, having under his orders First Lieuts. Eric Bergland, Samuel E. Tillman,

*Appendix N N 3.

and Thomas W. Symons, and Second Lieuts. Eugene Griffin and Willard Young, Corps of Engineers; First Lieut. Rogers Birnie, jr., Ordnance Department; First Lieut. Charles C. Morrison, Sixth Cavalry; Second Lieuts. Benjamin H. Randolph and Henry H. Ludlow, Third Artillery; and Second Lieut. M. M. Macomb, Fourth Artillery.

During the year the following gentlemen have been engaged in the investigation of special subjects: Dr. F. Kampf, astronomer, triangulation observer, and computer; John A. Church, mining engineer; A. R. Conkling, geological assistant; H. W. Henshaw, ornithologist.

Dr. F. Kampf died at his residence in Washington after a short illness, resulting from a concussive blow upon the forehead, accidentally received while on duty in the field.

Dr. J. T. Rothrock, professor of botany at the University of Pennsylvania, has devoted considerable time to the final preparation of the manuscript for volume VI, and now, with the assistance of the colaborers in this branch, is engaged in reading proof.

Prof. F. W. Putnam, curator of the Peabody Museum, Cambridge, Mass., has, at intervals taken from his other professional labors, advanced nearly to completion his part of the manuscript of volume VII of the quarto reports, and has superintended the preparation and production of the illustrative cuts.

Prof. John J. Stevenson, late of the Pennsylvania State geological survey, and member of the expedition of 1873, resumes his labors upon Western geology, and will pay especial attention during the coming season to the outcrops of the Coal Measures at the east base of the Rocky Mountain ranges of Colorado and New Mexico.

The funds appropriated for this survey by the act approved March 3, 1877, having been made immediately available, the members of the expedition of this year were enabled to take the field early in May, during which month the entire working field force of the survey, consisting of three sections, known as the Colorado, Utah, and California, composed of ten parties, was effectively organized and engaged in the prosecution of its labors.

The several parties were distributed in those portions of California, Oregon, Nevada, Utah, Idaho, Montana, Wyoming, Colorado, New Mexico, and Texas embraced by atlas sheets 23 B, 32 C, 32 D, 38 B, 38 D, 41 A, 41 B, 47 B, 48 D, 52 D, 56 B, 61 A, 77 D, and 84 B. (See Progress map accompanying Appendix N N.) The field season, as usual, was extended as late as the early and extreme cold of the mountain regions visited would permit. The parties, during the latter days of November and early part of December, disbanded at Carson, Nev., Ogden, Utah, Fort Garland, Colo., and Fort Union, N. Mex.

The drainage basins occupied were portions of the northwestern arm of the "great interior basin," and those of the Pecos, Rio Grande, Arkansas, Gunnison and its tributaries, Bear and Snake rivers, and creeks entering the latter from the south, together with areas bordering on several streams of various magnitudes debouching from the Sierra Nevada, upon the great inland valleys of Central California.

During the month of March, a special topographical and hydrographical survey of the Great Salt Lake basin was begun. This contemplates, in addition to the detailed topographical survey of the entire basin that has Great Salt Lake as its reservoir, an accurate meander of the shores of the lake and its islands, with the soundings needed to determine its present volume, observations upon the evaporation at the surface, with periodic rise and fall, the measurement at different seasons of the inflow and rainfall, and other meteorological observations at stations located upon the incoming streams. The Jordan, Weber, and Bear rivers, the principal sources of supply, were measured. Nearly two-thirds of the meander has been completed, and a number of soundings made. The continuation, at a trifling expense, of this work, will be prosecuted, as circumstances permit, from the Ogden office of the survey.

While the expeditionary parties are engaged in the field, a small annual office force is employed in completing the necessary computations and the delineation of the final atlas sheets. A temporary field office was established at Ogden, Utah, during the past winter, and will hereafter be occupied by such of the assistants as may be available. Such field astronomical latitude stations only as have been found requisite for checking the measured lines of survey through mountain passes, cañon defiles, and along routes from which main and secondary triangulation points are not visible, have been determined.

The project submitted for the season of 1878 contemplated the establishment of at least five longitude and latitude determinations at main stations, selected at positions favorable for checking the extended belts of triangulation. During the season of 1877 five bases were measured, at the following points: (1) Ogden, Utah; (2) between Terrace, Utah, and Lucin, Utah, on the Central Pacific Railroad; (3) near Austin, Nev.; (4) near Bozeman, Mont.; (5) near Verdi, Nev., on the Central Pacific Railroad. In each case connection was made with the initial astronomical stations in the vicinity and with the vertices of triangles of the main belts adjacent. During the same season 145 sextant latitude stations were occupied, 56 triangles about bases measured, and observations made at 106 main and 264 secondary triangulation stations, 2,474 three-point and cross-sight stations, and 12,366 minor points occupied.

Magnetic variations were determined at 424 points and 10,801 miles measured. The necessary observations were made at 10,438 cistern and aneroid barometer stations for differences of altitude. The locations of 60 mineral and thermal springs have been defined, and 19 mining camps visited. A number of lots and specimens of minerals, fossils, mammals, birds, reptiles, fishes, insects, shells, &c., have been collected.

In the office, 106 astronomical positions have been computed, 87 stations adjusted by method of least squares, 1,149 triangles, 2,298 distances, 295 longitudes and latitudes, and 352 azimuths computed, and 1,356 cistern barometer and 7,798 aneroid altitudes have been computed.

There have been 14 sheets and parts of sheets plotted on a scale of 1 inch to 2 miles and 6 special sheets drawn to various scales.

The number of final or completed atlas sheets drawn and submitted with the report for the year is ten; 1,542 reports and 12,768 maps have been distributed. The increasing call for reports and maps from various sections of the country, and notably from those interested in the settlement of these Western regions, is an indication that the results of the survey to a certain extent meet a popular want.

After the passage of the appropriation for this survey on the 20th of June, the regular parties, nine in number, of which two admit of operating as double parties, consisting of forty-six observers, took the field early in July in three divisions, known as the Colorado, Utah, and California sections.

Three main astronomical parties also proceeded to their respective posts for the purpose of establishing the longitude, latitude, and altitude of stations at Walla Walla, Washington Ter.; Dalles, Oreg.; Fresno, Cal.; Fort Bliss, Tex.; and Fort Bayard, N. Mex. These parties, twelve in all, are distributed in the following political divisions: Two in California; one in parts of Nevada, California, and Oregon; three in parts of

Nevada and California; one in Utah; one in Oregon and California; two in Colorado and New Mexico; two in New Mexico and Texas; and in areas embraced by atlas sheets Nos. 12, 20, 29, 38, 47, 56, 48, 73, 80, 41, 70, 78, 84, and 90. (See Progress map of 1878.) The Washington office continues its labors as usual. The expedition of 1878, larger than any other in number of observers, takes the field well equipped, and the season, when prolonged as intended until December, will admit of still further accumulation of topographical data required for the thorough and vigorous prosecution toward completion of the survey needed for the detailed topographical map of the entire region.

Prof. J. J. Stevenson, with one assistant, is to be engaged during the season along the mountain ranges between the Rio Grande and the plains and south of the Spanish Peaks, in Colorado. He will make sections of the coal croppings and worked beds. Having the detailed topographical maps of this section, already published, to facilitate his labors, it is expected that the geological formations can be laid down with great rapidity and accuracy. The special examinations of the Comstock lode are being prosecuted, consisting of the completion of the contour map; the following of the works in depth and along the Sutro tunnel; further data for the longitudinal, vertical, and horizontal sections; observations upon temperatures, ventilation, and drainage of the mines, and of the geology of the surface, and collections from various tunnel and other levels.

The officer in charge suggests that, were funds available, winter parties could successfully conduct their operations in the southern portion of the field and near the Mexican border, while during the summer months parties can operate north of the Pacific railroads, thus keeping an expedition permanently in the field; and this course, being in the direction of a rapid completion of the work, more especially commends itself in view of the Indian campaigns of the past few years, rendered necessary against the hostiles, in which the want of accurate and detailed topographical maps of the Western mountain regions has been felt. And I have again the honor to suggest that the item for continuing this survey may with propriety be placed upon the Army appropriation bill. (See letter of Lieutenant Wheeler, in appendix to Book of Estimates for 1879 and 1880.)

Volume II (Astronomy and Barometric Hypsometry) of the quarto reports authorized to be published by act of Congress has been issued from the press, and proof reading of volume VI (Botany) is now being rapidly advanced. The tables of declinations of 2,018 latitude stars are in print and available for the special astronomical work of the present season. As soon as Vol. VI goes to press the manuscripts of Vols. I and VII, the remainder of those now approved, will be placed in the hands of the Printer. With slight exceptions, the illustrations for the above volumes have been engraved and printed.

Nine topographical sheets have been added to the atlas, and 19 others approach completion in the various stages of progress. The geological information requisite for delineation upon the sheets to accompany Vol. III, and for others of the regular atlas, is being gathered.

The special topographical sheet, on a scale of 1 inch to 1 mile, of the vicinity of Lake Tahoe, embracing the Virginia and Truckee Railroad, and that part of the Central Pacific Railroad across the Sierras, with the Washoe mining region, of the size of 6 full atlas sheets, is finally plotted and awaits publication. The plot, on a scale of 1 inch to 500 feet, of the contour survey of the vicinity of the Comstock lode, equivalent in size, when reduced to 1 inch to 1,500 feet, of four uniform atlas sheets, needs but a small amount of data for its completion. These maps, based upon a comparatively large number of computed points, are the most detailed yet produced by the survey.

Land classification maps, based upon the regular topographical sheets, are being prepared and published as fast as possible, and hereafter the notes for a more minute representation of the character of the surface of the region visited are required of the several parties in the instructions given by the officer in charge. Besides the value of these maps to the land branch of the government, they must prove of service to the emigrant settler and capitalist interested in the regions represented.

The topographical maps, which are the main results of the survey, are regularly published as fast as completed, and become at once available for the purposes of the War Department and other branches of the government service, and subsequently to the public, through the usual distribution, or, in various scales, through map publishers in this and foreign countries.

The area surveyed and mapped during the years 1869, 1871, 1872, 1873, 1874, 1875, 1876, and 1877, as reported by Lieutenant Wheeler, aggregates the amount of 332,515 square miles, distributed as follows:

	Square miles.
California	54, 751
Nevada	62, 181
Utah	38, 969
Arizona	61, 816
Colorado	33, 041
Wyoming	231
New Mexico	71, 427
Oregon	1, 242
Idaho	8, 877

Initial points have been established (including the season of 1877) in Kansas, Nebraska, Texas, Montana, and Washington. Parts of the work will have been, at the close of the season, carried on in fourteen of the fifteen of the political divisions lying west of the one hundredth meridian, and from the Columbia River on the north to the Mexican border.

The labors of this survey are annually carried on in accordance with projects regularly submitted by the officer in charge to the Chief of Engineers, and by him to the Secretary of War, by whom they are approved before the parties commence the duties of each season. These projects are in the direction of a systematic, thorough, and economic prosecution of a detailed survey in connected areas (according to a plan submitted by Lieutenant Wheeler and adopted in 1872), the necessary data being obtained by means of astronomical, geodetic, topographical, and barometric observations. This work may be considered as supplemental to, binding together, and developing systematically over completed areas, by the use of more refined instruments and later methods, the Pacific Railroad and military and geographical surveys west of the Mississippi River, suspended at the outbreak of the war of the rebellion.

Incident to the principal objects of the survey, and as far as practicable without too greatly increasing the cost, all the information necessary at the present stage of settlement of the country concerning the branches of mineralogy and mining, geology, paleontology, zoology, botany, archæology, ethnology, and philology is collected by specialists, experts in their branches of science. Information concerning this and other Engineer Department surveys in the West will be found in House Ex. Doc. 88, Forty-fifth Congress, second session. (See Appendix NN 2.)

The continuation of this most valuable and useful work, in its present stage of advancement, will, it is believed, commend itself to and receive favorable consideration from Congress.

The amount estimated by Lieutenant Wheeler for the continuation of the survey, viz, $120,000, is earnestly recommended.

His annual report, with appendixes and estimates, is appended.

(See Appendix N N.)

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APPENDIX N N.

ANNUAL REPORT OF LIEUTENANT GEORGE M. WHEELER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

GEOGRAPHICAL SURVEYS OF THE TERRITORY OF THE UNITED STATES WEST OF THE ONE HUNDREDTH MERIDIAN, IN THE STATES AND TERRITORIES OF CALIFORNIA, COLORADO, KANSAS, NEBRASKA, NEVADA, OREGON, TEXAS, ARIZONA, IDAHO, MONTANA, NEW MEXICO, UTAH, WASHINGTON, AND WYOMING.

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REPORT.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 30, 1878.

SIR: I have the honor to submit the following report for the fiscal year ending June 30, 1878:

At the close of the present field season parties of the survey will have been engaged in fourteen of the fifteen States and Territories, a part or all of which lie west of the 100th meridian of longitude; the remaining political division (Dakota) alone having been unvisited. The progress of the work since its commencement has been directed over connected areas, and in such manner that, at a minimum of time and expense, as large areas as practicable, pursuant to required methods, shall be topographically surveyed in detail, to the end that the War Department shall have, at as early a date as possible, a complete map of the entire region.

SUMMARY OF FIELD AND OFFICE OPERATIONS.

The commencement of the fiscal year found the parties of three sections, the organization of which had been perfected in May previous, actively employed in prosecuting their labors in the areas assigned to the survey for that year in portions of Colorado, New Mexico, Texas, Utah, Idaho, Wyoming, Montana, Nevada, California, and Oregon, embraced by atlas sheets 23, 32 A, 32 B, 38 B, 38 D, 41 A, 41 B, 47 B, 47 D, 56 B, 61 A, 78 A, 77 B, and 77 D (see progress map herewith). The areas thus occupied connect in every instance with those heretofore mapped by the expeditions of 1876 and prior years. The disbandment of the parties of the 1877 expedition took place between November 25 and December 10, 1877, at Carson, Nev., Ogden, Utah, Fort Garland, Colo., and Fort Union, N. Mex.

The season's operations included an interval of from six to seven months, and, other than the casualties hereafter to be noted, was in all respects successful; the accumulation of data of the most important of the classes of observations being in excess of that gathered in any previous season. In addition to the regular or map-work proper, the progress of the special works, as of the surveys of the Lake Tahoe and Washoe mining regions, collections in natural history, &c., was satisfactory.

The expedition of 1878 was at the close of the fiscal year in readiness to take the field in three main sections, with three separate astronomical parties, in pursuance of the preliminary project submitted June 7, 1878, and made complete the 27th of that month after the approval of the appropriation act. Nine separate and distinct parties, two of which operate along double lines, independent of the three astronomical parties are proposed, and the scene of their labors is laid in areas situate in Colorado, New Mexico, Texas, Utah, Nevada, California, Oregon, and Washington Territory, and is shown upon atlas sheets Nos. 20, 29, 38, 41, 47, 56, 64, 73, 78 A, 80, 84, and 90. (See progress map for 1878.) Forty-six observers are prepared to take the field, being slightly in excess of the number engaged in former years.

The main astronomical stations to be occupied, time-signals being exchanged with the observatory or connecting-station at Ogden, Utah, are, (1) Walla Walla, Wash., (2) Dalles, Oreg., (3) Fresno, Cal., (4) Fort Bliss, Tex., (5) Fort Bayard, N. Mex., and, if time permits, Fort Dodge, Kans., near the one hundredth meridian on the Atchison, Topeka and Santa Fé Railroad.

At the Washington office a number of draughtsmen and computers are meanwhile employed in steadily reducing the results heretofore obtained, and in the delineation of the final atlas sheets. Mr. McChesney has been engaged at this office in the entering of the field records as received, in the preliminary preparation of money and property accounts, and upon the general record. The distribution of maps and reports also receives attention at this office during the field season. Computations are begun as early as practicable after the observations are received from the field, from which they are forwarded bimonthly.

A temporary field-office in connection with the observatory at Ogden was established at the close of the last field season, and placed in charge of Lieut. Willard Young, who was there assisted by Francis Klett, and in addition to his office duties was engaged during a part of the later winter months in special survey work about Great Salt Lake. Hereafter it is proposed that this office shall be occupied by such officers and assistants as may be available, thereby saving time and expense of transportation to and from Washington, D. C., and that a second be established at Denver, Colo., during the coming year.

The following changes among the officers detailed for duty with the survey during the year have occurred:

Lieut. Eric Bergland, Corps of Engineers, having been ordered to report to the Superintendent of the United States Military Academy, West Point, N. Y., on or before August 28, 1878, was granted a leave of absence until that period, of which he availed himself May 5, 1878.

First Lieut. Rogers Birnie, jr., late of the Thirteenth Infantry, was transferred to the Ordnance Corps June 13, 1878.

Lieut. Charles C. Morrison is under orders to report to the Superintendent of the Military Academy on or before August 28, thus preventing his taking the field. He remains in charge of the Washington office, upon special duties assigned him there, until the date of leaving to join his new station.

Second Lieut. Willard Young, Corps of Engineers, reported for duty at Ogden, Utah, September 13, 1877.

Second Lieut. Eugene Griffin, Corps of Engineers, in obedience to paragraph 3, Special Orders No. 86, headquarters of the Army, Adjutant-General's Office, April 22, 1878, reported for duty May 4, 1878.

Second Lieut. B. H. Randolph, Third Artillery, reported for duty June 25, 1878, and Second Lieut. H. H. Ludlow, Third Artillery, reported May 6, 1878, in obedience to paragraph 5, Special Orders No. 95, headquarters of the Army, Adjutant-General's Office, May 3, 1878.

In pursuance of paragraph 2, Special Orders No. 88, headquarters of the Army, Adjutant-General's Office, April 25, 1877, and continued by virtue of paragraph 1, Special Orders No. 29, headquarters of the Army, Adjutant-General's Office, February 8, 1878, four enlisted men were detailed for duty and assigned to the parties of the Utah section during the field season, and upon the special survey about Great Salt Lake during the subsequent winter and spring, until again required in the expedition of 1878.

Among the older assistants whose term of service has given a lengthened experience, thereby adding to their proficiency, I desire to mention

Topographical Assistants Nell, Thompson, Maxon, and Spiller, and Messrs. Weyss, Herman, and Lang, draughtsmen.

Dr. J. T. Rothrock, professor of botany at the University of Pennsylvania, has devoted considerable time to the final preparation of the manuscript of his report, and those of the several other authors contributing to Vol. VI, and, with the assistance of the co-laborers in this branch, is now reading proof of the same.

Prof. F. W. Putnam, curator of the Peabody Museum, Cambridge, Mass., has, when practicable to spare the time from his other professional labors, advanced nearly to completion his portion of the manuscript for Vol. VII of the quarto reports, and has superintended the preparation and production of the illustrative cuts.

Prof. John J. Stevenson, late a member of the Geological Survey of Pennsylvania, and an assistant in the expedition of 1873, again resumes the field of Western geology, and will during the season be engaged, with Mr. J. C. Russell as an assistant, in the ranges facing the plains of Colorado and New Mexico south of the Spanish Peaks in Colorado.

Frank Carpenter, a former assistant, and Messrs. James S. Polhemus and Charles P. Kahler have been appointed as assistants, and assigned to topographical work in the field.

Three additional enlistments in the general service of the United States Army have been made, and the assistants thus obtained are assigned to barometric and minor topographical work, both in the field and office.

Prof. T. H. Safford and John H. Clark have received temporary field appointments as astronomical observers and computers, and are assigned to main field and connecting stations.

The Survey has sustained the loss of a valuable member in the person of Dr. F. Kampf, who died at his residence in Washington, D. C., April 27, 1878, after a short illness, being a relapse subsequent to the severe mental and physical prostration occasioned by a blow on the forehead, received while on field duty.

J. W. Ward, of the general service, United States Army, was almost instantaneously killed by the accidental discharge of his pistol while in camp on the Snake River, Idaho.

William A. Cowles, assistant, received a most untimely and unfortunate fall from the crest of a mountain peak of the Sierra Nevada, the loosened rock following him, reaching his legs with a crushing force that resulted in a compound fracture of both. By skillful treatment and care he is about to secure the renewed use of his limbs, and hopes to be a candidate for further survey-work.

A. R. Conkling concluded his geological field-work with the past season, and now submits his last report.

Messrs. C. J. Kintner and F. M. Lee, computers, terminated their services with the expedition during the past year.

I cheerfully take this opportunity to attest my appreciation of the unceasing energy and vigor which the officers and other assistants have shown in the prosecution of their arduous labors, whereby so much new geographical material has been added to the great map of the interior.

The aid extended by the supply branches of the War Department has brought the officers of the survey in contact with many of their brother officers in such service, and it is pleasant to be able to recognize the cheerful spirit with which this assistance is extended, thereby facilitating the operations of the survey, now so widely distributed in the area of its undertakings. I desire especially to mention the readiness with which the present Superintendent of the United Coast Survey, Capt. Carlile

P. Patterson, has responded to requests made upon his office for longitudes and latitudes, or other data, where the same has been of value to parties of this survey working in the mountains adjacent to the Pacific coast.

Certain of the prominent features of the results from the observations in the field and reductions in the office are herewith noted:

FIELD SEASON OF 1877.

Sextant-latitude stations	145
Bases measured	5
Triangles about bases measured	56
Azimuths about bases measured	13
Main triangulation stations occupied	106
Secondary triangulation stations occupied	264
Cross-sight stations observed	1,060
Three-point stations occupied	1,414
Stations on meanders	12,366
Miles measured	10,801
Cistern-barometer stations occupied	1,447
Aneroid stations occupied	8,900
Magnetic variations observed	424
Rivers and creeks gauged	58
Camps made	761
Monuments built	367
Mining camps visited	19
Mineral and thermal springs noted	60
Minerals, fossils, and ores, specimens collected (approximately)	1,100
Mammals, specimens collected	14
Birds, specimens collected	228
Reptiles, lots collected	11
Fishes collected { lots	23
Fishes collected { specimens	200
Insects, lots collected	14
Shells, lots collected	8

OFFICE—WINTER OF 1877-'78.

Astronomical positions computed	106
Adjusted by method of least squares { triangulation stations	87
Adjusted by method of least squares { geodetic figures	67
Distances computed	2,298
Azimuths computed	352
Longitudes and latitudes computed	295
Cistern-barometer altitudes computed	1,356
Aneroid-barometer altitudes computed	7,798
Sheets and parts of sheets plotted (1 inch to 2 miles)	14
Special sheets drawn (various scales)	8
Atlas maps (1 inch to 4 miles) published	8
Atlas maps (1 inch to 4 miles) approaching completion for publication	4
Atlas maps (1 inch to 4 and 1 inch to 8 miles) partially completed	15
Reports distributed	1,542
Maps distributed	12,768

Reports in course of publication: Volumes I, VI, VII; and tables of geographical positions, longitudes, latitudes, distances, &c.

Lieutenant Bergland, in command of party 1, Colorado section, was also employed as sextant and triangulation observer in the field and upon office reductions during the winter and in preparation of his report, herewith submitted as Appendix A.

Lieutenant Tillman was engaged in the field upon sextant and triangulation work until his party was divided, Lieutenant Young assuming command of the topographical branch and Lieutenant Tillman proceeding to the north to measure and develop a base at the astronomical station at Bozeman, near Fort Ellis, Mont. Lieutenant Tillman, during the winter season, had charge of the computing branch of the survey. The reports of the above officers are herewith, and marked Appendixes B and D respectively.

Parties 1 and 2 of the California section were in command, respectively, of Lieutenants Symons and Macomb, both engaged in the field upon sextant and triangulation observations and in the office upon their reductions and that of the topographical notes. Their reports, marked Appendixes C and G respectively, are herewith submitted.

Lieutenant Birnie, in command of party 2, Utah section, was, during the office season, engaged in the reduction of sextant, triangulation, and topographical observations made by him, and in the rendition of his accounts as acting assistant quartermaster and acting assistant commissary of subsistence and ordnance officer. His report of field operations is appended, and marked E.

Lieutenants Morrison and Macomb were also employed a portion of the winter interval in the completion of their accounts as acting assistant quartermaster, acting assistant commissary of subsistence, and ordnance officer. Hereafter these duties for the entire expedition will be performed by one officer. The New Mexico party of the Colorado section, under Lieutenant Morrison, completed its labors a little later than others of the expedition, and this officer has since been engaged upon topographical and other reductions in the office and upon a compilation of a table of positions, distances, altitudes, &c. His executive and descriptive report is herewith as Appendix F.

Each chief of party has been called upon to furnish a list of distances over the most important roads of the regions visited, and the same appear in the main body of the report.

ASTRONOMICAL.

The astronomical campaign to be carried out during the season of 1878 contemplates check points for belts of triangles from Ogden, on the Central Pacific Railroad, to the vicinity of Walla Walla, Wash.; from the base in Carson Valley, near Virginia City, to Dalles, Oreg.; that at Fresno, Cal., as a check intermediate between astronomical points at Virginia City, Nev., and Los Angeles, Cal.; the one at Fort Bliss, Tex., to check the belt extending from Santa Fé to the southward; and at Fort Bayard as one of the checks upon the belt of triangles extending from the Rio Grande, at its junction with the Mexican border, to Fort Yuma, on the Rio Colorado of the West. The signals are to be sent over the Western Union, Atlantic and Pacific, and government lines; the latter, from Santa Fé to the southward, having been placed at the disposal of the Survey for this purpose through the courtesy of General A. J. Myer, Chief Signal-Officer, U. S. A. The Ogden observatory, the longitude of which has been determined with great care and accuracy, is used as the connecting station. Longitudes, latitudes, and altitudes of a number of main astronomical stations will be found in vol. II of the quarto reports. The special lists of geographical positions, distances, altitudes, &c., the manuscript of which is now being prepared, will furnish the same for many points of local or topographical importance scattered through the extended region of the Survey. Improvements are to be made to the Ogden observatory during the present season, increasing its capacity for observing, office, and storage purposes, and in connection with it one of the field-offices of the Survey will be established. Title will be acquired to the ground upon which to erect a small observatory and temporary office-buildings near the most prominent elevation to the east of the center of Denver, Colo.

The latitudes of a number of points observed and computed by officers of the Survey during the season of 1877 are given in the following table, viz:

Geographical positions from sextant observations, variations of needle, altitudes, &c., for the year 1877.

Year.	Station.	State or Territory.	Atlas-sheet.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of the needle east.	Party.	Observer.	Computer.	Remarks.
					° ′ ″	*Feet.*	° ′				
1877	Alturas	Cal	38 B	α Coronæ Borealis α Andromedæ Polaris Altair	41 28 50. 8	4364. 9	17 37	Cal. I	Lt. Symons	Lt. Symons	
1877	Bannock Creek	Idaho	32 C	α Coronæ Borealis Polaris Markab Altair	42 41 20. 7	4693. 9	17 52	Utah II.	Lt. Birnie	Lt. Symons	Camp 41.
1877	Bankhead Creek	Idaho	41 A	α Lyræ Polaris Markab	42 11 19. 1	4783. 2	18 33	Utah II.	Lt. Birnie	Lt. Symons	Camp 82.
1877	Bannock Creek	Idaho	32 C	α Coronæ Borealis Polaris Markab Altair	42 29 26. 3	5071. 6	17 45	Utah II.	Lt. Birnie	Lt. Symons	Camp 42.
1877	Bear River, long. 111°	Wyo	41 B	α Lyræ Arcturus Polaris α Ophiuchi	41 54 07. 2	6150. 3	18 13	Utah I.	Lt. Tillman	Lt. Symons	Camp 20.
1877	Bear River, long. 111° 04′	Utah	41 B	Arcturus α Lyræ Polaris δ Ophiuchi	42 12 47. 1	6054. 8	17 59	Utah I.	Lt. Tillman	Lt. Symons	Camp 22.
1877	Bear River, long. 111° 12′	Utah	41 B	Arcturus α Lyræ Polaris δ Ophiuchi	42 12 26. 0	5920. 4	18 00	Utah I.	Lt. Tillman	Lts. Symons and Young.	Camp 23.
1877	Bear Valley	Cal	56 B	α Aquarii Polaris α Andromedæ	38 26 45. 2	6965. 1	....	Cal. II	Lt. Macomb	Lt. Symons	Camp 35.
1877	Blackfoot Station	Idaho	32 C	α Coronæ Borealis Polaris Markab Altair	43 09 32. 5	4446. 8	18 01	Utah II.	Lt. Birnie	Lt. Symons	
1877	Blue Creek, head of	Utah	41 A	Polaris α Lyræ Markab α Arietis	41 49 13. 0	4613. 7	17 38	Utah II.	Lt. Birnie	Lt. Symons	Camp 88.

1877	Branch Port Neuf, 8 miles N. W. from Mt. Sedgwick.	Idaho...	32 D	β Herculis α Andromedæ Altair Polaris	42 35 23.6	5171.0	....	Utah I..	Lt. Young....	Lt. Young....	Camp 73.
1877	Bridgeport	Cal.....	56 B	Sun	38 15 01.1	6503.6	16 18.5	Cal. II..	Lt. Macomb...	Lt. Symons...	
1877	Camp Bidwell	Cal.....	38 B	α Coronæ Borealis Polaris Altair, S. Sun	41 51 29.7	4612.2	17 53	Cal. I...	Lt. Symons...	Lt. Symons...	
1877	Camp Creek	Idaho...	32 C	α Andromedæ Polaris ε Pegasi α Lyræ	42 47 20.5	5245.5	18 22	Utah II.	Lt. Birnie.....	Lt. Symons...	Camp 68.
1877	Camp Warner	Oregon.	29 D	Arcturus α Andromedæ Polaris Altair, S.	42 23 42.3	5760.1	18 49	Cal. I...	Lt. Symons...	Lt. Symons...	Abandoned.
1877	Camp 22	Cal.....	47 D	α Coronæ Borealis α Cygni Polaris	39 19 49.0	6267.8	....	Cal. II..	Lt. Macomb...	Lt. Symons...	Near Red Mountain.
1877	Camp 41, 4 miles N. E. Mt. Pisgah.	Idaho...	32 D	α Ophiuchi Polaris α Cygni	43 07 20.7	6366.8	18 20	Utah I..	Lt. Tillman...	Lt. Symons...	
1877	Camp 43, long. 111° 48′	Idaho...	32 D	Polaris α Coronæ Borealis Markab Altair	40 10 10.1	6877.9	18 43	Utah I..	Lt. Tillman...	Lt. Symons...	
1877	Camp 53, 7 miles S. E. Mount Sedgwick.	Idaho...	32 D	Markab Polaris α Coronæ Borealis Altair	42 27 37.4	5248.7	18 18	Utah I..	Lt. Tillman...	Lt. Symons...	
1877	Camp 71, long. 112° 23′	Idaho...	32 C	Altair β Herculis α Andromedæ Polaris	42 38 31.1	6146.3	18 37	Utah I..	Lt. Young....	Lt. Young....	
1877	Camp 77, 3 miles N. W. Oxford Peak.	Idaho...	41 B	Altair ζ Herculis α Andromedæ Polaris	42 16 21.2	6292.8	17 50	Utah I..	Lt. Young....	Lt. Young....	
1877	Camp 78, 5 miles N. E. Elkhorn Peak.	Idaho...	32 D	α Andromedæ α Lyræ ε Pegasi Polaris	42 22 41.8	5783.9	17 51	Utah I..	Lt. Young....	Lt. Young....	
1877	Camp 80, 2 miles S. Oxford settlement.	Idaho...	41 B	α Andromedæ α Lyræ ε Pegasi Polaris	42 13 47.9	4865.9	18 21	Utah I..	Lt. Young....	Lt. Young....	
1877	Canteen Springs	Wyo....	41 B	Arcturus α Lyræ Polaris	42 01 47.6	6721.8	18 01	Utah I..	Lt. Tillman...	Lt. Symons...	Camp 21,

Year.	Station.	State or Territory.	Atlas-sheet.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of the needle east.	Party.	Observer.	Computer.	Remarks.
					° ′ ″	Feet.	° ′				
1877	South of Capitan Mountain	N. Mex.	84 A	α Coronæ Borealis, W. α Pegasi, E Polaris, N α Aquilæ, S	33 32 53.9	6628.6	12 12	Col. II	Lt. Morrison	Lt. Symons	Camp 60.
1877	Cople's Ranch	Cal	56 B	α Lyræ Arcturus Polaris	38 42 15	7780.5	16 47.5	Cal. II	Lt. Macomb	Lt. Symons	
1877	Cedarville Pass	Cal	38 B	Arcturus Polaris α Pegasi Altair	41 33 46.2	5438.8	....	Cal. I	Lt. Symons	Lt. Symons	Camp 34.
1877	Charity Valley	Cal	56 B	α Ophiuchi α Cygni α Coronæ Borealis Polaris	38 39 16.9	7843.6	16 15	Cal. II	Lt. Macomb	Lt. Symons	
1877	Cisco	Cal	47 D	Arcturus Polaris α Cygni	39 18 40	5654.4	17 11	Cal. II	Lt. Macomb	Lt. Symons	Camp 19, near.
1877	Clear Creek	Utah	41 A	Arcturus α Cygni Polaris α Ophiuchi	41 57 59.6	5753.0	17 16	Utah II.	Lt. Birnie	Lt. Symons	Camp 17.
1877	Clear Creek Mountains	Utah	41 A	α Lyræ Polaris	41 46 31.0	6440.9	17 30	Utah II.	Lt. Birnie	Lt. Symons	Camp 8, mouth Big Cañon.
1877	Cogswell's Creek	Oreg	38 B	β Pegasi α Coronæ Borealis Polaris Altair, S	42 04 07.3	4998.5	18 11	Cal. I	Lt. Symons	Lt. Symons	Camp 47.
1877	Cottonwood Creek	Oreg	38 B	Polaris α Coronæ Borealis β Pegasi Altair ξ Herculis	42 16 56.2	5187.4	....	Cal. I	Lt. Symons	Lt. Symons	Camp 41.
1877	Crooked Creek	Oreg	38 B	α Coronæ Borealis Altair α Andromedæ Polaris	42 20 18.7	4817.8	....	Cal. I	Lt. Symons	Lt. Symons	Camp 42.

1877	Deep Cañon	Nev	38 B	Altair, S. α Coronæ Borealis Polaris γ Pegasi	41 10 47.3	5561.7	18 08	Cal. I	Lt. Symons	Lt. Symons	Camp 62.
1877	Devil's Corral	Idaho	31 D	α Coronæ Borealis Polaris	42 33 14	3601.1	....	Utah II	Lt. Birnie	Lt. Symons	Near Shoshone Falls.
1877	East Fork Carson River	Cal	56 B	α Coronæ Borealis α Andromedæ Altair Polaris	38 29 24	6816.8	....	Cal. II	Lt. Macomb	Lt. Symons	Camp 40.
1877	East Fork Logan River	Utah	41 B	α Lyræ Polaris	41 56 10.5	6859.5	17 33	Utah I	Lt. Tillman	Lt. Symons	Camp 16.
1877	Elkhorn Settlement, 1 mile north of.	Idaho	41 A	ε Pegasi α Lyræ Polaris β Andromedæ	42 17 40	5099.5	....	Utah I	Lt. Young	Lt. Young	Camp 75.
1877	Fall Creek	Idaho	32 C	Arcturus α Cygni Polaris α Ophiuchi	42 37 26.7	4080.5	....	Utah II	Lt. Birnie	Lt. Symons	Camp 24.
1877	Forni's Ranch	Cal	56 B	α Lyræ, 2 E. Arcturus, 2 W. Polaris, 2 N. α Serpentis, S.	38 53 36	4225.1	....	Cal. II	Lt. Macomb	Lt. Symons	
1877	Fort Hall	Idaho	32 D	Altair α Andromedæ Polaris α Lyræ	43 08 54.8	4752.1	18 13	Utah II	Lt. Birnie	Lt. Symons	
1877	Fort Hall Indian Agency	Idaho	32 C	α Coronæ Borealis Polaris Altair Markab	43 01 48.7	4544.7	17 23	Utah II	Lt. Birnie	Lt. Symons	
1877	Fort Hall Road and Port Neuf River.	Idaho	32 D	Markab α Coronæ Borealis Polaris Altair	42 59 55.2	5511.5	....	Utah I	Lt. Tillman	Lt. Symons	Camp 60.
1877	Forty-nine Cañon	Nev	38 B	β Pegasi Altair, S. Polaris ξ Herculis	41 36 09.1	5878.4	18 40	Cal. I	Lt. Symons	Lt. Symons	Camp 55.
1877	Fountain Spring	Idaho	32 C	α Coronæ Borealis Polaris Markab Altair	42 34 40.9	5234.6	18 34	Utah II	Lt. Birnie	Lt. Symons	Camp 43, Head West Fork, Bannack Creek.
1877	Game Creek, long. 111° 15′	Idaho	32 D	α Cygni Arcturus Polaris α Ophiuchi	42 46 26.0	6539.4	18 19	Utah I	Lt. Tillman	Lt. Symons	Camp 33.
1877	Genoa	Nev	56 B	α Lyræ Polaris β Libræ, S. γ Ursæ Majoris	38 59 24	4627.9	16 47	Cal. II	Lt. Macomb	Lt. Symons	Camp 1. 1 mile east.

Geographical positions from sextant observations, variations of needle, altitude, &c.—Continued.

Year.	Station.	State or Territory.	Atlas-sheet.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of the needle east.	Party.	Observer.	Computer.	Remarks.
					° ′ ″	*Feet.*	° ′				
1877	Gunnison River	Colo	61 A	α Coronæ Borealis Polaris Markab Altair	38 45 52.3	5017.7	14 34	Colo. I	Lt. Bergland	Lt. Symons	Camp 39.
1877	Gunnison River, near mouth White Earth Creek.	Colo	61 A	Sun Altair α Ophiuchi Polaris	38 27 48.2	7258.1	14 49	Colo. I	Lt. Bergland	Lt. Symons	Camp 47.
1877	Hawkins Creek, near Head of.	Idaho	32 D	Altair β Herculis α Andromedæ Polaris	42 31 45.8	5304.0	22 47	Utah I	Lt. Young	Lt. Young	Camp 74.
1877	Hays Station	Cal	56 B	α Lyræ α Pegasi α Arietis Polaris	38 19 46.5	5957.5	15 47	Cal. II	Lt. Macomb	Lt. Symons	Eureka Valley.
1877	Hitching's Ranch	Idaho	41 A	Arcturus α Cygni Polaris α Ophiuchi	42 14 20	5205.4	17 49	Utah II.	Lt. Birnie	Lt. Symons	Camp 19.
1877	Indian Creek	Idaho	41 B	α Lyræ γ Ursæ Majoris α Serpentis Polaris	42 05 44.7	6154.1	18 44	Utah I	Lt. Tillman	Lt. Symons	Camp 14.
1877	Indian Valley	Cal	56 B	Polaris α Cygni α Coronæ Borealis	38 35 33	8034.4	....	Cal. II	Lt. Macomb	Lt. Symons	
1877	Jack-knife Creek, Salt River Valley.	Idaho	32 D	Arcturus α Cygni α Ophiuchi Polaris	43 01 50.6	5755.3	18 27	Utah I	Lt. Tillman	Lt. Symons	Camp 39.
1877	Jess's Valley	Cal	38 D	α Cygni Arcturus α Ophiuchi α Coronæ Borealis Polaris	41 16 13.8	5274.3	....	Cal. I	Lt. Symons	Lt. Symons	On Brook's Creek.
1877	Jones's Ranch, Warner Valley.	Oreg	29 D	Polaris α Coronæ Borealis	42 24 27.7	4466.8	20 29	Cal. I	Lt. Symons	Lt. Symons	

1877	Lake City	Cal	38	B	α Andromedæ Altair, S α Pegasi β Pegasi α Coronæ	41 38 18.1	4547.0	....	Cal. I	Lt. Symons	Lt. Symons	
1877	10 miles S. E. Laketown, long. 111° 09′ 30″.	Utah	41	B	Altair, S Polaris Arcturus α Lyræ	41 45 08.3	6147.5	17 48	Utah I.	Lt. Tillman	Lt. Young	Camp 19
1877	Lakeview	Oreg.	38	B	Polaris α Coronæ Borealis β Pegasi	42 10 23.2	4825.1	19 24	Cal. I	Lt. Symons	Lt. Symons	
1877	Lane's Fork	Idaho	32	D	Polaris Altair, S α Cygni Arcturus	42 55 26.8	6635.4	18 26	Utah I.	Lt. Tillman	Lts. Symons and Young.	Camp 32.
1877	Lane's Ranch	Idaho	32	C	Polaris α Ophiuchi α Coronæ Borealis Polaris Markab	42 31 18.0	4322.6	18 37	Utah II.	Lt. Birnie	Lt. Symons	Marsh Lake.
1877	Lassen's Creek	Cal	38	B	Altair β Pegasi α Coronæ Borealis Polaris	41 51 18.3	5145.6	18 11	Cal. I	Lt. Symons	Lt. Symons	Camp 48.
1877	Lava Desert	Idaho	32	C	Altair, S α Coronæ Borealis Polaris Markab	42 59 03.9	4406.8	18 00	Utah II.	Lt. Birnie	Lt. Symons	Side Camp "G."
1877	Little Blackfoot River, near Caribou Road.	Idaho	32	D	Altair α Cygni Polaris Arcturus	42 56 56.0	6144.5	18 52	Utah I.	Lt. Tillman	Lt. Symons	Camp 36.
1877	Los Pinos Agency	Colo	61	A	α Ophiuchi Arcturus α Cygni	38 20 00.7	1471.5	14 41	Colo. I.	Lt. Bergland	Lt. Symons	Camp 27.
1877	Malade City	Idaho	41	B	α Ophiuchi Polaris Altair Polaris α Lyræ	42 11 03.1	4659.1	17 44	Utah II.	Lt. Birnie.	Lt. Symons	
1877	McConnaha's Ranch	Cal	56	B	α Arietis Markab α Serpentis, S Polaris	38 46 22	3980.8	16 06	Cal. II	Lt. Macomb	Lt. Symons	
1877	Meadowville, near	Utah	41	B	α Lyræ Arcturus α Serpentis, 2 Polaris, 2 α Lyræ, 2 [Arcturus, 2	41 50 40.2	5975.0	18 01	Utah I.	Lt. Tillman	Lts. Symons and Young.	Camp 18.

Geographical positions from sextant observations, variations of needle, altitudes, &c.—Continued.

Year.	Station.	State or Territory.	Atlas-sheet.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of the needle east.	Party.	Observer.	Computer.	Remarks.
					° ′ ″	*Feet.*	° ′				
1877	Mink Creek	Idaho	41 B	Polaris	42 12 50.6	4741.7	17 51	Utah I	Lt. Tillman	Lt. Symons	Camp 51.
				Altair							
				Markab							
				α Coronæ Borealis							
1877	Mud Meadows	Nev	39 C	ξ Bootis	41 20 11	4318.0	18 20	Cal. I	Lt. Symons	Lt. Symons	Camp 58.
				Polaris							
				α Andromedæ							
1877	Near junction of Salt, John Gray's, and Snake Rivers.	Idaho	32 B	Arcturus	43 10 03.3	5510.6	18 31	Utah I	Lt. Tillman	Lt. Symons	Camp 40.
				α Cygni							
				α Ophiuchi							
				Polaris							
1877	North Cañon	Utah	41 B	α Arietis	41 59 53.9	4996.0	....	Utah I	Lt. Young	Lt. Young	Camp 94.
				Altair							
				Polaris							
				Markab							
1877	Near Ojo Seco	N. Mex	84 A	α Coronæ Borealis, W.	33 39 50.2	5258.4	11 47	Colo. II	Lt. Morrison	Lt. Symons	Camp 61.
				α Pegasi, E.							
				Polaris, N							
1877	Pinto Springs	Nev	38 B	Altair, S.	41 18 05.6	5638.8	19 42	Cal. I	Lt. Symons	Lt. Symons	Camp 63.
				α Coronæ Borealis							
				γ Pegasi							
				Polaris							
1877	Poison Valley	Cal	56 B	α Coronæ Borealis	38 28 53.1	8029.3	16 53	Cal. II	Lt. Macomb	Lt. Symons	Camp 41.
				Altair							
				Markab							
				Polaris							
1877	Port Neuf River	Idaho	32 D	α Coronæ Borealis	42 46 58.3	5279.7	18 44	Utah I	Lt. Tillman	Lt. Symons	Camp 57.
				Altair							
				Markab							
				Polaris							
1877	Port Neuf, on	Idaho	32 C	α Andromedæ	42 51 38.8	4421.9	18 29	Utah II	Lt. Birnie	Lt. Symons	Camp 67.
				Polaris							
				ε Pegasi							
				α Lyræ							
1877	Raft River, near head	Utah	41 A	α Lyræ	41 46 31.7	6723.1	18 46	Utah II	Lt. Birnie	Lt. Symons	Camp 11.
				α Ursæ Majoris							
				α Serpentis							
				Polaris							

1877	Rattlesnake Creek	Idaho	32 C	α Andromedæ Polaris ε Pegasi α Lyræ	42 38 23.6	5177.5	....	Utah II	Lt. Birnie	Lt. Symons	Camp 70.
1877	Robbins's Ford, Bear River	Idaho	41 B	Markab α Coronæ Borealis Altair Polaris	42 09 52.6	4620.7	17 48	Utah I	Lt. Tillman	Lt. Symons	Camp 48.
1877	Rock Creek	Idaho	32 C	Arcturus α Cygni Polaris α Ophiuchi	42 37 24.3	4513.8	18 15	Utah II.	Lt. Birnie	Lt. Symons	Camp 23.
1877	Sawyer's Ranch	Cal	56 B	α Serpentis, S α Lyræ, E Arcturus, W Polaris, N	38 49 31	7654.0	16.30	Cal. II	Lt. Macomb	Lt. Symons	
1877	Shadow Lake	Idaho	32 C	α Coronæ Borealis Polaris Altair	42 43 01.0	4309.8	16 04	Utah II.	Lt. Birnie	Lt. Symons	Camp 52.
1877	Smoky Creek	Wyo	32 D	Arcturus, 2 Polaris, 2 α Cygni, 2 α Ophiuchi, 2	42 46 49.7	6181.4	18 25	Utah I	Lt. Tillman	Lts. Symons & Young.	Camp 31, two miles east Oneida Salt Works.
1877	Snake River	Idaho	32 C	α Coronæ Borealis Polaris Markab Altair	42 42 34.1	4275.3	17 46	Utah II	Lt. Birnie	Lt. Symons	Camp 37 (near).
1877	Snake River	Idaho	32 C	α Coronæ Borealis Polaris Markab Altair	42 39 20.1	4242.0	17 59	Utah II.	Lt. Birnie	Lt. Symons	Camp 57.
1877	Snake River	Idaho	32 C	α Andromedæ Polaris	42 34 41	4320.0	18 07	Utah II.	Lt. Birnie	Lt. Symons	Camp 58.
1877	Soda Springs Village, one-half mile north.	Idaho	32 D	α Cygni Arcturus Polaris α Ophiuchi	42 39 58.2	5778.3	21 10	Utah I	Lt. Tillman	Lts. Symons & Young.	Camp 35.
1877	South Fork House	Cal	56 B	δ Ophiuchi, S α Lyræ Arcturus Polaris	38 56 55.8	5192.5	....	Cal. II	Lt. Macomb	Lt. Symons	
1877	Saint Charles Cañon	Idaho	41 B	α Lyræ Arcturus Polaris	42 05 12.7	6359.4	18 08	Utah I	Lt. Tillman	Lt. Symons	Camp 11.
1877	Sublette's Creek	Idaho	41 A	α Ophiuchi α Coronæ Borealis α Cygni Polaris	42 19 18.3	5360.6	18 07	Utah II.	Lt. Birnie	Lt. Symons	Camp 21.
1877	Susanville	Cal	47 A	α Serpentis Polaris α Lyræ Arcturus	40 24 59.1	4287.0	18 21	Cal. I	Lt. Symons	Lt. Symons	

Geographical positions from sextant observations, variations of needle, altitudes, &c.—Continued.

Year.	Station.	State or Territory.	Atlas-sheet.	Objects observed.	Latitude.	Altitude above sea-level.	Variation of the needle east.	Party.	Observer.	Computer.	Remarks.
					° ′ ″	Feet.	° ′				
1877	Sweetzer's Ranch	Idaho	41 A	Arcturus α Cygni Polaris	42 15 34.9	4509.3	17 28	Utah II.	Lt. Birnie	Lt. Symons	
1877	Toll's Ranch	Cal	56 B	α Ophiuchi α Lyræ Arcturus Polaris	38 58 28.0	6765.8	17 23	Cal. II	Lt. Macomb	Lt. Symons	
1877	Tin-cup Run, south of Mount Pisgah.	Idaho	32 D	α Ophiuchi Polaris	42 58 54.0	6537.2	18 32	Utah I	Lt. Tillman	Lt. Symons	Camp 38.
1877	Tragedy Springs	Cal	56 B	α Cygni α Lyræ γ Ursæ Majoris Polaris	38 38 04.5	7988.8	16 43	Cal. II	Lt. Macomb	Lt. Symons	
1877	Trail Creek Cañon	Idaho	41 B	α Serpentis, S α Andromedæ α Lyræ ε Pegasi Polaris	42 00 38.9	5153.0	....	Utah I	Lt. Young	Lt. Young	Camp 84.
1877	Twin Springs	Idaho	41 A	Markab α Lyræ α Arietis Polaris	42 15 44.3	5207.5	....	Utah II.	Lt. Birnie	Lt. Symons	Camp 77.
1877	West Fork W. Walker River.	Cal	56 B	α Lyræ β Andromedæ Polaris	38 20 08.5	6723.9	....	Cal. II	Lt. Macomb	Lt. Symons	Camp 54.
1877	Willow Creek	Nev	38 B	Markab β Pegasi Altair, S Polaris	41 26 18.4	4714.2	18 39	Cal. I	Lt. Symons	Lt. Symons	Camp 54.
1877	Wood River	Idaho	31 D	ξ Herculis Polaris α Coronæ Borealis Markab Altair	43 05 43.9	4373.4	19 30	Utah II.	Lt. Birnie	Lt. Symons	Side camp "E."
1877	Wood River	Idaho	31 D	Altair α Ophiuchi α Coronæ Borealis Polaris Markab	43 07 36.2	4518.6	19 44	Utah II.	Lt. Birnie	Lt. Symons	Side camp "F."

GEODETIC AND TOPOGRAPHICAL.

Five measured and developed bases were established at the following localities: (1) Ogden, Utah, connecting with the observatory at that point; (2) between Terrace and Lucin, on the Central Pacific Railroad; (3) at Austin, Nev., to connect with the astronomical station established in 1871; (4) at Bozeman, Mont., connecting with the astronomical station occupied in 1873; and (5) Verdi, Nev., connecting with the station of the United States Coast Survey here established in close proximity to the 120th meridian.

OGDEN BASE.

The line is located along one of the main streets of Ogden, Utah. It was marked prior to the measurements by iron bolts at intervals of 200 feet, the extremities being permanently marked by 5-foot iron rods, encased in cement-laid brick piers. Duplicate measurements with a 50-foot compensated steel tape, held at a constant tension, were made in addition to two measurements with a 20-foot wooden rod, carrying a scale on either end divided to hundredths of an inch. The points at which these scales were read for each measurement are marked by lines finely engraved on a silvered surface attached to each of the cast-iron blocks upon which the ends of the rod rest. The inclination of the rod was observed at each measurement by means of a clinometer attached near the center. At every fifth measure temperature readings were made upon two thermometers attached to the ends of the rod. The rod and tapes were compared with 5-foot standard rods, at the morning and evening of each measuring-day. The two observers handling the rod were required to read both scales at each measurement. The mean of the four determinations (two sets of readings to each measure) is 23209.007 feet=4.395 miles. The line was measured by assistants Dr. F. Kampf, Miles Rock, and Charles J. Kintner. The rod used in the above measurement is described on page 1219 of the Annual Report for 1877.

TERRACE BASE.

This line was measured between Terrace, Utah, and Lucin, both stations on the Central Pacific Railroad, between which the track follows sensibly a straight line. Its total length is 121318.0478 feet, or 22.9768 miles. The measurement was made with a 50-foot compensated steel tape held at a uniform tension, adjusted to a temperature of 80° Fahrenheit, and compared morning and evening with standard metallic rods, the temperature being observed at every fifth distance of 50 feet. For a distance of 3,500 feet from Terrace the measurements were made on posts firmly driven, marking the ends of the tape with common pins. The remainder was measured upon the north rail of the track, a cold chisel being used to mark the rail near the extremities of each 50-foot distance. Each mark was made a little in advance of the notch in the tape, the excess then being measured by a steel rule graduated to $\frac{1}{100}$ of an inch. The first measurement from Terrace was made by Assistant Charles J. Kintner, and the return by Assistant Francis Klett. The line was first reduced to the horizontal by using the levels as furnished by Lew Tashiera, division engineer of the Central Pacific Railroad. The line has since been leveled, between the extremities of each 50 measured feet, by Lieutenant Young, Corps of Engineers.

AUSTIN BASE.

This line was measured in Reese River Valley, near Austin, Nev., its measured lengths being as follows: first measurement, 21389.66 feet; second measurement, 21391.09 feet; mean length, 21390.375 feet = 4.012

miles. A 50-foot compensated steel tape was used, the ends of each line being marked by pins on wooden benches. The temperature was recorded at the end of each 500 feet. A double line of levels was run between the extremities. The measurements were here made by Assistants Charles J. Kintner and Francis Klett.

BOZEMAN BASE.

This line was located in Gallatin Valley, about 2 miles west from the astronomical monument at Bozeman, Mont. Its length, being the mean of two measurements, is as follows: First measurement, 24126.792 feet; second, 24127.217 feet; difference, .425; mean length, 24127.004 feet =4.569 miles. The line was measured by a 50-foot compensated steel tape, at first employing wooden pins driven 50 feet apart, and again on wooden benches 18 inches high. The line was leveled using the above stations. Temperatures were noted for every change of 10 degrees. The tape was twice compared with standard steel rods. The line was measured by Lieut. Samuel E. Tillman, Corps of Engineers.

VERDI BASE.

This line was measured with a 50-foot compensated steel tape, used at a constant tension, near Verdi, Nev., on the Central Pacific Railroad. The measurement by Lieutenant Symons gave 8522.52 feet; by Assistant Spiller, 8522.385 feet; mean, 8522.45 feet=1.614 miles. The separate measurements were marked by common pins on wooden pins firmly driven, and levels taken between each of these distances. Temperatures were recorded at each advance of 400 feet. The tape was compared morning and evening with standard steel rods.

Observations have been made to establish the number of outlying triangles necessary to the development of each of the five bases, and their connections with the initial astronomical points of the vicinity, and with the vertices of the main triangles adjacent. Azimuths of the bases and of selected sides of triangles have been observed. The necessary number of main triangulation stations in areas surveyed by the Colorado, Utah, and California sections, for the establishment of well-conditioned belts of triangles, quadrilaterally disposed, have been occupied. Secondary triangulation stations, using natural objects, principally minor mountain peaks, mark the vertices of a series of triangles embracing special ranges and mountainous areas. From main triangulation stations cross-sight pointings on as many outlying prominent natural objects, usually in advance of the area under survey, are made, thus establishing approximately a number of points lying in contiguous areas, for reference in subsequent years. The number of these points and meander stations has been determined by the character of the profiles of the roads, trails, streams, &c., necessary to be traversed in order to obtain the detailed topographical data required. The measured miles within a given area note to some extent the character of its drainage and of the routes through it, and the most practical lines that can be delineated upon a general map are the natural lines of drainage and the routes of communication, present and prospective, all of which are required to be measured. The magnetic variations at each camp have been taken, as also on prominent peaks, at settlements of note, &c. When practicable, known stakes, marking the surveys of the public lands, have been connected by triangulation with established points of the survey, and their geographical positions, in numbers of cases, can thus be checked.

The distances, azimuths, triangles, longitudes, and latitudes computed, as shown in the résumé of office work, are at once made available in map construction, and where considered of sufficient importance are added to the special lists being prepared for publication.

The areas surveyed topographically in 1877 embrace portions of the following drainage basins: the northwestern arm of "the great interior basin," with the basins of the Pecos, Rio Grande, Arkansas, Gunnison and its tributaries, Bear and Snake Rivers, and creeks entering the latter to the southward, together with areas bordering on a number of streams leading out from the Sierra Nevada to the interior plain-like valleys of Central California. The instructions for the year 1877, as well as of the season of 1878, indicate that the weight of the observations shall be directed to the data of the highest grade, the measure of success to be determined by the largest number of observations of the highest order of accuracy, rather than governed by the area covered within a specified interval. The flow of streams of importance within the region of survey, to the number of eleven, together with forty creeks and ditches by estimation for the past season, has been gauged, and from time to time results of this work will be published. The instructions for taking notes for determining approximately the classification of the lands contemplate a division into the following classes, viz:

1. Agricultural { without irrigation. / with irrigation. }
2. Timber: { 1. Large / 2. Small } with prevailing species.
3. Grazing: { 1. Good / 2. Bad } with species and quality of grasses.
4. Arid or barren, including rock exposures.
5. Location of the precious and economic minerals, such as—
    1. Gold, in place or placer.
    2. Silver.
    3. Copper.
    4. Lead.
    5. Iron.
    6. Coal.
    7. Tin.
    8. Antimony.
    9. Sulphur.
    10. Alum, sulphur, and borates.
    11. Peats, marls, and clays.

Parties one and two of the Utah section traced the Bonneville Beach, or outlines of an ancient lake, at one of its stages, noticed by members of the expedition of 1872, mentioned by Mr. Gilbert in his report (see Vol. III, Geology, page 91), a plat of which accompanies the sheets of the Geological Atlas, from Ogden, Utah, to the northward through Cache Valley, thence west through Malade Valley. The information thus obtained suffices to complete the outline of the ancient sheet of fresh water for which Mr. G. K. Gilbert suggested the name of "Lake Bonneville." The barometer profile through Red Rock Pass indicates an elevation of 4,893 feet above sea-level. The elevation of Bonneville Beach, near Salt Lake City, obtained by connecting with railroad levels at Corinne, Utah, is 5,178 feet. This value for its level is as accurate as can be obtained until levels of precision by trigonometrical methods extending across the continent shall have been run. The levels of other points of this beach have also been checked, and this subject will be pursued further in connection with the topographical and hydrographical survey of Great Salt Lake Basin, now in progress.

At the close of the season of 1878 the topographical work of the survey will have extended from the Columbia River, between Dalles and Wallula on the north, to the Mexican border near El Paso at the south, and from the 103d meridian near Fort Lyon, Colo., on the east, to the Pacific coast between Los Angeles and Santa Barbara. Where the settlement of the country justifies, detail for a map of a scale of one inch to four miles is gathered, while in localities of special industrial interest, as mining-regions of more than ordinary prominence, still more details of the topographical contour are observed, and maps of a scale to correspond are made. All of the special sheets thus resulting are finally to be reduced to the scale of one inch to eight miles, and then appear as integers, each connecting with those surrounding, to make up the great map, in ninety-five sheets, of the entire region.

SURVEYS OF GREAT SALT LAKE BASIN.

The special topographical and hydrographical survey of the Great Salt Lake Basin, that has for its object, in addition to the detailed topographical survey of the region, an accurate meander of the shores of the lake and its islands, with soundings necessary for the determination of its present volume; observations upon the evaporation of its surface with periodic rise and fall; the measurement at different seasons of the inflow and rainfall, with other meteorological observations at selected stations upon its affluents, was commenced by Lieutenant Young during the winter months with a small force, as time in connection with other duties was available. The Jordan, Weber, and Bear Rivers, the principal sources of supply, were gauged, and the depth, width, and velocity of forty entering creeks and ditches measured by estimation. Nearly two-thirds of the meander was completed and a number of soundings made. Nine main and secondary triangulation stations were occupied, 128 three-point stations, and 255.8 miles measured along the meander. Cistern-barometer observations were made at 134 stations, and aneroid observations taken at 273 points. It is intended to continue to completion during a subsequent season the part of the work about the lake, which may be done at inconsiderable expense.

METHODS.

Anticipating in part the extended exemplification of the "methods of survey" to appear in Vol. I of the quarto reports, a brief statement is presented, concerning the instruments employed, observations made, computations and other reductions in use upon the survey.

The observations and reductions necessary for map constructions from original data will first receive mention, followed by allusion to the examinations made in the special subjects of mineralogy and mining, geology, paleontology, zoölogy, botany, and archæology.

The projection and scale upon which the map is to be made having been determined, geographical points, the co-ordinates of which are necessary as a basis for its construction, are obtained by means of astronomical, geodetic, topographic, and barometric observations. The classes of points employed in the horizontal projection of the main objects observed are: (1) main astronomical, (2) secondary astronomical, (3) sextant latitude, (4) main triangulation, (5) secondary triangulation, (6) cross-sight, (7) three-point, and (8) meander. The determinations for altitude result from barometric observations and from angles of elevation and depression. The initial points to which the geodetic and topographical determinations are referred, and by which checked, are established at the main and secondary astronomical stations. The sextant latitude stations check a special class of points on extended meanders. The number of main and secondary astronomically determined points required for checks over the entire area is comparatively few. The probable error of the resulting longitudes and latitudes is a minimum for the class of instruments and observations employed.

Field.

MAIN ASTRONOMICAL STATIONS.

The main astronomical stations, selected upon or at the termini of telegraph lines, and at intervals of from 250 to 300 miles, checking belts of triangles, are occupied with the best field astronomical instruments, the comparison of times being made by telegraphic exchanges. Near each point a base is laid out, measured, and connected therewith, and observations made at the vertices of triangles so disposed as to completely envelop the base and initial astronomical point, and to furnish computed bases to which the main triangulation stations next adjacent can readily be referred. The observations taken at the vertices of the triangles surrounding the base are similar in number and accuracy to those at main triangulation stations, and one initial point answers for each and all of the belts of triangles centering at a single base. The set of instruments and apparatus used at a main astronomical station are one combined meridian transit of 26 or 30 inch focal length, with appurtenances, or

1 astronomical transit, and
1 zenith telescope.
1 astronomical clock or break-circuit chronometer.
1 chronograph, and
1 personal equation apparatus.
1 connecting switch-board.
2 break-circuit keys.
1 battery of two jars, insulated connecting-wire, and battery fluid.
150 yards extra telegraph wire.
1 observing-tent, and the usual meteorological instruments, hereafter mentioned.

The observations are generally made from a brick pier surmounted by a stone slab, upon which the base of the instrument rests. This observing-pier acts as a permanent monument marking the spot, and may be available at a subsequent period for other astronomical observations.

The meridian is marked by north and south piers of stone, securely planted at conspicuous localities. The monument and meridian marks fix upon the ground a line, the length and true azimuth of which become known with much accuracy.

An hourly series of meteorological observations, including as long an interval as possible, is made at each main station.

The method of making and recording the observations for time and latitude, exchanging signals, computing results, and placing the same in form for publication, is shown in Vol. II of the quarto reports. The mean probable error at twenty stations, at which there is an average number of determinations of longitude of at least five, is found to be $\pm 0''.27$, and at the same stations, with an average number of determinations of latitude of at least one hundred and thirty-five, there appears a mean probable error of $\pm 0''.08$. The number of main astronomical stations that will have been established at the close of the season of 1878 is 32.

SECONDARY ASTRONOMICAL STATIONS.

These differ from the main stations more particularly in the lesser accuracy with which time and latitude are determined. The instruments used are the sextant and artificial horizon, with a mean solar or sidereal box or pocket chronometer. The observations are wholly by eye and ear. The exchanges, instead of by automatic signals, are arbitrarily selected and transmitted by the observers at the sending and receiving stations. An illustration of the manner of conducting observations at one of the statio ns, although still subject toimprovement, is shown in

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the Preliminary Report of the Reconnaissance of 1869. This class of observations may be availed of at stations far distant from railroad communication, thereby saving time and expense and the endangering of instruments by their transportation in rude vehicles over rough roads for long distances in the interior. The observations for time and latitude are similar in every respect to those employed in latitude observations, except that more weight is attached to the time determinations, and the number of sets of observations is multiplied and extended over a longer interval. The usual meteorological observations are made, and it is often found practicable to prosecute an hourly series of these at secondary astronomical stations. The point of observation is usually marked by a strong stone pier. The reductions are the same as those given in the next heading, and the probable error of time determinations and the resulting comparisons may or may not be determined by the aid of "least squares."

SEXTANT LATITUDE STATIONS.

Points are checked in latitude and approximately in longitude by sextant observations for time and latitude along measured lines that traverse long cañons, mountain defiles, or low valleys and ravines, that admit of but few three-point stations, the horizon of distant elevated points being intercepted by intervening obstacles. Observations of this grade are made at most of the camps occupied while surveying a given region. The instruments used are a sextant, with an artificial horizon, a mean solar or sidereal box or pocket chronometer. The usual meteorological observations are made during the interval. The local time is determined by sets of observations of single or double altitudes of the sun, or certain selected east and west stars. The latitude results from sets of circummeridian altitudes of selected south stars and altitudes of Polaris, arbitrarily selected. For each set of south-star observations a corresponding set of Polaris observations is required, and the same for the meridian altitudes of the sun. The record forms required for observations and computations are: (1) sextant observations; (2) time by single altitudes; (3) time by double altitudes; (4) latitude by Polaris; (5) latitude by circummeridian altitudes. The probable error of a mean latitude as determined from two sets of south star and three sets of Polaris observations $= \pm 1''.45$. (See Preliminary Report of 1869, p. 35.)

GEODETIC AND TOPOGRAPHICAL.

It becomes important to determine astronomically the longitudes and latitudes of a sufficient number of stations as points of departure for surveys, and as subsequent checks upon an extended triangulation. It having been determined upon to prosecute the survey over a given region, the most convenient astronomical station is selected, if one has been determined within or sufficiently near the area, or else observations to determine the co-ordinates of a well-selected point must be made. The location of the site for a base-line in the vicinity is selected, if practicable, upon a plain or in a valley surrounded by mountain ridges, so that its direction shall be nearly coincident with the longer axis of the curve passing through the triangulation points lying within its horizon. The extremities of the base are then permanently marked, and frequently stations along it. Base measurements have been, until the year 1876, made by the use of a compensated steel tape, held at a constant tension, compared frequently with standard rods, allowance being made for temperature. A wooden rod, approximately 20 feet in length, described on page 1219, Annual Report for 1877, is now used, careful comparisons being made before and after each day's measurement. Each base is measured at least twice, or forward and backward, and the mean of the results taken. The difference in level between the extremities and at each end of one measured length is determined by the use of an ordinary Y-level. The astronomical azimuth of the base is determined from either extremity, and from one of the extremities to the end of a developed base being the vertex of one of the surrounding triangles. The vertices of the surrounding triangles are so selected that the direction of the line of greatest distance between any two is such that this triangular side with each of the two others joining with the majority of the main triangulation stations shall make a number of well-shaped or as nearly isoceles triangles as possible. From observations made at the vertices of a sufficient number of triangles, a proper connection is made between the initial astronomical point and each of the main triangulation stations surrounding it. The grade of the observations made at developed triangulation points is the same as that employed at the main stations.

MAIN TRIANGULATION STATIONS.

These are selected in advance, usually prominent mountain peaks, buttes, mesa edges, and from among natural objects easily identified, so that the triangles of which they become the vertices shall be as nearly equilateral as practicable. Main triangles usually quadrilaterally connected, having sides from twenty to sixty and seventy miles in length, cover the entire area. Sides of trangles of greater length than forty miles are to be avoided when possible. From six to ten and twelve pointings are made from each station to each adjacent station of the same order within the horizon.

The instrument used* is a transit theodolite of 10 or 8 inch limb, graduated to read by vernier to 5 or 10 seconds in arc, and with magnifying power sufficiently strong to recognize objects at a distance of seventy-five miles in the rare, clear atmosphere of the Western mountains. Both vernier and repeated angles are read at each station. A profile of the entire horizon, usually consisting of mountain ridges, is then made, serving to identify distant stations and aiding also the topographer. Angles of elevation and depression are read to the most prominent mountain peaks. The azimuth of one side of each triangle is required. Incidentally the variation of the needle is determined. The set of meteorological observations is taken at extremities of measured and developed bases, and also main and secondary triangulation stations. The point is marked by a compact, conical-shaped mound of stones, in which a staff is firmly imbedded. A record of the occupation, on parchment paper, incased in a metallic box, is left buried in the cairn.

The accuracy and refinement with which measurements and observations are made at bases, main and secondary triangulation and other topographical stations, are to be varied in accordance with the scale required for the map and the importance of the region under survey.

The computed positions of the main stations give the co-ordinates of a large number of initial points not alone of value in the mapping enterprises of the present day, but which will prove of permanent usefulness in the future, as more details are added to existing maps, and might now be availed of with advantage to the land surveys in checking their main and minor lines.

* The triangulation instrument used at the main triangulation stations is the result of the experience of the survey, combining portability and strength with the requisite accuracy. It may also be available for astronomical time and azimuth observations.

SECONDARY TRIANGULATION STATIONS.

These stations are selected among minor peaks and natural objects, usually at lower altitudes than the main stations. The belts of triangles connecting these stations do not necessarily make a network covering the entire area, but embrace the mountain portions lying between the valleys and plains. The observations are frequently made with the same instruments and in like manner to those at the main stations, with fewer multiplications. A triangulation instrument of lesser graduation and focal power may be used, and the observations repeated from three to five times. The horizon sketch, barometric observations, &c., are the same as at main stations. The sides of the secondary triangles vary in length from two to twenty miles.

CROSS-SIGHT STATIONS.

These points lie outside of the area being occupied, and are such as may be available for main triangulation stations for occupation in subsequent seasons. From the main station at which pointings are taken these stations are treated the same as a distant main triangulation station, and they come into the system of triangulation as the same is extended to include them.

THREE-POINT STATIONS.

These may be minor peaks or topographical objects, but are usually taken along measured lines. Each station must be in clear view of three others determined in position as main or secondary triangulation stations. The readings are made by a transit theodolite, graduated to read by vernier to one minute. Aneroid readings are always taken, but not necessarily the full set of meteorological observations, variation, &c., as is required at main and secondary stations. The number of this class of stations is great as compared with main and secondary stations. The longitude and latitude of the most important are computed, and others are reduced graphically.

MEANDER STATIONS.

These occur at short intervals along the measured lines that follow the roads, trails, streams, divides, natural routes of communication, and, in fact, over nearly all traveled routes. The angles of deflection of the line and its azimuth, from given points, are read by a transit theodolite specially made for the survey, of three and a half inch limb, and graduated to read to minutes in arc by the vernier, and of focal power necessary for distances not exceeding twelve miles. The observations at these stations are made by the topographer and recorded upon book blanks of special form; those at the three grades before mentioned by the observer, and are recorded upon special forms. The number of meander stations is determined by the sinuosities of the road, the complexity of the topography, and the scale required for the map.

The assistant engaged upon topographical work takes the necessary angles and sketches at all the stations of the several grades, and records them in blank forms specially prepared for the uses of the survey, the principal of which are the "mountain station" and "topographical" books. The observations at main and secondary triangulation stations include a profile sketch of the entire horizon, the marked points being governed by measured angles, a horizontal sketch in contour of the declivities from the summit to the levels of the adjacent valley or plain, particular attention being paid to the character and direction of drainage, sources of which are usually found at each station occupied. Horizontal sketches of the adjacent topography are made at each "three-point" and "meander" station, and sketches at points arbitrarily selected of all marked topographical reliefs. He also notes the changes in elevation given by the aneroid readings, and enters at each station all notes of practical importance, whether actually needed for the map or indicative of the surface of the country, and the limits of the grades of land that are required to be designated. Each horizontal sketch thus made should overlap each succeeding one, and each sheet of the topographical record-book serves as a rude plane table, the reductions from which, referred to the initial points of the several grades, make a connected plot completely delineating the area entire. Measurements along the roads, trails, water-courses, &c., result from the number of revolutions, indicated by an odometer, of a single wheel attached by shafts and other rigging to an animal, usually a mule, ridden by the observer. The actual number of revolutions to the mile made by the wheel is found from practical tests on different classes of traversed routes, and also over the different profiles found of each class. Tables are then prepared, from which the distance for any given number of revolutions can be taken, the arguments being the character and profile of the route and the number of revolutions per mile resulting therefrom. The recorder enters also the aneroid readings at each station of the route, indicates the character of each camp, as to wood, water, grass, and other camping facilities. He notes also the general character of the country, its opportunities for travel, the nature of the landscape, the amounts of timber and grass, and information concerning springs, streams, &c. In plotting the measured meanders allowance is made for the sinuosities of the road and the differences in elevation. The former is reduced by estimation; the latter is governed by the aneroid profiles.

In addition to the number of altitudes resulting from cistern and aneroid barometer observations, those deduced from vertical angles of elevation and depression taken by the topographer upon all marked points from each of the stations form no inconsiderable number. Variations of the needle are determined at each camp and at all stations of importance. The method employed is by observations upon Polaris at its elongation, the most rapid and accurate where an ordinary field-transit theodolite is employed, or by observing the magnetic azimuth of Polaris at any of its hour angles, the local time being given or known. The magnetic needle is not used in observing courses, except along unimportant meanders, and its use is to be discouraged even in these cases.

The degree and amount of evaporation are determined on lakes, ponds, and rivers of importance, and streams are gauged usually at their point of leaving the foot-hills for the valleys or plains. For the latter measurements the method given in Lee's tables has been adopted.

The instructions contemplate a connection, trigonometrically or by offsets, with stakes marking the surveys of the public lands where found. In the case of offsets the compensated steel tape or chain is used. The section of the survey bordering on the Pacific coast has been directed, where practicable, to join, by a triangulation connection, with monuments and stakes of the United States Coast Survey. The same holds good in all the sections with regard to monuments of the boundary lines between political divisions.

The recording of the notes upon which to base the delineation of the land traversed into agricultural, non-agricultural, timbered, grazing, mineral, &c., is now made mandatory. The data are entered in the topographical field-books, and the description is prepared by the chief of party and the topographer.

Magnetic observations for the determination of declination, dip, and intensity are taken, when practicable, at main astronomical stations, by means of a portable magnetometer and dip ci cle.

BAROMETRIC ALTITUDES.

Differences in altitude resulting from barometric observations are obtained for each of the stations of the several grades of observations. These are divided into *cistern* and *aneroid* barometer observations. A set of the cistern barometer observations consists of the reading of the mercurial column by a vernier scale, and of the attached thermometer for temperature of the column, and of the wet and dry bulb thermometers. The anemometer, when at hand, indicates the force of the wind, its direction, and the character and extent of clouds are estimated. The maximum and minimum thermometers are each recorded once during every twenty-four hours. At main astronomical stations the rain-gauge is also employed. Aneroid barometer readings are, in all cases, referred to those of the cistern barometer, and frequently during each twenty-four hours the comparative index error is determined. Aneroid observations consist of reading by the index arm the inches and decimals of an inch, and upon the altitude scale the number of feet, as also the attached thermometer. The general meteorological conditions are noted and the hygrometers are frequently read. The methods of observation, of reduction, care, repair, and filling of instruments are described in the manual of instructions.

The temperature of mineral and thermal springs of the area surveyed is noted, and specimens therefrom taken for examination and analysis.

The difference of readings of the wet and dry bulbs in the atmosphere adjacent to and over surfaces of water, as lakes, ponds, hot springs, rivers, &c., is in many instances noted. For the observations in the branches of mineralogy and mines, geology, paleontology, zoölogy, botany, and archæology, usually made by experts and specialists, requiring but few instruments, the eye unaided so frequently noting phenomena, no formulated methods as guides have so far been devised. Different observers may reach the same results by slightly different methods. The collection of data is dependent upon the objects sought, whether scientific or practical. The results are the determination of the structural geology of the region, with characteristic profiles, the collection of fossils, vertebrates and invertebrates, from discovered beds. In mineralogy and mines the examinations take a wider range, involving engineering plans and methods of execution, as in the mining and milling of ores, &c. Specimens are, when practicable, collected illustrating the lithological characteristics of all grades of rock, deposits of ores, from saline, alkaline, borax, and other beds.

In zoology collections of mammals, birds, fishes, insects, &c., are made, and when a sufficient amount of any one class is secured, are placed in the hands of a specialist for examination and report. The same rule applies in botany. Many new and interesting discoveries have resulted, and knowledge of geographical distribution is thus increased. A study of the present and extinct Indian tribes, as to their habits, language, customs, burial places, mounds, &c., has developed much interesting archæological material, a part of which is reported upon in Vol. VII, forthcoming. Photographs of landscape and stereoscopic size have been made, illustrative of peculiar landscape features, of particular geological formations, of ruins, and of several Indian tribes.

Office.

The office reductions necessary in the construction of the map and accompanying report are, computation of the longitudes, latitudes, and altitudes of points of the several orders of value, determined astronomically, geodetically, and barometrically; the projection and construction of the preliminary plotting sheets, and of the resulting topographical maps, upon which the land classification and geological sheets are based; in the computations of latitudes and departures, and for variations of the needle, and in the reduction of the meanders and other topographical data; the preparation of tables of distances, of longitudes, latitudes, altitudes, variations, &c.; and in the reduction of magnetic and other observations. The reduction of the astronomical observations of two of the three grades employed has been adverted to, and those necessary for latitude results are made upon blank forms upon which are entered the arguments required in computations for errors of local times, from single or double altitudes of the sun or stars, from circum-meridian observations, and those upon Polaris off the meridian for latitude. The triangles are grouped in the best conditioned figures, and the necessary computations for the adjustments, distances, azimuths, longitudes, and latitudes are made, as indicated in the notes herewith upon geodetic computations. Computations are thus made of the main and secondary triangulation, cross-sight, and three-point stations.

The computations necessary for the determinations of differences ot altitude from cistern and aneroid barometer observations are made by referring each set of observations to one or more initial points well established in altitude, at which simultaneous observations have been taken, and by means of the methods so well pointed out by Bvt. Lieut. Col. R. S. Williamson, Corps of Engineers, in his treatise on the barometer. (See Professional Papers of the Corps of Engineers, No. 15.) The co-ordinates of the check-points having been determined, they are plotted upon a sheet projected upon a scale of 1 inch to 2 miles, known as the topographer's plotting-sheet. The projection employed, and for which co-ordinates are computed at the Washington office of the survey, as required, is that of a secant cone intersecting the spheroid in latitudes 34° and 44° north; the initial element of the cone being the line joining the points at which the parallels above mentioned are intersected by the 111th meridian of west longitude. The resulting maps admit of conjoining; and the amount of distortion, both in distance and azimuth, for so large an area is less in the aggregate than in the polyconic projection. The topographer, after the computation of the latitudes, longitudes, and meanders, reduces upon the field-plot all the topographical data, following the conventional signs adopted for these sheets.

The topographer's plot is a complete and accurate representation of all the topographical information secured in the field, adjusted to the projection upon which are laid down all the initial check-points upon which the work is based. Upon photographs of these plots the classification of the lands into grades is made, as also upon the completed map when reproduced by photolithography. The final sheets are drawn upon boards upon which paper has long been mounted, and by the same or secant-conic projection on a scale one-third larger than the published representation, *i. e.*, 1 inch to 4 miles and 1 inch to 8 miles, or to such scales as may be decided upon in order that the advantages resulting to photolithography from a reduction in scale may be secured. The finished map is prepared by office draughtsmen and the work is divided into construction, line-drawing and lettering, and hill-shading. The plotting-sheets are drawn in conjectural contours, and the final maps in both hachures and contours, as also by a combination of the two. To accurately represent the true contour or vertical relief of the ground upon a horizontal projection by conventional signs has long been a desideratum, several methods having been adopted. These resolve themselves into two distinct forms, (1) by contours and (2) by hachures. The first, for the highest use to which a map may be applied, *i. e.*, for construction purposes, where accurate working profiles are required, is well nigh indispensable. Such a use presupposes the accurate determination of a large number of points at short distances apart on each contour, an accuracy to which but few if any of the most refined surveys of the world have reached for large areas. The engineer's contour or the contour of precision is, it must be understood, far different from those the result of sketching between points of each contour determined at irregular intervals, that might be termed, in consequence, conjectural contours.

Contours have to some extent been used in this country as the basis upon which to delineate geology, thereby rendering the coloration of the formations as first in importance. Hachures, or lines normal to the contours, of two kinds, have been employed in certain foreign surveys: (1) of uniform strength and varying number per linear inch; (2) of uniform number per inch and varying strength. These have sometimes been called mathematical contours. In either of these forms they are stiff and inexpressive. The hachures employed upon the final maps of the survey are arbitrarily selected as to direction, number, and strength, allowance being made for light and shade, as best suits the scale where they have been employed. By combining the two (hachures and contours), the former being used only to represent the steepest declivities, the most striking effect is produced, the map is less obscured by heavy lines, and the more practical information, showing routes of communication, lines of drainage, settlements, &c., appears in bolder relief. Neither plan has yet been adopted by the survey, the hachure method having been most used. Each map is made a completed original, ready for reproduction by the camera, and becomes one of the most important records of the survey.

From the computation-forms the longitudes, latitudes, azimuths, altitudes, distances, variations, &c., are entered upon a book record specially prepared, and are held for reference or publication. The geology of the areas represented is shown by a scale of colors selected to indicate the different formations upon the topographical maps as a base. The three originals, (1) topographical, (2) land classification, (3) geological, of each map are filed as a part of the records of the survey. The reports of operations embrace a description of the annual labors of the survey and discussion of the results. The quarto reports aggregate results in special subjects, as geology, palæontology, &c., prepared by assistants engaged upon the survey, and by others, authorities in their several scientific branches. The methods pursued in the examinations upon data, and collections in mineralogy, geology, zoology, &c., requiring so much comparison and research, cannot be reduced to the exactitude of mathematical computations, map projections, and constructions, but are more the result of individual effort after long training and experience.

The field instruments that have been employed are as follows:

ASTRONOMICAL, GEODETIC, TOPOGRAPHICAL, AND BAROMETRIC INSTRUMENTS.

Astronomical transits.
Meridian transits (Coast Survey pattern).
Zenith telescopes.
Sextants and artificial horizons.
Astronomical clocks at observatories.
Mean solar and sidereal box-chronometers.
Mean solar and sidereal pocket-chronometers.
Mean-time watches.
Chronographs, cylinder and fillet patterns.
Personal-equation apparatus (survey pattern).

Connecting switch-boards (Harkness pattern).
Break-circuit keys and battery.

	Size of limb.	Reading in arc by vernier to—
Transit theodolites	10 inch	5 seconds.
Transit theodolites	8 inch	10 seconds (Survey pattern).
Transit theodolites	7 inch	30 seconds.
Transit theodolites	6 inch	60 seconds.
Topographers transit theodolites	3½ inch	60 seconds (Survey pattern).
Gradienter	3½ inch	60 seconds.

Levels and staffs.
Altazimuths.
Pocket sextants.
Prismatic and pocket compasses.
Magnetometers.
Dip circles.
Five-foot steel standard rods (U. S. C. S. pattern).
Twenty-foot wooden rods, with scales and stands.
Compensated steel tapes, 50 feet.
Steel and linen tapes, 50 feet.
Steel chains, 50 feet.
Odometers, with vehicles.
Pedometers.
Cistern-barometers, double vernier, with mountain attachment.
Mountain cistern-barometers (special pattern).
Aneroid barometers, reading to 20,000 feet (Survey pattern).
Hygrometers (Survey pattern).
Pocket thermometers.
High temperature thermometers.
Maximum and minimum thermometers (Survey pattern).
Anemometers.
Aerometers.
Rain gauges.
One set field drawing instruments, with protractors, scale, rules, and triangles.

The record forms for observations in the astronomical, geodetic, topographical, and barometric branches of the work exceed thirty in number, and are mainly the outgrowth of the practical experience of the survey, and particularly calculated to facilitate both field and office operations.

Thus a brief, imperfect glance at the methods employed has been given. For a more complete view, reference to the manuals for geodetic, topographic, and astronomical observations and their reduction, being prepared, and to the treatment of this subject in Vol. I of the quarto reports when issued, will be necessary.

The expenses of the survey up to March 8, 1878, are given in House Ex. Doc. No. 88, Forty-fifth Congress, second session, as follows:

The amount expended by the Engineer Department for this survey during the last ten years, including the preparation of reports, maps, and illustrations, has been $432,259. From this sum should be deducted the value of the instruments and other property on hand, amounting to the estimated sum of $57,000, and proceeds of sales of condemned property, amounting to $6,488.45, deposited in the Treasury of the United States, leaving a balance of $368,770.55.

The value of the aid and assistance received from the Quartermaster's Department in ten years, as reported by the Quartermaster-General (but not including certain vouchers not in his office, these vouchers being on file in the Treasury Department), has amounted to $85,238.70, from which should be deducted the value of quartermaster's property now on hand and available for the further use of the survey, $9,801.52, leaving a balance of $75,437.18. Lieutenant Wheeler, however, after a careful estimate, reports the *total* value of the aid and assistance of all kinds received from the Quartermaster's Department in the last ten years as $121,348. The Chief of Ordnance reports the total value of ordnance stores expended and lost within the last ten years, on the surveys west of the 100th meridian, as $4,062.63. This amount does not include the value of ordnance stores on hand and available for the further use of the survey, nor the deterioration of ordnance stores returned to the Ordnance Department, or to various military posts in the West, the amount of such deterioration being unknown. The value of the aid and assistance received from the Subsistence Department within ten years, as stated by the Commissary-General, has been $5,135.54. Transportation and office-rents have been paid for partly from the appropriations for the survey, and partly by the Quartermaster's Department.

GEODETIC COMPUTATIONS.*

ADJUSTMENT OF ANGLES.

When the angles at any station are to be obtained from vernier readings, the adjustment is made in the following manner: Take the means of the two vernier readings upon each point included in the observations around the horizon, for the reading upon that point; the two readings thus obtained for the point of beginning will usually differ;† when they do not, no corrections are to be applied to the readings. When there is a difference between the two readings upon the point of beginning, this difference is to be divided by the number of points observed upon; the quotient is the correction to be applied to the reading upon the second point. The corrections then increase in arithmetical progression, being applied in order to the consecutive readings. The corrections will all have the + or — sign, according as the measurement around the horizon falls short or exceeds 360°. Each set of observations around the horizon is to be thus corrected when necessary. The angles between the points are then derived by differences between consecutive readings in each set of observations. The means of the values for the different angles thus obtained are taken for the final values of the adjusted angles.

When the measurements at any station are repeated angles, the adjustment is made by the method of least squares, and is as follows: It is evident that between the n objects which surround any point, there are necessarily $n-1$ angles. Any angle measured between two points, not consecutive, is the sum of two or more consecutive angles; hence when all the angles are measured, any measure between points, not consecutive, gives an equation of condition. As many conditional equations as possible should be formed, care being taken that no one is introduced which is a consequence of two or more already considered. The sum of all the angles at a station should be 360°, and this rigid condition must always enter among the conditional equations. The method of forming the conditional equation is shown in the accompanying example.

Measured angles at station.

	° ′ ″		° ′ ″
(1) Castle—Sierra	20 07 37	(4) Peavine—Washoe ...	12 39 50
(2) Washoe—Castle......	21 23 24	(2) Washoe—Castle......	21 23 24
	42 31 01		34 03 14
(3) Washoe—Sierra	42 30 49	(5) Peavine—Castle......	34 03 12
	12		02
(6) Summit—Washoe ...	11 47 00	(8) Onjumi—Peavine ...	25 14 18
(3) Washoe—Sierra	42 30 49	(4) Peavine—Washoe ...	12 39 50
	54 17 49		37 54 08
(7) Summit—Sierra	54 17 56.5	(9) Onjumi—Washoe....	17 53 59
	07.5		09

* The description of the methods employed in the geodetic computations has been prepared by Lieut. Samuel E. Tillman, Corps of Engineers, and the late Dr. F. Kampf, assistant, United States Geographical Surveys.

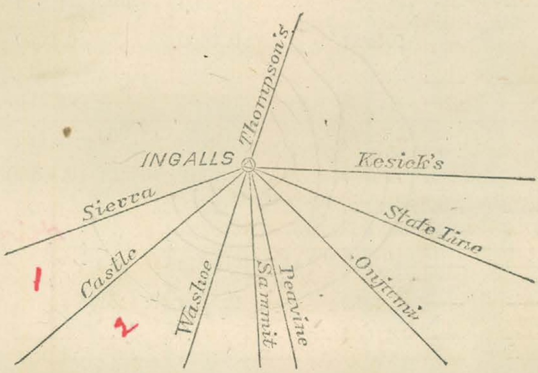
† If this difference is produced by a slipping of the instrument, at any particular setting, it will be observed by inspecting the differential angles, and should be corrected without other consideration.

	° ′ ″
(10) Onjumi—Summit....	26 07 04.5
(6) Summit—Washoe ...	11 47 00
	37 54 04.5
(9) Onjumi—Washoe....	37 53 59.0
	5.5
(13) McKesick's—Onjumi	30 09 29.5
(14) Thompson—McKesick's	60 15 29.1
	90 24 58.6
(15) Thompson—Onjumi .	90 24 54.5
	4.1

	° ′ ″
(11) State Line—Onjumi .	16 02 41
(12) McKesick's—State Line	14 06 43
	30 09 24
(13) McKesick's—Onjumi	30 09 29.5
	5.5
(15) Thompson—Onjumi .	90 24 54.5
(10) Onjumi—Summit .. .	26 07 04.5
	116 31 59.0
(16) Thompson—Summit .	116 31 33
	26.0

$$0 = +12 + (1) + (2) - (3)$$
$$0 = +2 + (4) + (2) - (5)$$
$$0 = -7.5 + (6) + (3) - (7)$$
$$0 = +9 + (8) + (4) - (9)$$
$$0 = +5.5 + (10) + (6) - (9)$$
$$0 = -5.5 + (11) + (12) - (13)$$
$$0 = +4.1 + (13) + (14) - (15)$$
$$0 = +26 + (15) + (10) - (16)$$
$$0 = +25.5 + (7) + (17) + (16)$$

	° ′ ″
(7)	54 17 56.5
(17)	189 10 56.0
(16)	116 31 33.0
	360 00 25.5



These equations of condition, containing a greater number of unknown quantities than there are equations, are to be solved by means of correlatives (Chauvenet, 556, Vol. II). To obtain the coefficients in the normal equations, the following form for the equations of correlatives is to be used:

	1	2	3	4	5	6	7	8	9	Corrections.	Corrected angles.		
											° ′ ″		
1	+1									− 9.68	21 07 27.32	1	Castle—Sierra.
2	+1	+1								− 9.68 + 5.53	21 23 19.85	2	Washoe—Castle.
3	−1		+1							+ 9.68 − 11.53	42 30 47.15	3	Washoe—Sierra.
4		+1		+1						+ 5.53 − 9.03	12 37 46.50	4	Peavine—Washoe.
5		−1								− 5.53	34 03 06.37	5	Peavine—Castle.
6			+1		+1					−11.53 + 12.56	11 47 01.03	6	Summit—Washoe.
7			−1						+1	+11.53 − 19.87	54 17 48.16	7	Summit—Sierra.
8				+1						− 9.03	25 14 08.97	8	Onjumi—Peavine.
9				−1	−1					+ 9.03 − 12.56	37 53 55.47	9	Onjumi—Washoe.
10					+1			+1		+12.56 − 22.58	26 06 54.48	10	Onjumi—Summit.
11						+1				− 1.27	16 02 39.73	11	State Line—Onjumi.
12						+1				− 1.27	14 06 41.73	12	McKesick's—State Line.
13						−1	+1			+ 1.27 − 9.32	30 09 21.45	13	McKesick's—Onjumi.
14							+1			− 9.32	60 15 19.78	14	Thompson—McKesick's.
15							−1	+1		+ 9.32 − 22.58	90 24 41.24	15	Thompson—Onjumi.
16								−1	+1	+22.58 − 19.87	116 31 35.71	16	Thompson—Summit.
17									+1	−19.87	189 10 36.13	17	Sierra—Thompson.

NOTE.—Rule as many parallel columns as there are equations of condition; to the left of the first column arrange in vertical order the symbols indicating the unknown quantities (usually figures) in the equation of condition. The factors to the unknown quantities, beginning with the first conditional equation, are placed in order in the vertical columns, opposite their respective quantities, and with their proper signs. The numerical terms in the normal equations will be the same as in the conditional equations. The coefficients of the unknown quantities in the normal equations are obtained by multiplying the several factors in every column each into itself and into the corresponding ones in every other, and summing the products of the respective columns. When the unknown quantities are of different weights, an additional column is introduced in the correlates, the weights being placed opposite their respective quantities, and employed in the combination of the factors. The normal equations in this case are:

0=+12	+3.000	+1.000	−1.000	—	—	—	—	—	—
0=+ 2	+1.000	+3.000	—	+1.000	—	—	—	—	—
0=− 7.5	−1.000	—	+3.000	—	+1.000	—	—	—	−1.000
0=+ 9	—	+1.000	—	+3.000	+1.000	—	—	—	—
0=+ 5.5	—	—	+1.000	+1.000	+3.000	—	—	+1.000	—
0=− 5.5	—	—	—	—	—	+3.000	−1.000	—	—
0=+ 4.1	—	—	—	—	—	+1.000	+3.000	−1.000	—
0=+26	—	—	—	—	+1.000	—	−1.000	+3.000	−1.000
0=+25.5	—	—	−1.000	—	—	—	—	−1.000	+3.000

These equations are solved by logarithms, as shown below:

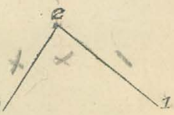
0=+ 8.5	—	—	−0.333	—	—	—	—	−0.333
0=+26					+1.000		−1.000	+3.000
+34.5	—	—	−0.333	—	+1.000	—	−1.000	+2.667
1.5378			9.5224		0.0000		0.0000	(0.4260)
0=+ 4.1	—	—	—	—	—	−1.000	+3.000	−1.000
+12.94	—	—	−0.125	—	+0.375	—	−0.375	
+17.04			−0.125		+0.375	−1.000	+2.625	
1.2315			9.0969		9.5740	0.0000	(0.4191)	
0=− 5.5	—	—	—	—	—	+3.000	−1.000	
+ 6.49	—	—	−0.048	—	+0.143	−0.381		
+ 0.99	—	—	−0.048	—	+0.143	+2.619		
9.9956	—	—	8.6812	—	9.1553	(0.4181)		
0=+ 5.5	—	—	+1.000	+1.000	+3.000	—	—	+1.000
−12.94	—	—	+0.125	—	−0.375	—	+0.375	
0=− 7.44	—	—	+1.125	+1.000	+2.625	—	+0.375	
− 2.435	—	—	+0.018	—	−0.054	+0.143		
− 9.875	—	—	+1.143	+1.000	+2.571	+0.143		
− 0.054	—	—	+0.003	—	−0.008			
− 9.929	—	—	+1.146	+1.000	+2.563			
0.9969	—	—	0.0592	0.0000	(0.4087)			
0=+ 9	—	+1.000	—	+3.000	+1.000			
+ 3.874	—	—	−0.447	−0.390				
+12.874	—	+1.000	−0.447	+2.610				
1.1096	—	0.0000	9.6503	(0.4166)				
0=+ 8.5	—	—	−0.333	—	—	—	—	−0.333
0=− 7.5	−1.000	—	+3.000	—	+1.000	—	—	
+ 1.000	−1.000	—	+2.667	—	+1.000	—	—	−0.333
+ 4.300	—	—	−0.042	—	+0.125		−0.125	
+ 5.300	−1.000	—	+2.625	—	+1.125	—	−0.125	
+ 0.811	—	—	−0.006	—	+0.018	−0.048		

```
+ 6.111—1.000   ——  +2.619   —— +1.143 —0.048
+ 0.018  ——     ——  —0.001   —— +0.003
+ 6.129—1.000   ——  +2.618   —— +1.146
+ 4.44   ——     ——  —0.512 —0.447
+10.569—1.000   ——  +2.106 —0.447
+ 2.205  ——  +0.171 —0.077
+12.774—1.000 +0.171 +2.029

  1.1062 0.0000  9.2330 (0.3073)

0 =+ 2.000+1.000 +3.000   ——  +1.000
   — 4.820  ——   —0.383 +0.171
   — 2.820+1.000 +2.617 +0.171
   — 1.08 +0.084 —0.014
   — 3.90 +1.084 +2.603

  0.5911  0.0351 (0.4155)

0 =+12.00 +3.000 +1.000 —1.000
   + 6.29 —0.493 +0.084
   +18.29 +2.507 +1.084
   + 1.62 —0.451
   +19.91 +2.056
```

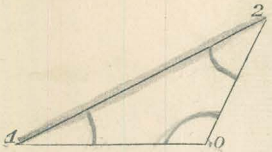
	κ 1	κ 2	κ 3	κ 4	κ 5	κ 6	κ 7	κ 8	κ 9
1.2991									
0.3131	—9.68	+5.53	—11.53	—9.03	+12.56	—1.27	—9.32	—22.58	—19.87
0.9860									

NOTE.—The solution gives the indicated values for the correlatives, which, multiplied into their corresponding factors in the equations of correlatives, determine the corrections to the unknown quantities, as shown in the example above.

After the angles at all the stations are corrected by either of the above methods, these angles are to be used in the formation of the triangles. The adjustment of the figure composed of several triangles is next accomplished. This adjustment involves what are called both angle and side equations. The first result from the necessity of the three angles of any triangle being equal to 180° + the spherical excess; the side equations from the necessity of the several directions to any one station intersecting in the same vertical line. The conditions are simultaneous, and the angle and side equations must be solved together. The figure for adjustment should include those points which give the best triangles. This result is obtained when each point is occupied and each observed from every other. It usually facilitates work to include 5 to 7 points in a figure. It is also advantageous to embrace triangles in which the smallest angles exist. After all the triangles possible between the points selected are formed, the "spherical excess" (ε) of each must be computed; four-place decimals are sufficient. This computation should always be controlled by observing whether the sum of the corrections of two of the triangles of a quadrilateral be equal to the sum of the corrections of the other two into which it can be divided. Each angle is formed by two sights, and is represented by figures, thus: 1. 2. 0. The number at the vertex is always placed in the center; or it may be represented thus: $-(\frac{1}{2})+(\frac{0}{2})$, the left-hand sight being given the nega-



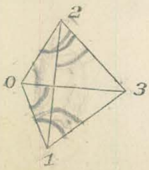
tive sign. The spherical excess (ε) is computed thus (the side 1—2 being known):



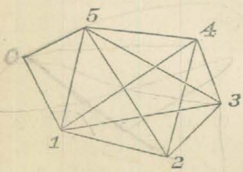
		log 1—2	4.6391	
1.0.2	149° 56′ 20″.74	a. c. sine	0.3002	
0.2.1	19 37 54 .26	sine	9.5263	
2.1.0	10 25 45 .00	sine	9.2577	8.6626
		log 0—1	4.4656	9.6998
	$\varepsilon = 0.58$	log 0—2	4.1970	1.4047
				9.7671

The sum of the two sides (0 — 1) and (0 — 2) multiplied into sine of included angle and into a constant depending on the latitude gives (ε).

The number of equations.—In every quadrilateral there can be formed three independent triangles; the fourth is a consequence of these three. In each figure one has therefore three angle equations. In forming these equations those triangles should be used with largest error, that is, the maximum difference from $180° + \varepsilon$. The side equation results from a principle of solid geometry.



Considering (0. 1. 2) as the base, the whole figure, 0. 1. 2. 3., may be considered as the projection of a pyramid, in which the sum of the logarithmic sines of the angles at the base taken in one direction, must be equal to the sum of the logarithmic sines taken in the opposite direction; in this case log. sine 3. 2. 0. + log. sine 3. 0. 1. + log. sine 2. 1. 3. = log. sine 3. 2. 1. + log. sine 0. 1. 3. The vertex must be so chosen as to give the smallest angles in these equations. That station is best for the vertex the sum of whose distances from the other three is a minimum, or that point which is observed more often to than from. To illustrate the method of forming angle and side equations, suppose one has five



points at which the angles have been adjusted. Commencing with any point, number them around in order to the right; join 1 with 2, and 2 with 3, and 1 with 3; this gives one angle equation. Then join 4 with each of the other 3 points; this gives two more independent angle equations and one side equation. If, now, the fifth point be joined with the other four, the first two new lines will give a new angle equation, and then each additional line will give one, and so on for each point brought into the combination. When each point is observed from every other, the number of angle equations will be equal to the sum of the natural numbers from 1 to a number 2 less than the number of points, that is, from 1 to $n-2$ inclusive. After the first three points are joined, it will require three new lines to bring into existence a side equation. As each new point is brought into the figure it *first* requires three lines to introduce a side equation; then each line to the remaining points gives one; so that the number of side equations under above conditions, all points being observed from all others, will be equal to the sum of natural numbers from 1 to $n-3$ inclusive. When each point is not observed from every other, the number of angle and side equations may be known by the following formulæ:

$l - n + 1$ = number of angle equations.
$l - 2n + 3$ = number of side equations.
l = number of lines. (Report of Chief of Engineers, 1872, p. 1046.)

The numerical term in each angle equation is the difference between $180° + \varepsilon$ and the sum of the angle in that triangle, + when the sum of the angles is $>$ and − when $< 180° + \varepsilon$. The numerical term in each side equation is obtained by summing the log. sines of the angles taken in one direction and obtaining the difference between this sum and the sum of the log. sines in the opposite direction. The logarithmic differences of the sines for 1″ become the coefficients of the correction to the directions. (Coast Survey Report, 1854, p. 80.)

The following example will illustrate the preceding explanations:

(1) *Formation of triangles in the figure.*

	Angles observed.	Corrections derived by method of l. sq.		Angles observed.	Corrections derived by method of l. sq.
	° ′ ″	″		° ′ ″	″
2.0.1	114 12 27.14	+ 10.73	1.3.4	69 24 39.92	+ 14.69
0.1.2	43 46 12.38	— 0.13	3.4.1	22 42 58.73	+ 5.05
1.2.0	22 1 14.22	— 4.30	4.1.3	87 52 2.61	— 0.66
	179 59 53.74			179 59 41.26	
Sph. exc.	0.04			Sph. exc. 0.34	
Error of triangle:	— 6.30			Error: — 19.08	
1.3.2	43 41 33.55	+ 12.71	1.4.0	7 21 40.90	+ 2.74
3.2.1	46 44 50.36	+ 16.87	4.0.1	127 11 3.61	— 4.09
2.1.3	89 33 0.00	+ 6.64	0.1.4	45 27 9.77	+ 7.17
	179 59 23.91			179 59 54.28	
	Sph. exc. 0.13			Sph. exc. 0.10	
	Error: — 36.22			Error: — 5.82	
1.4.2	1 5 9.63	— 13.78	2.3.4	25 43 6.37	+ 1.98
4.2.1	177 13 48.25	+ 11.22	3.4.2	23 48 8.36	— 8.73
2.1.4	1 40 57.39	+ 7.30	4.2.3	130 28 57.89	— 5.65
	179 59 55.27			180 0 12.62	
	Sph. exc. 0.01			Sph. exc. 0.22	
	Error: — 4.74			Error: + 12.40	
1.3.0	12 36 33.95	+ 16.11	4.0.2	12 58 36.47	— 14.82
3.0.1	34 4 1.47	— 10.38	0.2.4	160 44 57.53	— 6.92
0.1.3	133 19 12.38	+ 6.51	2.4.0	6 16 31.27	+ 16.52
	179 59 47.80			180 0 5.27	
	Sph. exc. 0.04			Sph. exc. 0.05	
	Error: — 12.24			Error: + 5.22	
2.0.3	80 8 25.67	+ 21.11	4.0.3	93 7 2.14	+ 6.29
0.3.2	31 4 59.60	— 3.40	0.3.4	56 48 5.97	— 1.42
3.2.0	68 46 4.58	+ 12.57	3.4.0	30 4 39.63	+ 7.79
	179 59 29.85			179 59 47.74	
	Sph. exc. 0.13			Sph. exc. 0.40	
	Error: — 30.28			Error: — 12.66	

(2) *Formation of side equations.*

	Obs. sph. angles.	Corrected sph. angles.	Logarithms of sines.	Var. for 1″.	Last 4 places of log. of sines of corr. angles.
	° ′ ″	″			
$-\binom{0}{1}+\binom{3}{1}$	133 19 12.38	18.89	9.8618522	— 0.199	8392
$-\binom{0}{3}+\binom{2}{3}$	31 4 59.60	56.20	9.7128875	+ 0.350	8756
$-\binom{1}{2}+\binom{0}{2}$	22 1 14.22	9.92	9.5739620	+ 0.521	9396
			9.1487017		6544

	Obs. sph. angles. ° ′ ″	Corrected sph. angles. ″	Logarithms of sines.	Var. for 1″.	Last 4 places of log. of sines of corr. angles.
$-\binom{3}{2}+\binom{0}{2}$	68 46 4.58	17.15	9.9694725	+ 0.082	4827
$-\binom{1}{3}+\binom{0}{3}$	12 36 33.95	50.06	9.3390615	+ 0.941	2131
$-\binom{0}{1}+\binom{2}{1}$	43 46 12.38	12.25	9.8399595	+ 0.220	9592
			9.1484935		6550
			+ 20.82		
$-\binom{2}{1}+\binom{3}{1}$	89 33 0.00	6.64	9.9999866	+ 0.002	9867
$-\binom{2}{3}+\binom{4}{3}$	25 43 6.37	8.35	9.6374387	+ 0.438	4474
$-\binom{1}{4}+\binom{2}{4}$	1 4 69.63	55.85	8.2776845	+11.110	1513
			7.9151098		5854
$-\binom{3}{4}+\binom{2}{4}$	23 47 68.36	59.63	9.6059322	+ 0.477	8905
$-\binom{1}{3}+\binom{2}{3}$	43 41 33.55	46.26	9.8393458	+ 0.221	3739
$-\binom{2}{1}+\binom{4}{1}$	1 40 57.39	64.69	8.4677980	+ 7.170	3209
			7.9130760		5853
			+ 203.38		
$-\binom{4}{0}+\binom{2}{0}$	12 58 36.47	21.65	9.3513255	+ 0.914	1901
$-\binom{0}{1}+\binom{2}{1}$	43 46 12.38	12.25	9.8399595	+ 0.220	9592
$-\binom{1}{4}+\binom{2}{4}$	1 4 69.63	55.85	8.2776845	+11.110	1513
			7.4689695		3006
$-\binom{2}{4}+\binom{0}{4}$	6 16 31.27	47.79	9.0386469	+ 1.914	9631
$-\binom{2}{0}+\binom{1}{0}$	114 12 27.14	37.87	9.9600263	− 0.095	0162
$-\binom{2}{1}+\binom{4}{1}$	1 40 57.39	69.69	8.4677980	+ 7.170	3209
			7.4664712		3002
			+ 249.83		

(3) *Equations of condition.*

$$0=-\ 12.24-\binom{1}{3}+\binom{0}{3}-\binom{3}{0}+\binom{1}{0}-\binom{0}{1}+\binom{3}{1}$$
$$0=+\ 12.40-\binom{2}{3}+\binom{4}{3}-\binom{3}{4}+\binom{2}{4}-\binom{4}{2}+\binom{3}{2}$$
$$0=-\ 12.66-\binom{4}{0}+\binom{3}{0}-\binom{0}{3}+\binom{4}{3}-\binom{3}{4}+\binom{0}{4}$$
$$0=-\ 19.08-\binom{1}{3}+\binom{4}{3}-\binom{3}{4}+\binom{1}{4}-\binom{4}{1}+\binom{3}{1}$$
$$0=-\ 30.28-\binom{2}{0}+\binom{3}{0}-\binom{0}{3}+\binom{2}{3}-\binom{3}{2}+\binom{0}{2}$$
$$0=-\ 36.22-\binom{1}{3}+\binom{2}{3}-\binom{3}{2}+\binom{1}{2}-\binom{2}{1}+\binom{3}{1}$$
$$0=+\ 20.82+0.419\binom{0}{1}-0.220\binom{2}{1}-0.199\binom{3}{1}+0.439\binom{0}{2}-0.521\binom{1}{2}+0.082\binom{3}{2}$$
$$-1.291\binom{0}{3}+0.941\binom{1}{3}+0.350\binom{2}{3}$$
$$0=+203.38+7.168\binom{2}{1}+0.002\binom{3}{1}-7.170\binom{4}{1}+0.221\binom{1}{3}-0.659\binom{2}{3}+0.438\binom{4}{3}$$
$$-11.110\binom{1}{4}+10.633\binom{2}{4}+0.477\binom{3}{4}$$
$$0=+249.83+0.095\binom{1}{0}+0.819\binom{2}{0}-0.914\binom{4}{0}-0.220\binom{0}{1}+7.390\binom{2}{1}-7.170\binom{4}{1}$$
$$-1.914\binom{0}{4}-11.110\binom{1}{4}+13.024\binom{2}{4}$$

(4) *Correlatives.*

										Resulting corrections for directions.
$\binom{1}{0}$	+1								+ 0.095	− 0.939
$\binom{2}{0}$					−1				+ 0.819	−11.666
$\binom{3}{0}$	−1		+1		+1					+ 9.448
$\binom{4}{0}$			−1						− 0.914	+ 3.157
$\binom{0}{1}$	−1						+ 0.419		− 0.220	− 3.388
$\binom{2}{1}$						−1	− 0.220	+ 7.168	+ 7.390	− 3.520
$\binom{3}{1}$	+1			+1		+1	− 0.199	+ 0.002		+ 3.126
$\binom{4}{1}$				−1				− 7.170	− 7.170	+ 3.782
$\binom{0}{2}$					+1		+ 0.439			+ 3.800
$\binom{1}{2}$						+1	− 0.521			+ 8.097
$\binom{3}{2}$		+1			−1	−1	+ 0.082			− 8.772
$\binom{4}{2}$		−1								− 3.125
$\binom{0}{3}$	+1		−1		−1		− 1.291			+ 5.235
$\binom{1}{3}$	−1			−1		−1	+ 0.941	+ 0.221		−10.877
$\binom{2}{3}$		−1			+1	+1	+ 0.350	− 0.659		+ 1.829
$\binom{4}{3}$		+1	+1	+1				+ 0.438		+ 3.813
$\binom{0}{4}$			+1						− 1.914	+ 6.766
$\binom{1}{4}$				+1				−11.110	−11.110	+ 4.020
$\binom{2}{4}$		+1						+10.633	+13.024	− 9.760
$\binom{3}{4}$		−1	−1	−1				+ 0.477		− 1.026

(5) From these correlatives are formed the following normal equations:

0 =	− 12.24	+ 6.000	——	− 2.000	+ 2.000	− 2.000	+ 2.000	− 2.850	− 0.219	+ 0.315
0 =	+ 12.40	——	+ 6.000	+ 2.000	+ 2.000	− 2.000	− 2.000	− 0.268	+ 11.283	+ 13.024
0 =	− 12.66	− 2.000	+ 2.000	+ 6.000	+ 2.000	+ 2.000	——	+ 1.291	− 0.039	− 1.000
0 =	− 19.08	+ 2.000	+ 2.000	+ 2.000	+ 6.000	——	+ 2.000	− 1.140	= 4.198	− 3.940
0 =	− 30.28	− 2.000	− 2.000	+ 2.000	——	+ 6.000	+ 2.000	+ 1.998	− 0.659	− 0.819
0 =	− 36.22	+ 2.000	− 2.000	——	+ 2.000	+ 2.000	+ 6.000	− 1.173	− 8.046	− 7.390
0 =	+ 20.82	− 2.850	− 0.268	+ 1.291	− 1.140	+ 1.998	− 1.173	+ 3.409	− 1.600	− 1.718
0 =	+ 203.38	− 0.219	+ 11.283	− 0.039	− 4.198	− 0.659	− 8.046	− 1.600	+ 340.823	+ 366.687
0 =	+ 249.83	+ 0.315	+ 13.024	− 1.000	− 3.940	− 0.819	− 7.390	− 1.718	+ 366.687	+ 404.305

The solution of these equations is made by means of four-place logarithms. In order to obtain an equation corresponding to No. 8, No. 9 is multiplied by $\frac{366.687}{404.305}$. This factor will be, for No. 7, $\frac{1.718}{404.305}$, and so forth. These factors are easily obtained by subtracting log. 404.305 from all logarithms of factors of equation No. 9. The value of the different correlatives will not quite satisfy the equations of condition, and therefore a second computation is made by introducing the new residuals in the normal equations. The following table contains the logarithmic elimination, the first column giving the second computation:

1.2788	2.3976	9.4983	1.1146	0.0000	0.5955	9.9133	0.8686	0.2350	2.5643	(2.6067)
+17.24	−226.570	−0.286	−11.808	+0.907	+3.573	+0.743	+6.702	+1.558	−332.585	
+19.00	+203.380	−0.219	+11.283	−0.039	−4.198	−0.659	−8.046	−1.600	+340.823	
+36.24	− 23.190	−0.505	− 0.525	+0.868	−0.625	+0.084	−1.344	−0.042	+ 8.238	
1.5592	1.3653	9.7033	9.7202	9.9385	9.7959	8.9243	0.1284	8.6232	(0.9158)	
− 0.08	+ 1.061	+0.001	+ 0.055	−0.004	−0.017	−0.003	−0.031	−0.007	+ 1.558	
+ 8.00	+ 20.820	−2.850	− 0.268	+1.291	−1.140	+1.998	−1.173	+3.409	− 1.600	
+ 7.92	+ 21.881	−2.849	− 0.213	+1.287	−1.157	+1.995	−1.204	+3.402	− 0.042	
+ 0.18	− 0.118	−0.003	− 0.003	+0.004	−0.003	+0.000	−0.007	−0.000		
+ 8.10	+ 21.763	−2.852	− 0.216	+1.291	−1.160	+1.995	−1.211	+3.402		

0.9085	1.3377	0.4551	9.3345	0.1109	0.0645	0.3000	0.0831	(0.5318)	
− 0.35	+ 4.565	+0.006	+ 0.238	−0.018	−0.072	−0.015	−0.135	−0.031	+ 6.702
+ 0.70	− 36.220	+2.000	− 2.000	——	+2.000	+2.000	+6.000	−1.173	− 8.046
+ 0.35	− 31.655	+2.006	− 1.762	−0.018	+1.928	+1.985	+5.865	−1.204	− 1.344
+ 5.91	− 3.783	−0.082	− 0.086	+0.142	−0.102	+0.014	−0.219	−0.007	
+ 6.26	− 35.438	+1.924	− 1.848	+0.124	+1.826	+1.999	+5.646	−1.211	
+ 2.88	+ 7.745	−1.015	− 0.077	+0.459	−0.413	+0.710	−0.431		
+ 9.14	− 27.693	+0.909	− 1.925	+0.583	+1.413	+2.709	+5.215		

0.9609	1.4424	9.9586	0.2845	9.7657	0.1501	0.4328	(0.7173)		
− 0.04	+ 0.506	+0.001	+ 0.026	−0.002	−0.008	−0.002	−0.015	−0.003	+ 0.743
+ 0.70	− 30.280	−2.000	− 2.000	+2.000	——	+6.000	+2.000	+1.998	− 0.659
+ 0.66	− 29.774	−1.999	− 1.974	+1.998	−0.008	+5.998	+1.985	+1.995	+ 0.084
− 0.37	+ 0.237	+0.005	+ 0.005	−0.009	+0.006	−0.006	+0.014	+0.000	
+ 0.29	− 29.537	−1.994	− 1.969	+1.989	−0.002	+5.997	+1.999	+1.995	
− 4.75	− 12.761	+1.672	+ 0.127	−0.757	+0.680	−1.170	+0.710		
− 4.46	− 42.298	−0.322	− 1.842	+1.232	+0.678	+4.827	+2.709		
− 4.75	+ 14.385	−0.472	+ 1.000	−0.303	−0.734	−1.407			
− 9.21	− 27.913	−0.794	− 0.842	+0.929	−0.056	+3.420			

0.9643	1.4458	9.8998	9.9253	9.9680	8.7482	(0.5340)			
− 0.18	+ 2.434	+0.003	+ 0.127	−0.010	−0.038	−0.008	−0.072	−0.017	+ 3.573
+ 0.70	− 19.080	+2.000	+ 2.000	+2.000	+6.000	——	+2.000	−1.140	− 4.198
+ 0.52	− 16.646	+2.003	+ 2.127	+1.990	+5.962	−0.008	+1.928	−1.157	− 0.625
+ 2.75	− 1.760	−0.038	− 0.040	+0.066	−0.047	+0.006	−0.102	−0.003	
+ 3.27	− 18.406	+1.965	+ 2.087	+2.056	+5.915	−0.002	+1.826	−1.160	
+ 2.76	+ 7.420	−0.972	− 0.074	+0.440	−0.396	+0.680	−0.413		
+ 6.03	− 10.986	+0.993	+ 2.013	+2.496	+5.519	+0.678	+1.413		
− 2.48	+ 7.502	−0.246	+ 0.522	−0.158	−0.383	−0.734			
+ 3.55	− 3.484	+0.747	+ 2.535	+2.338	+5.136	−0.056			
− 0.15	− 0.457	−0.013	− 0.014	+0.015	−0.001				
+ 3.40	− 3.941	+0.734	+ 2.521	+2.353	+5.135				

0.5315	0.5956	9.8657	0.4016	0.3716	(0.7105)				
− 0.05	+ 0.618	+0.001	+ 0.032	−0.002	−0.010	−0.002	−0.018	−0.004	+ 0.907
+16.20	− 12.660	−2.000	+ 2.000	+6.000	+2.000	+2.000	——	+1.291	− 0.039
+16.15	− 12.042	−1.999	+ 2.032	+5.998	+1.990	+1.998	−0.018	+1.287	+ 0.868
− 3.82	+ 2.443	+0.053	+ 0.055	−0.091	+0.066	−0.609	+0.142	+0.004	
+12.33	− 9.599	−1.946	+ 2.087	+5.907	+2.056	+1.989	+0.124	+1.291	
− 3.07	− 8.256	+1.082	+ 0.082	−0.490	+0.440	−0.757	+0.459		
+ 9.26	− 17.855	−0.864	+ 2.169	+5.417	+2.496	+1.232	+0.583		
− 1.02	+ 3.095	−0.102	+ 0.215	−0.065	−0.158	−0.303			
+ 8.24	− 14.760	−0.966	+ 2.384	+5.352	+2.338	+0.929			
+ 2.50	+ 7.582	+0.216	+ 0.229	−0.252	+0.015				
+10.74	− 7.178	−0.750	+ 2.613	+5.100	+2.353				
− 1.56	+ 1.806	−0.336	− 1.155	−1.078					
+ 9.18	− 5.372	−1.086	+ 1.458	+4.022					

0.9628	0.7302	0.0358	0.1638	(0.6044)					
+ 0.61	− 8.043	−0.010	− 0.419	+0.032	+0.127	+0.026	+0.238	+0.055	− 11.808
+ 2.70	+ 12.400	——	+ 6.000	+2.000	+2.000	−2.000	−2.000	−0.268	+ 11.283
+ 3.31	+ 4.357	−0.010	+ 5.581	+2.032	+2.127	−1.974	−1.762	−0.213	− 0.525
+ 2.31	− 1.478	−0.032	− 0.023	+0.055	−0.040	+0.005	−0.086	−0.003	
+ 5.62	+ 2.879	−0.042	+ 5.548	+2.087	+2.087	−1.969	−1.848	−0.216	
+ 0.51	+ 1.382	−0.181	− 0.014	+0.082	−0.074	+0.127	−0.077		
+ 6.13	+ 4.261	−0.223	+ 5.534	+2.169	+2.013	−1.842	−1.925		
+ 3.37	− 10.224	+0.336	− 0.711	+0.215	+0.522	+1.000			
+ 9.50	− 5.963	+0.113	+ 4.823	+2.384	+2.535	−0.842			
− 2.27	− 6.272	−0.195	− 0.207	+0.229	−0.014				
+ 7.23	− 12.835	−0.082	+ 4.616	+2.613	+2.521				
− 1.67	+ 1.935	−0.360	− 1.238	−1.155					
+ 5.56	− 10.900	−0.442	+ 3.378	+1.458					
− 3.33	+ 1.948	+0.394	− 0.529						
+ 2.23	− 8.952	−0.048	+ 2.849						

0.3483	0: 9519	8.6812	(0.4546)						
+ 0.01	− 0.195	−0.000	− 0.010	+0.001	+0.003	+0.001	+0.006	+0.001	− 0.286
− 4.80	− 12.240	+6.000	——	−2.000	+2.000	−2.000	+2.000	−2.850	− 0.219
− 4.79	− 12.435	+6.000	− 0.010	−1.999	+2.003	−1.999	+2.006	−2.849	− 0.505
+ 2.22	− 1.422	−0.031	− 0.032	+0.053	−0.038	+0.005	−0.082	−0.003	
− 2.57	− 13.857	+5.969	− 0.042	−1.946	+1.965	−1.994	+1.924	−2.852	
+ 6.79	+ 18.239	−2.390	− 0.181	+1.082	−0.972	+1.672	−1.015		
+ 4.22	+ 4.382	+3.579	− 0.223	−0.864	+0.993	−0.322	+0.909		
− 1.59	+ 4.828	−0.158	+ 0.336	−0.102	−0.246	−0.472			
+ 2.63	+ 9.210	+3.421	+ 0.113	−0.966	+0.747	−0.794			
− 2.14	− 6.480	−0.184	− 0.195	+0.216	−0.013				
+ 0.49	+ 2.730	+3.237	− 0.082	−0.750	+0.734				
− 0.49	+ 0.563	−0.105	− 0.360	−0.336					
0.00	+ 3.293	+3.132	− 0.442	−1.086					
+ 2.48	− 1.451	− 0.293	+ 0.394						
+ 2.48	+ 1.842	+2.839	− 0.048						
+ 0.04	− 0.151	−0.001							
+ 2.52	+ 1.691	+2.838							

The different correlatives are:

	From first comp.	From second comp.
$a_1=$	-0.596	-0.0089
$a_2=$	$+3.133$	-0.0080
$a_3=$	$+0.072$	-0.0223
$a_4=$	-0.719	$+0.0088$
$a_5=$	$+8.764$	$+0.0291$
$a_6=$	$+2.205$	-0.0339
$a_7=$	-11.324	-0.0494
$a_8=$	$+3.129$	-0.0481
$a_9=$	-3.553	$+0.0436$

The sum of these values introduced in the correlatives gives the resulting corrections of the directions as given before.

The computation of distances, after the final adjustment of figures, is but the solution of the triangles, and is always checked by duplicate reduction from the common triangles to which any side may belong, plane angles being used.

Example.

	° ′ ″			° ′ ″	
		log. 2—3 = 5.1069389			log. 4—3 = 5.2260258
1.	86 15 33.41	a. c. l. sin = 0.0009262	1.	97 53 4.34	a. c. l. sin = 0.0141250
2.	60 53 57.78	l. sin = 9.9413956	4.	41 14 58.54	l. sin = 9.8191098
3.	32 50 28.81	l. sin = 9.7342512	3.	40 51 57.12	l. sin = 9.8157706
		log. 1—3 = 5.0492607			log. 1—3 = 5.0492608
		" 1—2 = 4.8421153			" 1—4 = 5.0459216

Cross-sight stations.—To compute the position of a point observed from only two other points, the problem is reduced to the solution of a simple triangle, the two observed angles and included side being the known quantities. The third angle is obtained by difference from 180°, the two remaining sides are then determined approximately, and the spherical excess (e) computed. The operation is then repeated with the new angle. When the station is cross-sighted from three points, the problem becomes the simplest case of the more general problem already given, for adjustment of figure, and involves only one side equation. The sum of the two observed angles in each triangle, taken from 180°, gives the third approximately. The spherical excess (e) and the two unknown sides in each triangle are then computed approximately. The side equation is solved, requiring only one correlative and giving one normal equation. The corrections to the angles thus obtained, introduced at the same time with the spherical excess (e), give the determination of distances to the required degree of accuracy. When the point is cross-sighted from more than three stations, all possible triangles should be formed, and the problem is similar to the general case already given. The "three-point" problem is solved by the formula given in "Lee's Tables and Formulæ" (p. 87). The more general form of this problem is shown in "Coast Survey Report," 1864 (p. 116).

The computation of latitudes, longitudes, and azimuths is made by the formulæ given in Appendix No. 36, "Coast Survey Report," 1860 (p. 361).

PROGRESS MAP FOR 1878.

The regions surveyed in 1877 appear on the progress sheet as a part of the colored areas, of which maps are published or in course of preparation. The total area surveyed and shown on the progress sheets in colors aggregates 332,515 square miles. The main astronomical stations and areas proposed for occupation by the expedition of 1878 are also indicated. The season of 1877 consisting of *all* the working months at the altitudes visited, the entire area proposed for that year was occupied. By taking advantage of the lower altitudes to be reached by the parties at the close of the present season, although funds were only available at a late period, the unusually large area intended to be surveyed, it is believed, may be completed.

To the progress map, being but a skeleton sheet of the territory west of the Mississippi, there have been added the areas of the Indian reservations, the positions of signal-service stations, and the names and positions of abandoned military posts, showing the large number of points at which the Army has acted as a nucleus of support to the pioneer settlements since the acquisition of this vast territory. As usual, the distances over which certain railroad and telegraph lines which have been under construction have advanced are added, as well as a limited number of the more prominent settlements, and a few elevations.

The time that could be spared by the officer in charge from increasing office duties was employed, independent of the general supervision of the work after the organization of the Colorado, Utah, and California sections of the survey, mainly at the Washoe mining district, and in parts of Bear River and adjacent basins in Northern Utah and Southern Idaho.

SURVEYS OF LAKE TAHOE AND WASHOE MINING REGIONS.

The area of the Lake Tahoe region, over which a more detailed survey has been made, is bounded on the north by Reno, on the Central Pacific Railroad; on the south by the old overland stage road from Carson Valley to Placerville, Cal.; on the west by the headwaters of the Forks of the American River; and extends eastward to a line crossing the Carson River at a point east of the Washoe mines. The scale selected is that of 1 inch to 1 mile, by means of which the conjectural contours at vertical distances of 200 feet are clearly shown. The greater portion of that part of the Central Pacific Railroad where it crosses the Sierra Nevada is included; the Virginia and Truckee Railroad entire; the Washoe mining, milling, and timber region; as well as Lake Tahoe, lying partly in California and partly in Nevada, five counties adjoining along this portion of the boundary; and a number of outlying lakes nestled among the surrounding peaks of the Sierras. The size of the map is equivalent to six regular atlas sheets of 19 by 24 inches. Independent of its being a permanent topographical representation of an unique portion of the Sierra Nevada and adjacent industrial districts, it will serve also as the basis for the detailed land classification of the domain delineated, and of the geology of this most interesting portion of the mountain ridges between the California plains and the great interior basin to the eastward. The detailed map of the Washoe mining region, constructed upon a scale of 1 inch to 500 feet, upon which contours of each 50 feet in elevation are shown, embraces an area limited upon the north by the summit of the Geiger Grade; on the west by a meridian line through Empire, the most southwesterly mill locality; on the south by an east and west line through the same point; and on the east by a north and south line crossing the Carson River due east from the mouth of the Sutro Tunnel. This scope of country shows the entire district within which mines have been discovered and worked, and the location of all present mill-sites. The map, when reduced to a scale of 1 inch to 1,500 feet, upon which it is proposed that it be published, will be of the size of four atlas sheets 19 by 24 inches. It can be used as a map for constructions upon the surface when differences in elevation between given datum points are required. This map will be used as a basis upon which may be shown the geology and mineralogy of the region, and to which will be referred the vertical, horizontal, and longitudinal sections, showing the entire underground workings of the Comstock. This map and the memoirs accompanying it should form a permanent record of the advancement of

UNITED STATES GEOGRAPHICAL SURVEYS. WEST OF THE ONE HUNDREDTH MERIDIAN.

SEASONS of 1869, 1871, 1872, 1873-1874, 1875, 1876 & 1877.

1st Lieut. Geo. M. Wheeler, Corps of Engineers, in charge.

EXPLANATIONS.

Index Areas to Atlas Maps.
Primary Astronomical Stations completed.
Secondary Astronomical Stations completed.

Atlas Sheets published
Areas of which maps are in course of preparation.
Areas proposed for occupation Season of 1878
Geological Exploration of the 40th Parallel (Clarence King)

Lines of Expeditions, prosecuting Explorations and Surveys conducted by "Officers of the Line," "Corps of Topographical Engineers," and "Corps of Engineers," U.S. Army
Occupied Military Posts, Abandoned Military Posts, Signal Service Stations, Telegraph Lines

BY ORDER OF THE HONORABLE THE SECRETARY OF WAR.

UNDER THE DIRECTION OF BRIG. GEN. A. A. HUMPHREYS, CHIEF OF ENGINEERS. U.S. ARMY.

gold and silver mining of ores in place at the date of issue; and at the proper time the grouping of the results will be recommended as available material for an additional quarto volume with special atlas.

The names of the chiefs of party, triangulation and sextant observers, and topographical assistants engaged in procuring field data for the maps herewith mentioned, will be stated on the face of each.

LAND-CLASSIFICATION MAPS.

The division into classes of the lands is shown by colors upon several of the topographical atlas sheets. The limiting lines between the different grades are, of necessity, arbitrary, and not governed by exact reference to well-established points, but the percentages given are approximately correct. But four principal divisions are shown by color, the subdivisions appearing in the description. The location of the precious and economic minerals, earths, &c., noted, is usually shown upon the underlying topographical sheet.

The percentages of the various grades into which the land is classed will appear upon the face of each sheet.

ROUTES OF COMMUNICATION.

A few of the distances between terminal points of importance, taken from the road measurements of 1877, are given in the tables that follow. A discussion of the main routes, present and prospective, of the areas surveyed to date, with their profiles and approaches, will be given in the introduction to the special publication on this subject. As circumstances permit, such distances along the shortest traveled routes between certain military posts of the frontier are prepared and forwarded for the use of the Quartermaster and Pay Departments.

LIST OF ROAD DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 1, COLORADO SECTION, 1877.

Gunnison to Ouray, Colo.
Saguache to Gunnison Post Office, Colo.
Saguache to Gunnison River, Colo.
Saguache to Ouray Post Office, Colo.

From Gunnison to Ouray, via Gunnison River and Los Pinos Indian Agency—Atlas-sheets Nos. 61 A and C.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Gunnison.	From Ouray Post Office.		
Crossing south	4.0	....	....	....	
Crossing north	7.4	....	....	7,291	
Last crossing	7.6	....	....	7,258	At mouth of White Earth Creek.
Lake Fork	6.1	....	....	7,280	Crossing.
Blue Creek	11.5	....	....	8,462	Do.
Cimarron Creek	7.0	....	....	7,314	Do.
Los Pinos Indian Agency	16.5	....	....	6,400	On left bank of Uncompahgre River.
Hot Springs	16.5	....	....	6,988	On right bank of Uncompahgre River.
Ouray Post Office	8.8	....	....	7,772	On Uncompahgre River at confluence of Cañon Creek.

From Saguache to Gunnison Post Office.—Atlas-sheets Nos. 61 *A, B, and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Saguache.	From Gunnison Post Office.		
Old Agency	44. 8	....	....	9, 088	Lake City Road.
White Earth Post Office	18. 3	....	....	8, 163	White Earth Creek.
Hot Springs	3. 1	....	....	....	Road forks to Varnum's Post Office.
Beaver Creek	18. 7	....	....	7, 635	Crossing.
Gunnison Post Office	6. 5	....	....	7, 429	Valley of the Gunnison and Tomichi.

From Saguache to Gunnison River.—Atlas-sheets Nos. 61 *A, B, and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Saguache.	From Gunnison River.		
Old Agency	44. 8	....	....	9, 088	Via Lake City and Saguache Road.
White Earth Post Office	18. 3	....	....	8, 163	Do.
Lake Fork crossing	11. 0	....	....	7, 821	Crossing road.
Blue Creek crossing	14. 7	....	....	8, 462	Do.
Cimarron Creek crossing	10. 4	....	....	6, 851	Do.
Johnson's Ford	19. 2	....	....	5, 702	Crossing of Uncompahgre River.
Gunnison River	26. 5	....	....	4, 920	Along left bank of Uncompahgre River.

From Saguache to Ouray Post Office.—Atlas-sheets Nos. 61 *A, B, C, and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Saguache.	From Ouray Post Office.		
Old Agency	44. 8	....	....	9, 088	Lake City road.
White Earth Post Office	18. 3	....	....	8, 163	White Earth Creek.
Varnum's Post Office	9. 6	....	....	7, 990	On Indian Creek.
Lake Fork crossing	4. 3	....	....	7, 959	Along left bank of.
Lake City	17. 0	....	....	8, 753	Lake Fork.
Cottonwood Junction	16. 2	....	....	....	Following Lake Fork.
Animas Fork	12. 3	....	....	11, 181	Via Tellurium.
Ouray Post Office	12. 0	....	....	7, 772	Via Poughkeepsie Gulch.

LIST OF ROAD DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 2, COLORADO SECTION, 1877.

Santa Fé to Fort Stanton, N. Mex.
Punta del Agua to Fort Stanton.
Annaya Spring to Fort Stanton.
Annaya Spring to Fort Stanton, via Mal Pais Spring.
Antelope Spring to Socorro.
Albuquerque to Socorro, via east bank of Rio Grande.
Manzano to Pedernal Spring, via Ojo Chico.
Pedernal Spring to Tejique.

From Santa Fé to Fort Stanton, N. Mex.—Atlas-sheets Nos. 69 *D*, 77 *B*, *D*, *and* 84 *B*.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Santa Fé.	From Fort Stanton.		
Santa Fé	....	....	178.13	7,044	Headquarters district New Mexico.
Antelope Spring	61.60	....	116.53	6,221	Government agency.
Tanques de las Animas	28.05	89.65	88.48	6,404	Water, except in very dry weather.
Posos del Pino	16.37	106.02	72.11	6,168	Alkaline wells; government agency.
Gallinas Ranch	19.78	125.80	52.33	6,912	Wood and grass plenty; water in barrels.
Winter Ranch	20.23	146.03	32.10	6,582	Do.
Pato Spring	10.00	156.03	22.10	6,290	Wood, water, and grass; government agency.
Puercito	13.84	169.87	8.26	6,847	Water, in wet seasons, in holes.
Fort Stanton	8.26	178.13	....	6,151	Four-company post.

From Punta del Agua to Fort Stanton, N. Mex.—Atlas-sheets Nos. 77 *D and* 84 *B*.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Punta del Agua.	From Fort Stanton.		
Punta del Agua	....	....	99.10	6,599	Mexican town; government agency.
Los Aguajes	14.00	....	85.10	6,524	Water on east of road, except dry season.
Gallinas Waterhole	16.44	30.44	68.66	6,392	Usually water near road.
Gallinas Spring	9.16	39.60	59.50	7,636	Spring half mile east of road, high on slope.
Winter Ranch	27.40	67.00	32.10	6,582	Government agency; temporary water.
Fort Stanton	32.10	99.10	....	6,151	Four-company post.

From Annaya Spring to Fort Stanton, N. Mex.—Atlas-sheets Nos. 84 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Annaya Spring.	From Fort Stanton.		
Annaya Spring	....	....	103.27	4,717	Poor water; fair grazing; no wood.
First Divides	18.61	....	84.66	5,572	Water-hole at point of hill, 1 mile north.
Opposite Dripping Spring	5.00	23.61	79.66	5,385	Spring in drain ¾ mile south of road.
Waterholes	2.39	26.00	77.27	4,960	Except in dry season.
Mound Spring	15.02	41.02	62.25	4,336	Poor water; poor grazing; no wood.
Jaralosa Spring	22.66	63.68	39.59	4,783	Fair alkaline water; grass; no wood.
Nogal Creek	19.93	83.61	19.66	6,570	Good wood, water, and grass.
McGowan's	6.48	90.09	13.18	6,642	Ranch, wood, water, and grass.
Salado	6.48	96.57	6.70	6,321	Hamlet.
Fort Stanton	6.70	103.27	....	6,151	Military post.

From Annaya Spring to Fort Stanton, via Mal Pais Spring.—Atlas-sheets Nos. 84 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Annaya Spring.	From Fort Stanton.		
Annaya Spring	....	....	121.34	4,717	Poor water; fair grazing; no wood.
Opposite Dripping Spring	23.61	....	97.73	5,385	Spring ¾ mile south of road; water scarce.
Mal Pais Spring	17.79	41.40	79.94	4,105	Large spring; bad water; no wood or grass.
Tularosa	24.00	65.40	55.94	4,344	Mexican town; government agency.
Mescalero Agency	16.67	82.07	39.27	6,475	Indian agency on Tularosa Creek.
Dowlin's Mill	18.39	100.46	20.88	6,435	Government agency; wood; water; grass.
Copeland's	11.97	112.43	8.91	6,800	Do.
Fort Stanton	8.91	121.34	....	6,151	Four-company military post.

Road generally good.

From Antelope Spring to Socorro, N. Mex.—Atlas-sheet No. 77 D.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Antelope Spring.	From Socorro.		
Antelope Spring			85. 37	6, 221	McAfee's government agency.
Eslancia	5. 30		80. 07	6, 177	Fine spring; ranch; good grass.
Punta del Agua	17. 17	22. 47	62. 90	6, 599	Mexican town, government agency.
Abo	13. 41	35. 88	49. 49	6, 240	Do.
Juan Lujan Tanks	7. 31	43. 19	42. 18	6, 010	In wet season north of road.
Tomasceños Tanks	17. 59	60. 78	24. 59	5, 502	Water in pools south of road.
Parida Spring	16. 00	76. 78	8. 59	4, 929	Alkaline water; poor grass; ranch.
Parida	4. 38	81. 16	4. 21	4, 627	On Rio Grande; ford.
Socorro	4. 21	85. 37		4, 658	Town on west bank of Rio Grande.

From Albuquerque to Socorro, N. Mex., by road on east bank of Rio Grande.—Atlas-sheets Nos. 77 B and D.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Albuquerque	From Socorro.		
Albuquerque			83. 11	4, 919	Government agency.
Los Pinos	18. 84		64. 27	4, 675	Town on Rio Grande.
Valencia	3. 51	22. 35	60. 76	4, 980	Do.
Tome	5. 28	27. 63	55. 48	4, 879	Do.
Constancia	5. 71	33. 34	49. 77	4, 711	Do.
Casa Colorado	8. 25	41. 59	41. 52	4, 679	Do.
Las Nutrias	7. 76	49. 35	33. 76		Do.
La Joya	10. 27	59. 62	23. 49		Do.
La Joyila	6. 54	66. 16	16. 95		Do.
Sabina	7. 05	73. 21	9. 90		Do.
Parida	5. 69	78. 90	4. 21	4, 627	Do.
Socorro	4. 21	83. 11		4, 658	Do.

From Manzano to Pedernal Spring, N. Mex., via Ojo Chico.—Atlas-sheets Nos. 77 B and D.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Manzano.	From Pedernal Springs.		
Manzano			54. 72	6, 961	Mexican town, government agency.
Mesteño	8. 55		46. 17	6, 399	Ranch; water and grass.
Mesteñito	6. 44	14. 99	39. 73	6, 268	Ranch; water and grass; no wood.
Ojo Chico	8. 70	23. 69	31. 03	6, 162	Small spring south of road.
Cañoncitos	10. 12	33. 81	20. 91	6, 353	Water-holes; sometimes dry.
Water-holes	8. 94	42. 75	11. 97	6, 449	Do.
Pedernal	11. 97	54. 72		7, 140	Water on slope east of gap, 100 yards from road.

From Pedernal Spring to Tejique, N. Mex.—Atlas-sheets Nos. 77 D and 78 A.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Pedernal Spring.	From Tejique.		
Pedernal Spring	....	....	38.88	7,140	Water east of road, near gap.
Estancia	25.77	....	13.11	6,177	Spring Ranch; grass, but no wood.
Tejique	13.11	38.88	....	6,682	Mexican town.

LIST OF ROAD DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 1, UTAH SECTION, 1877.

Corinne to Logan, Utah.
Brigham to Hampton's Bridge, Utah.
Franklin, Idaho, to Paradise, Utah.
Logan to Jackson's Mills, Utah.
Franklin to Soda Springs, Idaho, via Three Fords of Bear River—summer route.
Franklin to Soda Springs, Idaho, via Ten-Mile Ford.
Franklin to Soda Springs, Idaho, via Packer's Bridge, Burton, and Ten Mile Ford.
Franklin to Soda Springs, Idaho, via Packer's Bridge.
Franklin to Fort Hall, Idaho.
Franklin, Idaho, to Laketown, Utah.
Soda Springs to Liberty, Idaho.
Soda Springs to Cariboo, Idaho.
Ross Fork Indian Agency to Montpelier, Idaho, via Oneida and Mormon Salt Works.
Corinne to Harkness Station, via Montana Freight road.
Corrinne, Utah, to Clifton, Idaho.
Corinne, Utah, to Malade, Idaho, via Samaria.

From Corinne, Utah, to Logan.—Atlas-sheet No. 41 B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Corinne.	From Logan.		
Corinne	....	....	34.168	4,233	
Danishtown	5.409	5.409	28.759	4,400	
Forks of road above Hampton's Bridge	12.659	18.068	16.100	4,400	
Hampton's Bridge	0.737	18.805	15.363	4,370.7	
Hampton's Station	1.563	20.368	13.800	4,700	
Bridge over Logan River	7.500	27.868	6.300	4,415	
Logan	6.300	34.168	....	4,533.1	

From Brigham to Hampton's Bridge.—Atlas-sheet No. 41 B.

Brigham	....	....	20.384	....	
Honeyville	9.028	9.028	11.356	....	
Deweyville	4.832	13.860	6.524	4,414	
Hampton's Bridge	6.524	20.384	....	4,370.7	
Brigham		....	....	....	
Corinne	6.423	....	....	4,233	

From Franklin, Idaho, to Paradise, Utah.—Atlas-sheet No. 41 B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Franklin.	From Paradise.		
Franklin, Idaho	....	....	20. 606	4, 585. 4	Altitude refers to Webster's shop.
Richmond, Utah	6. 830	6. 830	13. 776	4, 655. 7	
Smithfield, Utah	5. 696	12. 526	8. 080	4, 623. 1	
Hyde Park, Utah	3. 065	15. 591	5. 015	4, 411. 7	
Logan, Utah	5. 015	20. 606	0. 0	4, 533. 1	
Mendon, Utah	9. 667	30. 273	9. 667	4, 553. 3	
Wellsville, Utah	5. 450	35. 723	15. 117	4, 600	
Paradise, Utah	9. 660	45. 383	24. 777	4, 862. 8	

From Logan to Jackson's Mills.—Atlas-sheet No. 41 B.

Logan	....	....	....	4, 533. 1	Direct road.
Paradise	17. 7	....	....	4, 862. 1	
Jackson's Mills	4. 520	....	....	5, 150. 0	

From Franklin to Soda Springs, Idaho, via Three Fords, Bear River (summer route).—Atlas-sheets Nos. 32 D and 41 B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Franklin.	From Soda Springs.		
Franklin, Idaho	....	....	58. 472	4, 585. 4	
Robbin's Ford, Bear River	11. 956	11. 956	46. 516	4, 620. 7	First ford above Packer's bridge.
Burton's Ford, Bear River	25. 916	37. 872	20. 600	4, 916. 5	Good camping.
Ten-mile Ford, Bear River	9. 900	47. 772	10. 700	5, 514. 4	
Morristown	9. 000	56. 772	1. 700	5, 716. 4	
Soda Springs	1. 700	58. 472	....	5, 778. 3	Water and grass abundant; wood scarce.

From Franklin to Soda Springs, via Ten-mile Ford.—Atlas-sheets Nos. 32 D and 41 B.

Franklin, Idaho	....	....	57. 694	4, 585. 4
Mink Creek Bridge	20. 570	20. 570	37. 124	5, 022. 6
Ten-mile Ford, Bear River	26. 424	46. 994	10. 700	5, 514. 4
Morristown	9. 00	55. 994	1. 700	5, 716. 4
Soda Springs	1. 700	57. 694	....	5, 778. 3

From Franklin to Soda Springs, via Packer's Bridge, Burton, and Ten-mile Ford.—Atlas-sheets Nos. 32 D and 41 B.

Franklin, Idaho	....	....	63. 327	4, 585. 4
Packer's Bridge, Bear River	10. 937	10. 937	52. 390	4, 486. 4
Burton's Ford, Bear River	31. 790	42. 727	20. 60	4, 916. 5
Ten-mile Ford, Bear River	9. 900	52. 627	10. 70	5, 514. 4
Morristown	9. 00	61. 627	1. 70	5, 716. 4
Soda Springs	1. 70	63. 327	....	5, 778. 3

From Franklin to Soda Springs, Idaho, via Packer's Bridge.—Atlas-sheets Nos. 32 *D and* 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Franklin.	From Soda Springs.		
Franklin, Idaho	....	....	66. 927	4, 585. 4	
Packer's Bridge	10. 937	10. 937	55. 99	4, 486. 4	Grass poor; wood scarce.
Burton's Ford	31. 790	42. 727	24. 20	4, 916. 5	Grass, wood, and water.
Forks of road, near Sulphur Springs	8. 500	51. 227	15. 70	5, 475. 2	Wood and water scarce.
Morristown	14. 00	65. 227	1. 70	5, 716. 4	
Soda Springs	1. 700	66. 927	....	5, 778. 3	

From Franklin to Fort Hall, Idaho.—Atlas-sheets Nos. 32 *D and* 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Franklin.	From Fort Hall.		
Franklin, Idaho	....	....	107. 660	4, 585. 4	
Packer's Bridge, Idaho	10. 937	10. 937	97. 723	4, 486. 4	
Clifton, Idaho	6. 680	17. 617	90. 043	4, 926	
Oxford, Idaho	5. 909	23. 526	84. 134	4, 866	
Elkhorn Mail Station	20. 236	43. 762	63. 898	4, 998	
Junction Montana freight-road	3. 500	47. 262	60. 398	4, 793	
Junction Soda Springs road	2. 00	49. 262	58. 398	4, 790	
Harkness Toll-gate	6. 874	56. 136	51. 524	4, 802	
Black Rock Stage Station	11. 773	67. 909	39. 751	4, 589	
Pokatillo Stage Station	10. 050	77. 959	29. 701	4, 620	
Ross Fork Indian Agency	12. 651	90. 610	17. 050	4, 544. 7	
Warren's Junction	9. 570	100. 180	11. 930	....	
Fort Hall	11. 930	112. 110	....	4, 752. 1	Adjutant's office.
Ross Fork Indian Agency	17. 050	90. 610	17. 050	4, 544. 7	
Fort Hall		107. 660	....	4, 752. 1	

From Franklin, Idaho, to Laketown, Utah.—Atlas-sheets Nos. 32 *D and* 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Franklin.	From Laketown.		
Franklin, Idaho			78.583	4,585.4	
Bridge over Mink Creek	20.570	20.570	58.013	5,022.6	On Soda Springs road; grass, wood, and water.
Junction Liberty Road	3.924	24.494	54.089	5,057	Grass and water; no wood.
Liberty, Idaho	16.250	40.744	37.839	6,104.7	
Paris, Idaho	7.279	48.023	30.560	6,018	
Bloomington, Idaho	2.611	50.634	27.949	6,076.3	
Saint Charles, Idaho	4.600	55.234	23.349	6,057.4	
Fish Haven, Idaho	5.450	60.684	17.899	5,963	
Utah and Idaho boundary line	2.837	63.521	15.062	6,001.2	
Crossing Swan Creek, Utah	1.027	64.548	14.035	5,979	
Pleasant Valley Post Office, Utah	5.300	69.848	8.735	6,064	
Laketown, Utah	8.735	78.583		5,993	
Eden Cañon, Utah	7.671		7.671		Water & grass; wood scarce.
North Eden Cañon, Idaho	4.538		12.209		Do.
Indian Creek, Idaho	7.00		19.209	5,990	Do.
Bridge over outlet to Bear Lake, Idaho	5.029		24.238	5,950	
Saint Charles, Idaho	2.813		27.051	6,057.4	

From Soda Springs to Liberty, Idaho.—Atlas-sheets Nos. 32 *D and* 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Soda Springs.	From Liberty.		
Soda Springs, Idaho			30.265	5,778.3	
Georgetown, Idaho	18.872	18.872	11.393	6,019	
Bennington, Idaho	7.077	25.949	4.316	6,132	
Montpelier Idaho	4.316	30.265		5,935.9	
Ovid, Idaho	9.280	39.545	9.280	6,022.2	
Liberty, Idaho	3.50	43.045	12.780	6,104.7	

From Soda Springs to Cariboo Post-Office.—Atlas-sheets Nos. 32 *D and* 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Soda Springs.	From Cariboo Post-office.		
Soda Springs			54.494	5,778.3	
Landers Crossing	27.524	27.524	26.970	6,330	
Keenan City	18.970	46.494	5.000	6,641	
Cariboo Post Office	8.00	54.494			
Soda Springs to Fort Hall, Idaho	56.11			5,778.3	Via Ten Mile Springs and Warm Springs.
Soda Springs to Ross Fork Agency	59.850			4,544.7	Do.
Soda Springs to Harkness Toll-gate	38.574			4,802	Through Port Neuf Cañon.

From Ross Fork Indian Agency, to Montpelier, via Oneida and Mormon Salt Works, and Old Lander Road.—Atlas-sheets Nos. 32 *D and* 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Ross Fork Indian Agency.	From Montpelier.		
Ross Fork Indian Agency	....	....	134. 820	4, 544. 7	Water good; wood and grass scarce.
Warm Spring	24. 400	24. 400	110. 420	5, 790	Water and grass.
Crossing Blackfoot River	18. 000	42. 400	92. 420	6, 000	Good camping.
Junction Taylor's Bridge road	9. 250	51. 650	83. 170	6, 310	Grass and water, no wood.
Lander's Crossing	3. 000	54. 650	80. 170	6, 330	Bad camping.
Lane's Fork, crossing	14. 750	68. 400	65. 400	6, 635. 4	Good grass and water; wood scarce.
Oneida Salt Works	16. 000	85. 400	49. 420	6, 341. 2	Poor camping.
Mormon Salt Works	25. 220	110. 620	24. 200	6, 597. 5	Good camping.
Montpelier	24. 200	134. 820	....	5, 935. 9	Good camping near.

From Corinne, Utah, to Harkness Station, via Montana freight-road.—Atlas-sheets Nos. 32 *D and* 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Corinne.	From Harkness Station.		
Corinne (railroad track at depot)	....	....	83. 956	4, 233	
Danishtown	5. 409	5. 409	78. 557	4, 400	
Forks of road near Hampton's Bridge	12. 659	18. 068	65. 898	4, 400	
Plymouth	6. 000	24. 068	59. 898	4, 666	
Old Portage	8. 252	32. 320	51. 646	4, 696	
Henderson Creek	6. 250	38. 570	45. 396	4, 762	
Cherry Creek	2. 600	41. 170	42. 796	4, 653	
Willow Spring	2. 098	43. 268	40. 698	4, 650	
Malade Post Office	4. 571	47. 839	36. 127	4, 663	
Junction	27. 253	75. 082	8. 874	4, 793	Junction of road with Franklin stage-route to Montana.
Harkness Station	8. 874	83. 956	....	4, 802	

From Corinne, Utah, to Clifton, Idaho.—Atlas-sheet No. 41 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Corinne.	From Clifton.		
Corinne	....	....	50. 191	4, 233	
Danishtown	5. 409	5. 409	44. 782	4, 400	
Fork of road above Hampton Bridge	12. 659	18. 068	32. 123	4, 400	
Clarkston	10. 500	28. 568	21. 623	4, 853	
Weston	10. 623	39, 191	11. 00	5, 011. 1	
Five-mile settlement	5. 500	44. 691	5. 500	4. 890	
Clifton	5. 500	50. 191	....	4, 926. 3	
Weston to Malade, along Weston Creek.	25. 469	....	....	....	

From Corinne to Malade City, via Samaria.—Atlas-sheet No. 41B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Corinne.	From Malade.		
Corinne	....	....	55.025	4,233	
Point Lookout	13.264	13.264	41.761	4,564	
Toponce Ranch	8.000	21.264	33.761	5,071.6	
Portage	12.450	33.714	21.311	4,700	
Samaria	12.766	46.480	8.545	4,560.5	
Malade	8.545	55.025	....	4,663	

LIST OF ROAD DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 2, UTAH SECTION, 1877.

Malade to Ross Forks, Idaho, via Bannock Creek.
Malade Spring to Cache Creek, Idaho, via Sublett road.
Malade to Twin Springs, Idaho.
Malade to Hansel Spring, Idaho.
Corinne to Cache Creek, via Black Pine Pass, Utah.
Ogden to Corinne, Utah.
Corinne to Kelton, Utah.
Kelton, Utah, to Birch Creek, Idaho.
Kelton, Utah, to Rice Ferry, Idaho.
Ross Fork to Rice Ferry, Idaho.

From Malade to Ross Forks, Idaho, via Bannock Creek.—Atlas-sheets Nos. 32 *C and* 41 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Malade.	To Ross Fork.		
Malade	....	....	77.78	4,663.1	Post Office.
Elkhorn	10.50	....	67.28	4,949.9	Water and grass.
Sublett road	7.30	17.80	59.98	5,149.9	At Little Malade River.
Malade Spring	.28	18.08	59.70	5,149.9	Head of Little Malade.
Summit	5.14	23.22	54.56	6,461.4	Malade Range.
Taponce Ranch	6.33	29.55	48.23	5,071.5	On Bannock Creek.
Rattlesnake Creek	16.25	45.80	31.98	4,778.5	Water and gas.
Indian Village	14.45	60.25	17.53	4,476.8	On Bannock Creek.
To Emigrant road	6.19	....	....	4,314.9	At crossing of Bannock Creek.
Forks of road	2.19	62.44	15.34	4,383.6	Leave Bannock Creek.
Indian Village	3.08	65.52	12.26	....	On Monsiem Creek.
Port Neuf Ford	4.90	70.42	7.36	4,476.7	Water and grass.
Ross Fork	7.36	77.78	....	4,544.7	Post Office.

This road to forks of road near Indian Village was former stage-road to old Fort Hall.

From Malade Spring to Cache Creek, via Sublett road, Idaho.—Atlas-sheets Nos. 32 *C and* 41 *A.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Malade Spring.	From Cache Creek.		
Malade Spring	....	....	64. 94	5, 149. 9	Sublett road crosses near head of Little Malade.
Summit	7. 75	....	57. 19	6, 557. 7	Malade Range.
Twin Springs	15. 96	23. 71	41. 23	5, 207. 5	Near head Bankhead Creek.
Pine Spring	10. 09	33. 80	31. 14	6, 177. 7	Sublett Mountains.
Head Sublett Creek	5. 16	38. 96	25. 98	5, 469. 0	
Sublett	7. 37	46. 33	18. 61	5, 155. 1	Settlement.
Sweetser's	12, 80	59. 13	5. 81	4, 509. 3	On Raft River.
Cache Creek	5. 81	64. 94	....	4, 722. 8	Also on Boisé and Kelton freight road.

From Cache Creek the old emigrant road through City of Rocks is no longer used.

From Malade to Twin Springs, Idaho.—Atlas-sheets Nos. 32 *C and* 41 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Malade.	From Twin Springs.		
Malade	....	....	29. 69	4, 659. 1	Post-office.
Big Malade bridge	5. 40	....	24. 29	....	On road to Samaria.
Forks of road	. 75	6. 15	23. 54	....	To Samaria.
Forks of road	2. 85	9. 00	20. 69	....	To Pocotalla Valley.
Summit	4. 07	13. 07	16. 62	5, 823. 1	Malade Range.
Spring	3. 12	16. 19	13. 50	5, 331. 5	Water and grass; no wood.
Head of Deep Creek	2. 43	23. 77	5. 92	4, 761. 1	Water, grass, and sage-brush.
Twin Springs	5. 92	29. 69	....	5, 207. 5	On Sublett road.
Forks of road	5. 15	21. 34	8. 35	....	To Curlew.
Co-operative Ranch	3. 75	25. 09	41. 28	4, 867. 0	Water and grass.
Lee's Ranch	6. 32	31. 41	34. 96	4, 718. 3	Do.
Crossing Deep Creek	5. 39	36. 80	29. 57	4, 592. 1	Settlement.
Curlew	8. 77	45. 57	20. 80	4, 396. 7	Water and grass; settlement.
Kelton	20. 80	66. 37	....	4, 222. 2	Post-office, on Central Pacific Railroad.

This branch is the route traveled between Malade and Curlew, and is also the best route from Malade to Kelton.

From Malade to Hansel Spring, Idaho.—Atlas-sheets Nos. 32 *C and* 41 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Malade.	From Hansel Spring.		
Malade	....	....	29.57	4,663.1	Post-office, at bridge.
Big Malade bridge	5.40	....	24.17	....	On road to Samaria.
Forks of road	.75	6.15	23.42	....	To Samaria.
Pocotalla Valley	5.23	11.38	18.19	5,161.8	Edge of.
Foot of hill	6.29	17.67	11.90	5,132.9	Across valley.
Corinne road	9.49	27.16	2.41	5,165.3	Between Hansel Spring and Blue Creek.
Hansel Spring	2.41	29.57	....	5,043.5	On road from Corinne to Curlew.

Between these last two points (75 miles from Hansel) a road branches to Salt Springs, distance 12.75 miles, passing two springs along the east base of the Hansel Mountains, within 3 miles of Hansel Spring.

From Corinne to Cache Creek, Utah, via Black Pine Pass.—Atlas-sheet No. 41 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Corinne.	From Cache Creek.		
Corinne	....	....	97.80	4,233	
Forks of road	9.67	....	87.13	4,348.6	To Portage and Samaria.
Head of Salt Creek	4.00	13.67	83.13	4,359.4	Poor water; little grazing; no wood.
To Sweetwater Spring	8.68	24.61	....	5,031	Ranch; good water, and grazing.
Head of Blue Creek	6.56	31.17	....	4,676.1	Poor water; grazing, but no wood.
Forks of road	2.26	15.93	80.87	4,476.2	To head of Blue Creek via Sweetwater Spring.
Blind Spring	3.67	19.60	77.20	....	Little water; good grazing.
Head of Blue Creek	10.00	29.60	67.20	4,675.1	Poor water; grazing, but no wood.
Summit	6.48	36.08	60.72	5,137.9	Promontory Range.
Forks of road	3.20	39.28	57.52	5,165.3	To Pocotalla Valley and Samaria.
Hansel Spring	2.44	41.72	55.08	5,043.5	Good water; grazing, and wood.
Forks of road	1.25	42.97	54.83	5,049.1	To Pow's Ranch, 2.73 miles, and Keith's Ranch, .65 mile further.
Deep Creek	5.07	48.04	49.76	4,600.3	Good water; no wood.
To Pilot Spring	11.83	64.03	....	4,704	Water and grazing; no wood.
Emigrant Spring	5.43	69.46	....	5,270.6	On Boise City and Kelton Road.
Curlew	4.16	52.20	45.60	4,396.7	Settlement. Road forks to Emigrant Spring.
Black Pine Ranch	15.99	68.19	29.61	5,114.4	Good water; grazing, and wood.
Summit	2.50	70.69	27.11	5,536.7	Black Pine Pass.
Sublett Creek	8.50	79.19	18.61	5,155.1	Settlement.
Sweetser's Ranch	12.80	91.99	5.81	4,509.3	Raft River.
Cache Creek	5.81	97.80	....	4,722.8	Settlement.

From Ogden to Corinne, Utah.—Atlas-sheets Nos. 41 *B and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Ogden.	From Corinne.		
Ogden	....	....	29. 39	4, 310. 6	Intersection Fifth and Main streets.
Ogden River Bridge	0. 90	....	28. 49	4, 267. 1	
North Ogden	5. 05	5. 95	23. 44	4, 509	Post-office.
Big Spring	4. 83	10. 78	18. 61	4. 316. 9	
Willard	4. 50	15. 28	14. 11	4. 287. 6	Post-office.
North Willard	1. 41	16. 69	12. 70	4, 275. 7	Settlement.
Brigham	6. 16	22. 85	6. 54	4. 475. 6	Court-house, Box Elder County.
Bear River Bridge	6. 29	29. 14	. 25	4, 197. 4	
Corinne	. 25	29. 39	....	4, 233	Post-office.

Two miles from Ogden River Bridge a more direct route leaves this, with North Ogden to the right, and joins this route again a little short of Big Spring, shortening the distance about one mile.
Grade and road-bed good, following along the east side of Utah Northern and Central Pacific Railroads, crossing the first at Brigham and the latter just before crossing Bear River.

From Corinne to Kelton, Utah.—Atlas-sheets Nos. 41 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Corinne.	From Kelton.		
Corinne	....	....	63. 81	4, 233. 0	Post-office.
Tibbal's Ranch	3. 20		60. 61	4, 204. 1	
To head of Salt Creek	10. 71	24. 98	....	4, 359. 4	On road, Corinne to Curlew.
Point Lookout road	11. 07	14. 27	49. 54	4, 210. 0	Near Connor's Springs.
Spring	. 77	15. 04	48. 77	4, 173. 1	Ranch; good water; spring.
To railroad crossing	3. 95	23. 93	....	....	Central Pacific Railroad (the direct road).
Blue Creek Crossing	4. 94	19. 98	43. 83	4, 134. 7	Water alkaline.
Skeen's Ranch	2. 81	22. 79	41. 02	4, 266. 2	Good water; no wood.
Railroad crossing	2. 73	25. 52	38. 29	4, 867. 2	Central Pacific Railroad.
To Cedar Spring	5. 25	31. 59	....	4, 843. 3	Good water, wood, and grazing.
To Salt Springs	8. 58	40. 17	....	4, 203. 2	Do.
Forks of road	. 82	26. 34	37. 47	4, 867. 2	To Cedar Spring.
Summit Promontory Range	4. 75	31. 09	32. 72	5, 337. 4	Good grazing; little wood; no water.
Cedar Spring road	5. 38	36. 47	27. 34	4, 199. 5	
Salt Springs	. 90	37. 37	26. 44	4. 203. 2	Grazing; no wood; water poor.
Monument Point	11. 18	48. 55	15. 26	4, 206. 2	On Central Pacific Railroad and Great Salt Lake.
Locomotive Spring	4. 75	53. 30	10. 51	4, 182. 8	No wood; grazing.
Railroad-crossing	3. 45	56. 75	7. 06	4, 163. 4	
Kelton	7. 06	63. 81	....	4, 222. 2	Post-office, on Central Pacific Railroad.

From Kelton, Utah, to Birch Creek, Idaho, via Boisé City stage-road.—Atlas-sheets Nos. 40 *B and* 41 *A.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Kelton.	From Birch Creek.		
Kelton	....	....	....	4, 222. 2	Post-office.
Ten-mile station	9. 48	....	....	5, 086. 4	On stage and freight road to Boisé City.
Forks of road	8. 99	18. 47	....	5, 241. 5	Freight-road forks to right.
Clear Creek Station	3. 81	22. 28	....	5, 548. 7	On Clear Creek.
Raft River Station	12. 61	34. 89	....	5, 040. 8	On Raft River.
Crossing, Raft River	6. 53	41. 42	....	5, 191. 0	Little wood; water and grass.
City of Rocks Station	8. 58	50. 00	....	5, 957. 9	Do.
Divide	7. 19	57. 19	....	....	Between Raft River and Birch Creek.
Summit Station	3. 30	60. 49	....	5, 945. 1	
Crossing, Birch Creek	5. 85	66. 34	....	....	
(Limit of our measurements, 1877.)					

The old emigrant road through City of Rocks, not now used, comes into this road just west of City of Rocks Station, follows with it about 1 mile, and forks to the left.

**From Kelton, Utah, to Rice's Ferry, Idaho.—Atlas-sheet Nos.* 32 *C and* 41 *A.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Kelton.	From Rice's Ferry.		
Kelton	....	....	69. 65	4, 222. 2	Colorado Central Railroad.
Ten-mile Station	9. 48	....	60. 17	5, 086. 4	On stage and freight road to Boise.
Emigrant Spring	4. 13	13. 61	56. 04	5, 270. 6	Do.
Forks of road	4. 86	18. 47	51. 18	5, 241. 5	Separation of stage and fr'ght roads to Boise.
Rice's	3. 78	22. 25	47. 40	4, 986. 8	Ranch.
Kelso's	3. 52	25. 77	43. 88	4, 836. 0	Do.
Clear Creek	4. 65	30. 42	39. 23	4, 605. 3	Bridge.
Raft River	2. 60	33. 02	36. 63	4, 603. 1	Bridge; road forks to Sweetser's Ranch.
Sweetser's Ranc	8. 10	41. 12	....	4, 509. 3	On road from Corinne to Cache Creek.
Cache Creek	9. 75	42. 77	26. 88	4, 722. 8	Bridge.
Richardson's	4. 14	46. 91	22. 74	5, 267. 7	Blacksmith-shop.
Howell's	6. 10	53. 01	16. 64	5, 040. 9	Ranch and store; road forks to Marsh Lake.
Marsh Creek	2. 75	55. 76	13. 89	4, 735. 8	Ranch.
Forks of road	4. 50	60. 26	9. 39	4, 431. 9	Separation of old and new freight-roads.
Snake River road	23. 79	64. 91	....	4, 166. 4	Crossing of Raft River on road from Ross's Fork to Rice's Ferry.
Goose Creek	7. 00	67. 26	2. 39	4, 250. 3	Settlement.
Rice's Ferry	2. 39	69. 65	....	4, 175. 0	Snake River.

* Portion of freight-road from Kelton to Boise City, Idaho.

Road from Sweetser's also joins Snake River road near Marsh Lake; distance, 21.84 miles.

Freight-road via Clark's Ferry crosses Goose Creek 7.25 miles from this point, the limit of our measurements.

This new road via Rice's Ferry passes close on the north side of the Great Falls 29 miles from the ferry. The road has been very little used as yet, and is not in good condition for that reason.

From Ross's Fork to Rice's Ferry.—Atlas-sheet No. 32 C.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Ross's Fork.	From Rice's Ferry.		
Ross's Fork	....	....	87.18	4,544.7	Post-office.
Port Neuf Ford	7.36	....	79.82	4,476.7	Good.
Bannock Creek	9.30	16.66	70.52	4,314.9	
McCrea's Ranch	9.47	26.13	61.05	4,331.1	Water and grass.
American Falls	4.22	30.35	56.83	4,457.2	
Rock Creek	11.24	41.59	45.59	4,212.8	Poor grazing.
Fall Creek	4.11	45.70	41.48	4,080.5	Good grazing.
Raft River	8.76	54.46	32.72	4,166.4	Little wood; good grazing.
Marsh Lake	16.41	70.87	16.31	4,316.5	Do.
Marsh Creek	5.72	76.59	10.59	4,227.6	Crossing.
Goose Creek	8.20	84.79	2.39	4,280.5	Labelle's ranch; road forks to Rice's Ferry from old road.
Rice's Ferry	2.39	87.18	....	4,175.0	New road.

This is the Snake River emigrant-road; the grade is good.

From Ross's Fork to Big Butte.—Atlas-sheets Nos. 32 A and 32 C.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Ross's Fork.	From Big Butte.		
Ross's Fork	....	....	46.61	4,544.7	Agent's house.
Meadows	4.44	....	42.17	4,417.1	Fort Hall bottom land.
Snake River	5.66	10.10	36.51	4,362.0	Boat crossing.
Anderson's	2.46	12.56	34.05	4,491.9	Ranch.
Big Springs	4.05	16.61	30.00	4,349.8	Last water on road to Big Butte.
Butte (estimated)	30.00	46.61	....	5,682.6	Spring on north slope.

Road across bottom land very marshy in places, animals must be swam at crossing. From Big Butte the road continues to Lost River, and thence to Boise City.

LIST OF ROAD DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 1, CALIFORNIA SECTION, 1877.

Alturas to Camp Bidwell, via Cedarville Pass, Cal.
Alturas to Camp Bidwell, via Lake City Pass, Cal.
Alturas, Cal., to Warner Valley, Oreg.
Alturas, Cal., to Drew's Valley, Oreg.
Eagleville, Cal., to Mud Meadows, Nev.
Carson, Nev., to Susanville, Cal.
Susanville to Camp Bidwell, Cal.
Susanville to Camp Bidwell, Cal.

From Alturas to Camp Bidwell, Cal., via Cedarville Pass.—Atlas-sheet Nos. 38 *B and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Alturas.	From Bidwell.		
Alturas	....	....	48.46	4,364.9	
Forks of road	6.63	6.63	41.83	....	Main road to north.
Divide	14.58	21.21	27.25	5,438.8	
Cedarville	2.28	23.49	24.97	4,674.5	
Lake City	8.65	32.14	16.32	4,623.5	
Bidwell	16.32	48.46	....	4,612.2	

From Alturas to Camp Bidwell, Cal., via Lake City Pass.—Atlas-sheet Nos. 38 *B and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Alturas.	From Bidwell.		
Alturas	....	....	45.01	4,364.9	
West entrance to Lake City Pass	17.92	17.92	27.09	5,000.0	On Swearengen Creek.
Divide	5.35	23.27	21.74	7,034.5	
Lake City	5.42	28.69	16.32	4,623.5	Town.
Bidwell	16.32	45.01	....	4,612.2	United States camp and town

From Alturas, Cal., to Warner Valley, Oreg.—Atlas-sheets Nos. 29 *D and* 38 *B and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Alturas.	From Warner Valley.		
Alturas	....	....	100. 35	4, 364. 9	County seat Modoc County, Cal.
Cedarville Road	6. 63	6. 63	93. 72	5, 239. 9	
Lake City Road	11. 29	17. 92	82. 43	5, 000. 0	
Lassen's Creek	13. 78	31. 70	68. 65	5, 145. 6	Road-crossing.
Snider's Store	3. 14	34. 84	65. 51	4, 925. 2	Willow Ranch, Fandango Creek.
Boundary Monument, Oregon and California.	7. 78	42. 62	57. 73	4, 939. 6	
Cogswell's Creek	6. 25	48. 87	51. 48	4, 998. 5	
Lakeview	9. 20	58. 07	42. 28	4, 825. 1	County seat of Lake County, Oregon.
Head Cammas Prairie	10. 01	68. 08	32. 27	5, 649. 8	Wood, water, and grass.
Cottage Springs	15. 62	83. 70	16. 65	5, 717. 5	Wood, water, and grass; off road to left.
Jones's Ranch, Warner Valley	16. 65	100. 35	....	4. 466. 8	Wood, water, and grass.

Good road all the way.

From Alturas, Cal., to Drew's Valley, Oreg.—Atlas-sheets Nos. 38 *A and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Alturas.	From Drew's Valley.		
Alturas	....	....	78. 37	4, 364. 9	County seat Modoc County.
Cedarville Road	6. 63	6. 63	71. 74	5, 239. 9	
Joseph's Creek	6. 22	12. 85	65. 52	4, 661. 9	
Lake City Road	5. 07	17. 92	60. 45	5, 000. 0	
Pit River Slough	6. 46	24. 38	53. 99	4, 790	
Fletcher's Ranch	4. 37	28. 75	49. 62	4, 819. 4	Water and grass.
Old Lassen Road	3. 70	32. 45	45. 92	....	Old Lassen road across Goose Lake; now submerged.
Meadows	17. 30	49. 75	28. 62	4, 733. 4	Water and grass.
Drew's Creek	12. 17	61. 92	16. 45	....	Water; very little feed.
Debouchure of Drew's Creek	3. 52	65. 44	12. 93	4, 800. 9	Water and grass.
Linkville Road	6. 15	71. 59	6. 78	5, 000. 9	Where road enters mountains from Goose Lake Valley.
Drew's Valley Post Office	6. 78	78. 37	....	4, 952. 6	Water and grass.

This is scarcely practicable for wagons in its present condition, but no trouble is experienced in getting along with pack animals.

From Eagleville, Cal., to Mud Meadows, Nev.—Atlas-sheets Nos. 38 *D and* 39 *C.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Eagleville.	From Mud Meadows.		
Eagleville	....	....	85. 83	4, 632. 5	
Willow Creek	13. 51	13. 51	72. 32	4, 714. 2	East Surprise Valley; water.
Mouth 49 Cañon (6)	9. 70	23. 21	62. 62	4, 645. 8	No water or grass; junction of roads.
Brown's Ranch	7. 58	30. 79	55. 04	4, 878. 4	Water and grass.
Massacre Creek	19. 08	49. 87	35. 96	5, 981. 0	Do.
Mouth Yellow Rock Cañon	17. 91	67. 78	18. 05	5, 120. 6	In High Rock Cañon; water and grass.
Mouth High Rock Cañon	8. 99	76. 77	9. 06	4, 966. 8	
Mud Meadows	9. 06	85. 83	....	4, 318. 0	Water and grass.

The crossing of Surprise Valley opposite Eagleville is very bad and miry. From thence to Massacre Creek the road is good. The road from thence through High Rock Cañon is now almost abandoned, and is very difficult to pass at places.

From Carson, Nev., to Susanville, Cal.—Atlas-sheets No. 47 *A, B, and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Carson.	From Susanville.		
Carson	....	....	123. 30	4, 664. 0	Capital of Nevada.
Franktown	6. 55	6. 55	116. 75	....	Virginia and Truckee Railroad station.
Winter's Ranch	6. 94	13. 49	109. 81	5, 145. 2	Camp.
Washoe	1. 48	14. 97	108. 33	5, 019. 5	Virginia and Truckee Railroad station; almost deserted.
Steamboat Springs	5. 50	20. 47	102. 83	....	Virginia and Truckee Railroad station; fine hotel and baths.
Huffakers	4. 71	25. 18	98. 12	....	Virginia and Truckee Railroad station; great wood flume.
Reno	6. 71	31. 89	91. 41	4, 484. 2	Junction Virginia and Truckee and Central Pacific Railroads.
Stage Station	2. 30	34. 19	89. 11	....	Water.
Peavine Ranch	8. 41	42. 60	80. 70	4, 951. 8	Camp.
Pine Stage Station	5. 03	47. 63	75. 67	....	Water; road to Loyalton and Sierraville.
Junction House	14. 00	61. 63	61. 67	....	Road to Sierra Valley.
Dunning's Ranch	3. 09	64. 72	58. 58	4, 585. 2	Camp.
Willow Ranch	14. 01	78. 73	44. 57	4, 275. 3	Road to Last Chance Valley.
Greeno's Ranch	2. 32	81. 05	42. 25	4, 187. 3	Camp.
McFadden's Ranch	15. 69	96. 74	26. 56	4, 420. 3	Do.
Millford	1. 52	98. 26	25. 04	4, 203. 7	Town.
Clark's Ranch	5. 22	103. 48	19. 82	4, 028. 5	
Bunnellsburg	4. 03	107. 51	15. 79	4, 277. 9	Store.
Janesville	2. 23	109. 74	13. 56	4, 386. 2	Do.
Susanville	13. 56	123. 30	....	4, 218. 0	County seat of Lassen County; land-office.

Main stage-road from Reno to the north.

From Susanville, to Camp Bidwell, Cal.—Atlas-sheets Nos. 38 *B and D and* 47 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Susanville.	From Bidwell.		
Susanville	....	....	140.41	4,218.0	
Willow Creek	14.00	14.00	126.41	....	Road crossing; from plot.
Shumway's Ranch	13.00	27.00	113.41	5,067.0	North of Horse Lake; from plot.
Cold Spring	28.65	55.65	84.76	5,375.0	Partly from plot, partly meandered.
Tuledad	14.75	70.40	70.01	....	
Junction of Roads	9.00	79.40	61.01	....	Road to Reno via Fish Spring; from plot.
Bares Ranch	8.42	87.82	52.59	4,679.6	
Eagleville	11.72	99.54	40.87	4,632.5	
Cedarville	15.90	115.44	24.97	4,674.5	
Lake City	8.65	124.09	16.32	4,623.5	
Bidwell	16.32	140.41	....	4,612.2	

Stage and mail route from Susanville to Camp Bidwell.

From Susanville, to Camp Bidwell, Cal.—Atlas-sheets No. 38 *B and D and* 47 *A and B.*

	Distance in miles,			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Susanville.	From Bidwell.		
Susanville	....	....	166.58	4,218.0	County seat Lassen County; to Hot Springs 3.18 miles.
Shafer's Station	18.55	18.55	148.03	4,026.1	Old emigrant camping place; wood, water, and feed.
Mud Springs	16.66	35.21	131.37	4,671.1	Small supply water; no grass.
Rush Creek	6.15	41.36	125.22	4,437.0	Water and grass; ranch.
Smoke Creek Depot	4.94	46.30	120.28	4,163.7	Old government military station; water and feed.
Forks of road to Reno	9.76	56.06	110.52	....	Main road from Surprise Valley to Reno via Fish Spring; to Wall Spring 15.71 miles.
Murphy's Salt Works	2.81	58.87	107.71	3,829.6	Very bad water; to Deep Hole 22.94 miles.
Buffalo Station	14.73	73.60	92.98	4,378.2	Water and grass.
Spring	13.06	86.66	79.92	....	Do.
Clark's Ranch	16.04	102.70	63.88	4,676.8	Good water and feed.
Forks of road	2.87	105.57	61.01	....	Road to Tuledad and Cold Spring.
Bares Ranch	8.42	113.99	52.59	4,679.6	South end Surprise Valley, on Silver Creek.
Eagleville	11.72	125.71	40.87	4,632.5	Post-office on Eagle Creek.
Cedarville	15.90	141.61	24.97	4,674.5	Small town.
Lake City	8.65	150.26	16.32	4,623.5	Do.
Bidwell	16.32	166.58	....	4,612.2	United States camp and town.

LIST OF ROAD-DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 2, CALIFORNIA SECTION, 1877.

Carson, Nev., to Georgetown Junction, Cal.
Georgetown Junction to Placerville, Cal.
Placerville to Georgetown, Cal.
Georgetown to Georgetown Junction, Cal.
Carson, Nev., to Placerville, Cal., via Amador Road.
San Andreas to Silver Mountain City via Big Tree Road, Cal.
Silver Mountain City to Woodford's, Cal.
Woodford's, Cal., to Carson, Nev.
Bridgeport to Columbia, Cal.
San Andreas to Tuttletown, Cal.
Carson, Nev., to Wellington, Cal., via Cradlebaugh's Toll-Road.
Carson, Nev., to Wellington, Cal., via McTanahan's Road across Como Range.
Silver City to Mogul, Cal.
Truckee, Nev., to Cisco, Cal.

From Carson, Nev., to Georgetown Junction, Cal., via Placerville and Virginia Toll-Road.—Atlas-sheets Nos. 47 *D and* 56 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Carson.	From Georgetown Junction.		
Carson	....	....	48.31	4,670	At the capitol.
Genoa (corner of lane)	12.96	12.96	35.35	4,797	Via upper road; 13.16 miles by river road.
Hot Springs	1.80	14.76	33.55	4,702	Hotel and bath-house.
Haines'	1.14	15.90	32.41	....	Foot of Kingsbury grade.
Summit of grade	5.04	20.94	27.37	7,297	Daggett's Pass, eastern summit.
Small's	3.22	24.16	24.15	....	Foot of Kingsbury grade.
Carney's	0.90	25.06	23.25	....	State Line House.
Sierra House	3.45	28.51	19.80	....	
Woodburn's saw-mill	1.44	29.95	18.36	....	Lake Valley Post-Office.
Myers' Ranch	3.25	33.20	15.11	....	Dairy Ranch.
Osgood's Toll-House	1.10	34.30	14.01	....	Forage for sale.
Summit	2.05	36.35	11.96	7,266	Johnson Pass, western summit.
Phillips' Station	2.81	39.16	9.15	6,871	No grazing; forage sold.
Strawberry Station (toll-house)	4.87	44.03	4.28	5,695	Do.
Georgetown Junction	4.28	48.31	....	....	Branch road to Georgetown Cal.

Fine double-track road; best route from the western foot-hills to the Comstock. Forage, &c., may be purchased at any of the stations.

From Georgetown Junction to Placerville, Cal.—Atlas-sheets Nos. 56 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Georgetown Junction.	From Placerville.		
Georgetown Junction	....	....	39.90	....	Toll-House.
Dick Yarnell's Toll-House	6.28	6.28	33.62	....	Wood, water, and forage.
McConnaha's	.72	7.00	32.90	3,981	Do.
Perrin's	1.16	8.16	31.74	....	Do.
Miles'	6.67	14.83	25.07	....	Do.
Moore's Station (toll-house)	0.91	15.74	24.16	....	Do.
Pacific House	4.28	20.02	19.88	3,451	Do.
Sportsman's Hall	7.30	27.32	12.58	....	Do.
Ten-Mile House	1.79	29.11	10.79	....	Do.
Painter's Station (Eight-Mile House)	1.32	30.43	9.47	....	Do.
Toll-House	6.25	36.68	3.22	....	Do.
Smith's Flat	0.47	37.15	2.75	....	Do.
Placerville (at post-office)	2.75	39.90	....	*1,893	Mining town; seat of Eldorado County.

Continuation of Virginia and Placerville route; forage, &c., to be had at all principal stations; grazing scanty.

*Observation for altitude taken at court-house steps.

From Placerville to Georgetown, Cal.—Atlas-sheet No. 56 *A.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Placerville.	From Georgetown.		
Placerville	....	....	15.68	....	At post-office.
Chili Bar Toll-House	3.25	3.25	12.43	....	Bridge over South Fork of American River.
Kelsey	2.48	5.73	9.95	....	Mining settlement.
Saint Lawrence Mine	2.76	8.49	7.19	....	Do.
Johntown	2.94	11.43	4.25	....	Do.
Georgetown	4.25	15.68	....	....	Mining village.

Road in good order.

From Georgetown to Georgetown Junction, Cal.—Atlas-sheets Nos. 56 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Georgetown.	From Georgetown Junction.		
Georgetown	....	....	47. 58	....	Mining village.
Hotchkiss Ranch	1. 52	1. 52	46. 06	2, 931	Forage obtainable.
Forni's Ranch	17. 69	19. 21	28. 37	4, 225	On Pilot Creek; wood and water; poor grazing.
Big Silver Creek	13. 22	32. 43	15. 15	4. 762	Ford.
Jones' Ranch	3. 01	35. 44	12. 14	....	Little Silver Creek.
Branch road to Sawyer's	9. 53	44. 97	2. 61	....	Sawyer's Dairy Ranch 4.72 miles.
Georgetown Junction	2. 61	47. 58	....	....	On Placerville and Virginia Toll-Road, South Fork American River.

Road kept in fair condition; is used principally by dairymen and stock-owners.

From Carson, Nev., to Placerville, Cal., via Amador road.—Atlas-sheets Nos. 47 *D and* 56 *A and B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Carson.	From Placerville.		
Carson	....	....	105. 42	....	At the capitol.
Woodford's	30. 87	30. 87	74. 55	5, 676	Mouth Carson Cañon; wood and water; forage bought; toll-house.
Carson Cañon Toll-House	3. 84	34. 71	70. 71	6, 596	Carson Cañon; wood and water.
*Nott's Ranch, Hope Valley	2. 42	37. 13	68. 29	7, 110	Wood, water, and grazing.
Stevens' Ranch, Hope Valley	4. 25	41. 38	64. 04	7, 382	Do.
Williams' Ranch	2. 60	43. 98	61. 44	7, 757	Do.
Carson Pass	1. 81	45. 79	59. 63	8, 634	Road crosses main Sierra.
Caples' Ranch	3. 68	49. 47	55. 95	7, 781	Wood, water, and grazing.
Kirkwood's	1. 70	51. 17	54. 25	7, 677	Do.
Silver Lake Hotel	5. 67	56. 84	48. 58	7, 174	Toll-house; wood and water; forage bought.
†Tragedy Spring	3. 00	59. 84	45. 58	7, 989	Wood and water; some grazing.
Leek Spring	6. 59	66. 43	38. 99	7, 242	Wood, water, and grazing.
Caples' Spring	11. 56	77. 99	27. 43	5, 512	Wood plenty; water scarce; no grazing.
Stonebreakers'	4. 25	82. 24	23. 18	4, 360	Wood and water.
Hazel Valley	4. 15	86. 39	19. 03	3, 404	Forage purchased; wood and water.
Hy Park	0. 77	87. 16	18. 26	....	Ranch.
Eldorado Door Factory	7. 04	94. 20	11. 22	....	
Pleasant Valley	0. 57	94. 77	10. 65	2, 405	Agricultural village; formerly some placer-mining.
Newtown	2. 30	97. 07	8. 35	....	Old settlement.
Smith's Flat	5. 60	102. 67	2. 75	....	Swedish settlement.
Placerville (at post-office)	2. 75	105. 42	....	....	County seat Eldorado County; mining town; supplies of all sorts.

* At Nott's Ranch an old stage road branches to the west, crosses western summit by Luther Pass crosses Lake Valley and strikes Placerville and Virginia road at Johnson Pass, about ¾ mile west of summit. Total distance about 10 miles. Road out of repair and little used.

† This route leaves Amador road about 3½ miles beyond Tragedy Spring near Corral Flat. From this point to Stonebreakers' road is principally used by sheep and cattle men.

From San Andreas to Silver Mountain City, Cal., via Big Tree Road.—Atlas-sheets Nos. 56 A and B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From San Andreas.	From Silver Mountain.		
San Andreas	....	....	77.59	1,033	Seat of Calaveras County, Cal.
Eldorado	9.53	9.53	68.06	....	Mining village.
Sheep Ranch	6.55	16.08	61.51	....	Mining settlement.
Half Way House	7.39	23.47	54.12	....	On Big Tree Road.
Big Tree Grove	7.30	30.77	46.82	4,794	Hotel.
Gardener's Station	2.82	33.59	44.00	....	Forage sold.
Black Springs	8.54	42.13	35.46	6,485	Wood and water; no grazing.
Blood's Station	11.04	53.17	24.42	7,269	Toll-house; pasturage and forage.
*Hermit Valley	12.72	65.89	11.70	7,044	Cummings' Ranch.
Summit	5.47	71.36	6.23	7,630	Silver Mountain Pass.
Silver Mountain City	6.23	77.59	....	6,446	At post-office.

* This route from Half Way House on is over Big Tree Road. Road kept in good condition. From Hermit Valley there is a branch road running to Williams' Ranch on the Amador Road; distance, 16.71 miles.

From Silver Mountain City to Woodford's, Cal.—Atlas-sheet No. 56 B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Silver Mountain.	From Woodford's.		
Silver Mountain City (at post-office)	....	....	17.89	6,446	Mining village on Silver Creek.
Mount Bullion Toll-House	5.81	5.81	11.08	....	Mouth Monitor Creek.
Bridge and old toll-house	3.63	9.44	8.45	....	Over East Branch, Carson.
Markleeville (Johnson's Hotel)	1.56	11.00	6.89	5,525	County seat of Alpine County.
Woodford's (post-office)	6.89	17.89	....	5,676	Stage station; forage sold.

From Woodford's, Cal., to Carson, Nev.—Atlas-sheets Nos. 47 D and 56 B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Woodford's.	From Carson.		
Woodford's	....	....	30.87	....	Mouth Carson Cañon; forage purchased.
Fredericksburg	5.10	5.10	25.77	....	Old settlement.
Sheridan (at post-office)	5.07	10.17	20.70	....	Settlement.
Haines	4.80	14.97	15.90	....	Foot of Kingsbury Grade.
Genoa	2.94	17.91	12.96	....	Agricultural village; seat of Douglas County, Nevada.
Carson (at capitol)	12.96	30.87	....	....	Via upper road.

Road passes through Carson Valley. Forage and pasturage may be obtained.

From Bridgeport to Columbia, Cal., via Sonora and Mono Wagon Road.—Atlas-sheets No. 56 B and D.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Bridgeport.	From Columbia.		
Bridgeport	....	....	94.38	6,504	Seat of Mono County; forage and pasturage.
Obenchain's Saw Mill	5.00	5.00	89.38	....	Formerly Taney's.
Hot Springs	9.30	14.30	80.08	7,388	Wood, water; poor grazing.
East Branch West Walker	3.29	17.59	76.79	6,724	Ford; grazing and wood on river banks.
West Walker River	2.40	14.99	79.39	....	Bridge.
Leavitt's	5.06	20.05	74.33	....	Horse Ranch.
Summit	7.59	27.64	66.74	9,660	Sonora Pass.
Hays' Station	11.20	38.84	55.54	5,957	Wood and water; no grazing.
Mill Creek	13.16	52.00	42.38	6,273	Wood and water; no grazing.
Strawberry	11.59	63.59	30.79	5,281	Wood and water; forage purchased.
Excelsior Hotel (Northrup's)	15.94	79.53	14.85	4,570	Wood and water; forage purchased; toll-house.
Columbia (at post-office)	14.85	94.38	....	....	Mining town.

Single-track road; condition, fair; some heavy grades between Leavitt's and Summit, and between Summit and Hays' Station. The main road runs on from Northrup's to Sonora, seat of Calaveras County.

From San Andreas to Tuttle Town, Cal.—Atlas-sheets Nos. 56 *A and D.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From San Andreas.	From Tuttle Town.		
San Andreas	......	....	21.61	1,033	Seat of Calaveras County, California.
Angels	12.88	12.88	8.73	....	Old mining village.
Terry	6.57	19.45	2.16	....	Stanislaus River.
Tuttle Town	2.16	21.61	....	....	Columbia, about 6 miles by road.

From Carson, Nev., to Wellington's, Cal., via Cradlebaugh's Toll Road.—Atlas-sheets No. 47 *D and* 56 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Carson.	From Wellington's.		
Carson (at capitol)	....	....	46.07	4,670	Capital of Nevada.
Cradlebaugh's	8.20	8.20	37.87	4,559	Toll-house and bridge over Carson.
Twelve Mile House	11.67	19.87	26.20	4,768	Stage-station; forage purchased.
Double Springs	10.11	29.98	16.09	5,998.0	Do.
Mountain House	3.75	33.73	12.34	5,641.4	Do.
Walker River Store and Post Office	8.48	42.21	3.86	....	
Wellington's	3.86	46.07	....	4,795	Stage-station; forage purchased.

Freight route to Bridgeport, Aurora, and Bodie, Cal.

From Carson, Nev., to Wellington's, Cal., via McTanahan's Road across Como Range.—Atlas-sheets Nos. 47 *D and* 56 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Carson.	From Wellington's.		
Carson (at capitol)	....	....	48.99	....	Capital of Nevada.
McTanahan's Road and Toll House	4.95	4.95	44.04	....	On Carson River.
Summit of grade near Mineral Hill	12.47	17.42	31.57	....	
Main Summit	4.70	22.12	26.87	7,211	Road crosses Como Range.
The Jews	5.25	27.37	21.62	....	Forage and pasturage.
Hot Springs	11.78	39.15	9.84	4,670	Hotel and bath-house; forage and pasturage.
Wellington's	9.84	48.99	....	4,795	Stage-station; forage, &c.

From Silver Mountain City to Mogul, Cal.—Atlas-sheet No. 56 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Silver Mountain.	From Mogul.		
Silver Mountain City Post Office	....	....	10.04	6,446	Mining village.
Mount Bullion Toll House	5.81	5.81	4.23	....	Mouth Monitor Creek.
Monitor (at Union Hotel)	1.75	7.56	2.48	....	Mining village.
Mogul	2.48	10.04	....	7,273	Deserted mining village.

From Monitor to Silver King, Cal.—Atlas-sheet No. 56 *B.*

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Monitor.	From Silver King.		
Monitor (Union Hotel)	13.87	....	....	....	Mining village.
Silver King		....	....	....	Deserted mining town.

From Monitor to Dumont's Wood-Camp, Cal.—Atlas-sheet No. 56 B.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Monitor.	From Dumont's Wood-Camp.		
Monitor (Union Hotel)	10.71	....	....	....	Mining village.
Junction Fish Valley Creek and Carson	7.69	10.71	....	6,392	Fine grazing; wood and water.
Dumont's Meadow	....	18.40	....	6,817	At foot of grade fine grazing; wood and water.
Dumont's Camp	3.01	21.41	....	7,879	Grazing; wood and water.

From Truckee to Cisco, Cal.—Atlas-sheet No. 47 D.

	Distance in miles.			Altitude in feet above sea-level.	Remarks.
	Between consecutive points.	From Truckee.	From Cisco.		
Truckee	....	....	22.76	....	Central Pacific Railroad.
Donner Lake	3.20	3.20	19.56	....	
Summit Station	7.05	10.25	12.51	6,983	Central Pacific Railroad.
Soda Springs Station	2.19	12.44	10.32	....	Central Pacific Railroad.
Cisco (site), South Fork Yuba River	10.32	22.76	....	5,654	Railroad station about ¼ mile.

From Soda Springs Station there is a good wagon road to the Berkeley Soda Springs hotel; distance, 10 miles. Main road passes on beyond Cisco to Emigrant Gap, Dutch Flat, &c. Branch road, Cisco to Ossaville (deserted mining hamlet), 7.9 miles. Ossaville to Meadow Lake (mining hamlet), 3.1 miles. Road between Ossaville and Meadow Lake disused and out of repair. Meadow Lake to Webber Lake, on Marysville road, 9.5 miles. Meadow Lake to Jackson's, on Marysville road, 9.6 miles.

BAROMETRIC HYPSOMETRY.

Results in this branch appear in Vol. II of the quarto reports, to which a list of cistern barometer altitudes is added. The barometric observers and recorders have made their field observations in accordance with the manual of instructions, and special computers have been employed during the winter months in obtaining differences in altitudes between observed and reference stations. Lieutenant Tillman was in charge of these computations, and of their final record upon the abstracts required by the topographical branch, and those upon which published altitudes are based.

From the number of cistern and aneroid barometer stations occupied and altitudes computed, it will be seen that good progress has been made. Transcripts of observations made by the Signal Service at points contiguous to the field of survey have been furnished through the courtesy of General A. J. Myer, Chief Signal Officer, U. S. A. Data for a large number of barometric profiles of routes, trails, streams, &c., have been collected. A list of altitudes of selected points of special importance in the regions occupied in 1877, prepared by Lieutenant Tillman, Corps of Engineers, is to be found herewith.

List of altitudes of prominent points supplemental to those found in Volume 2 of the quarto reports.

Number.	Name or locality.	State or Territory.	Atlas-sheet.	Number of observations.	Altitude, in feet.	Derived from—	When observed, year and date.	Executive officer.	Reference station.	Original records.	Observer.
1	Spanish Springs	Nev	47 D	1	4469.1	C. B	1876, Sept. 10	Lt. Macomb	Carson City	6, 32	DuBois.
2	Spanish Peak	Nev	47 D	5	7401.5	C. B	1876, Sept. 11	...do	...do	6, 32	Do.
3	Steamboat Springs	Nev	47 D	6	4595.1	C. B	1876, Nov. 17, 18, 21, 22, 24, 25.	Lts. Tillman and Macomb.	...do	6, 31, 6, 33	Lee & DuBois.
4	Washoe and Virginia City divide or road between.	Nev	47 D	1	7241.5	C. B	1876, Sept. 9	Lt. Macomb	...do	6, 32	DuBois.
5	Wilcox Ranch	Nev	47 D	4	5396.2	C. B	1876, Sept. 11	...do	...do	6, 32	Do.
6	Wabler Lake House	Cal	47 D	2	6807.8	C. B	1876, Oct. 25	Lt. Tillman	...do	6, 31	Lee.
7	Wadsworth, Central Pacific Railroad	Nev	47 D	2	4084.8	C. B	1876, Sept. 11, 12	Lt. Birnie	...do	6, 35	Cowles.
8	Clark's Ranch, Truckee River	Nev	47 D	4	4221.0	C. B	1876, Sept. 12, 13	Lt. Macomb	...do	6, 32	DuBois.
9	Marlette's Lake	Cal	47 D	1	7750.2	C. B	1876, Sept. 22	...do	Camp I	6, 32	Do.
10	Marlette's Peak	Cal	47 D	22	8631.0	C. B	1876, Sept. 23	...do	Carson City	6, 32	Do.
11	Marlette's Ranch	Cal	47 D	12	8074.3	C. B	1876, Sept. 22–24	...do	...do	6, 32	Do.
12	Ellis Mountain	Cal	47 D	4	8675.4	C. B	1876, Oct. 22	...do	...do	6, 32	Do.
13	Occidental Mills, Virginia City	Nev	47 D	1	5479.8	C. B	1876, Nov. 22	Lt. Symons	165 G st., Virginia City	7, 34	
14	Prospect Mining Company, Virginia City.	Nev	47 D	2	5866.4	C. B	...do	...do	...do	......	
15	Summit Peak	Cal	47 D	8	8301.9	C. B	1876, Sept. 12	Lt. Tillman	Carson City	6, 31	Lee.
16	Summit post-office, west of Beckworth's Pass.	Cal	47 D	2	4874.9	C. B	1876, Oct. 8, 9	...do	...do	6, 31	Do.
17	Sierraville post-office	Cal	47 D	1	4880.2	C. B	1876, Oct. 10	...do	...do	6, 31	Do.
18	Sulphur Spring Ranch (Camp 24)	Cal	47 D	8	4466.1	C. B	1876, Oct. 11, 12	...do	...do	6, 31	Do.
19	Sierraville, junction of Sierraville, Truckee, and Loyalton road.	Cal	47 D	2	4904.0	C. B	1876, Oct. 21, 22	...do	...do	6, 31	Do.
20	Sierra and Sardine Valleys, divide between, on road.	Cal	47 D	1	6345.8	C. B	1876, Oct. 23	...do	...do	6, 31	Do.
21	Sierra Valley and South Fork Yuba, divide between.	Cal	47 D	1	6700.3	C. B	1876, Oct. 22	...do	...do	6, 31	Do.
22	Summit Station, Central Pacific Railroad.	Cal	47 D	4	6983.0	C. B	1876, Nov. 1–3	...do	...do	6, 31	Do.
23	Sutro Monument on divide between Emma and Rose Mountains.	Nev	47 D	2	5836.9	C. B	1876, Nov. 6	Lt. Symons	165 G st., Virginia City	7, 34	Seckles.
24	Slaughter-house, on road between race-course and toll-gate.	Nev	47 D	1	6413.8	C. B	1876, Sept. 13	...do	Camp on Carson	7, 34	Do.
25	Sutro Springs	Nev	47 D	......	5365.6	C. B	1876, Sept. 23	...do	Biddeman's Ranch	7, 34	Do.
26	Sugar Loaf, rocky peak west of	Nev	47 D	......	5932.7	C. B	1876, Oct. 4	...do	...do	7, 34	Do.
27	Sugar Loaf, bare peak west of	Nev	47 D	......	5975.3	C. B	...do	...do	...do	7, 34	Do.
28	Sutro Tunnel, shaft 2	Nev	47 D	......	5537.2	C. B	...do	...do	...do	7, 34	Do.

29	Sutro Tunnel, mouth of	Nev	47 D		4466.8	Level	1876			7, 34	Do.
30	Sutro Tunnel, shaft 4	Nev	47 D		5990.4	C. B.	1876, Oct. 24	Lt. Symons	C.C.shaft, Virginia City	7, 34	Do.
31	Twin Peak	Cal	47 D	13	8823.9	C. B.	do	Lt. Macomb	Camp 24	6, 32	DuBois.
32	Tahoe City	Cal	47 D	2	6251.8	C. B.	1876, Oct. 25, 26	do	Carson City	6, 32	Do.
33	Truckee	Cal	47 D	1	5795.2	C. B.	1876, Nov. 2	do	Camp 37, Party I	6, 33	Do.
34	Truckee and Warm Springs (Lake Tahoe) divide, on road between.	Cal	47 D	1	7235.8	C. B.	1876, Nov. 4	do	do	6, 33	Do.
35	Twin Lakes	Nev	47 D	1	7843.1	C. B.	1876, Nov. 8	do	Camp 37	6, 33	Do.
36	Truckee and Sierra Valley divide or road between.	Cal	47 D	1	6893.5	C. B.	1876, Oct. 21	Lt. Tillman	Carson City	6, 31	Lee.
37	Turner's Ranch, Sierra Valley	Cal	47 D	2	4903.7	C. B.	1876, Oct. 21, 22	do	do	6, 31	Do.
38	Tibbie Mountain	Nev	47 D	4	7383.3	C. B.	1876, Sept. 12	Lt. Symons	Camp on Carson	7, 34	Seckles.
39	Utah mine	Nev	47 D	1	5995.5	C. B.	1876, Nov. 13	do	165 G st., Virginia City	7, 34	Do.
40	United States Coast Survey stake Nos. 82-85.	Nev	47 D		5858.5	C. B.	1876, Oct. 3	do	Biddeman's Ranch	7, 34	Do.
41	Virginia City astronomical monument.	Nev	47 D		6339.0	C. B.	1876, Oct. 23	do	Carson City	7, 34	Do.
42	Virginia City, No. 165 G street	Nev	47 D	D. m.	6117.6	C. B.	1876, Nov. 4–22	do	do	7, 34	Do.
43	Virginia City, Biddleman's milk ranch.	Nev	47 D	D. m.	5824.9	C. B.	1876, Sept. 21 to October 7.	do	do	7, 34	Do.
44	Virginia City, office Chollar Potosi Mine.	Nev	47 D	D. m.	6242.3	C. B.	1877, June 19 to Oct. 18.		Salt Lake	6, 32	
45	Washoe City	Nev	47 D	6	5020.6	C. B.	1876, Sept. 7, 8; Nov. 21, 22.	Lts. Macomb and Tillman.	Carson City	6, 31	Lee & DuBois.
46	Washoe Lake	Nev	47 D		5045.5	C. B.	1876, Nov. 17, 25	do	do	6, 31	Do.
47	Allen's Springs	Nev	48 C	2	4051.2	C. B.	1876, Nov. 18, 19	Lt. Birnie	do	6, 35	Cowles.
48	Buckland's Ranch	Nev	48 C	D. m.	4150.7	C. B.	1876, Sept. 8, 10	do	do	6, 35	Do.
49	Brown Knob Peak	Nev	48 C	2	6202.3	C. B.	1876, Nov. 20	do	do	6, 35	Do.
50	Desert Station, Central Pacific Railroad.	Nev	48 C	4	4013.9	C. B.	1876, Sept. 12–14	do	do	6, 35	Do.
51	Ragtown, Carson River	Nev	48 C	10	4002.4	C. B.	1876, Sept. 13–16	do	do	6, 35	Do.
52	Hill and Gaines Ranch	Nev	48 C	2	3944.4	C. B.	1876, Sept. 16, 17	do	do	6, 35	Do.
53	Old La Plata	Nev	48 C	6	6012.5	C. B.	1876, Sept. 17, 18, 20, 21.	do	do	6, 35	Do,
54	Tarogua Peak	Nev	48 C	1	8771.7	C. B.	1876, Sept. 19	do	do	6, 35	Do.
55	West Gate	Nev	48 C	D. m.	4503.6	C. B.	1876, Sept. 19–28	do	do	6, 35	Do.
56	Grant's Peak	Nev	48 C	2	9964.8	C. B.	1876, Sept. 29	do	Camp 9	6, 35	Do.
57	Ti-ba-ba Springs	Nev	48 C	2	6248.3	C. B.	1876, Nov. 8, 9	do	Carson City	6, 35	Do.
58	Tis-so-sok	Nev	48 C	2	5831.9	C. B.	1876, Nov. 9, 10	do	do	6, 35	Do.
59	Slate Peak	Nev	48 C	2	7115.2	C. B.	1876, Nov. 10	do	do	6, 35	Do.
60	Wah-ya-bah Springs	Nev	48 C	2	5187.6	C. B.	1876, Nov. 10, 11	do	Camp 22	6, 35	Do.
61	Deep Hollow Station	Nev	48 C		5244.2	C. B.	1876, Nov. 14–16	do	Carson City	6, 35	Do.
62	Sulphur Springs	Nev	48 C		3972	C. B.	1876, Nov. 16–18	do	do	6, 35	Do.
63	Boundary stake between Nevada and California.		47 D	1	5132.8	C. B.	1876, Sept. 10	Lt. Tillman	do	6, 31	Lee.
64	Beckworth's Pass	Cal	47 D	1	5192.6	C. B.	1876, Sept. 11	do	do	6, 31	Do.
65	Beckworth's Store	Cal	47 D	2	4887.2	C. B.	1876, Oct. 12 and 13	do	do	6, 31	Do.
66	Boundary stone between Nevada and California at Crystal City.		47 D	1	4918.4	C. B.	1876, Oct. 18	do	do	6. 31	Do.
67	Broncho	Cal	47 D	1	5309.7	C. B.	1876, Nov. 8	do	Camp 37	6, 31	Do.
68	Boca	Cal	47 D	1	5529.5	C. B.	do	do	do	6, 31	Do.
69	Base line on Carson River near Virginia City Main (Camp).	Nev	47 D	D. m.	4305.9	C. B.	1876, Sept. 3 to 18	Lt. Symons	Carson City	7, 34	Seckels.

List of altitudes of prominent points supplemental to those found in volume 2 of the quarto reports—Continued.

Number.	Name or locality.	State or Territory.	Atlas-sheet.	Number of observations.	Altitude, in feet.	Derived from—	When observed, year and date.	Executive officer.	Reference station.	Original records.	Observer.
70	Carson City, Friend's Observatory	Nev	47 D	D. m.	4660	C. B.	Sept., Oct., and Nov.	Signal Service	Salt Lake and San Francisco.		Friend.
71	Rendezvous Camp, 1876, Treadway's Ranch.	Nev	47 D		4700	By level,	from Friend's Obser	vatory			
72	Carson and Washoe Valley, divide between, on road from Carson to Washoe City.	Nev	47 D	2	5133. 8	C. B.	1876, Sept. 7 and Nov. 22.	Lt. Tillman and Macomb.	Carson City	6, 32	Lee & DuBois.
73	Carnelian Hot Springs	Cal	47 D	D. m.	6236. 8	C. B.	1876, Nov. 4 to 8	Lt. Macomb	Camp 37, Party 1	6, 32	Dubois.
74	Carson Hot Springs	Nev	47 D	1	4592. 3	C. B.	1876, Nov. 12	do	Carson City	6, 32	Do.
75	Coal mines	Nev	47 D		5880. 2	C. B.	1876, Nov. 14	do	do	6, 32	Do.
76	Como Peak	Nev	47 D	15	9016. 6	C. B.	1876, Nov. 15 to 17	do	do	6, 32	Do.
77	Cañon and Empire City roads, junction of.	Nev	47 D	1	6008. 0	C. B.	1876, Nov, 18	do	do	6, 32	Do.
78	Chapman's Ranch	Cal	47 D	3	4991. 9	C. B.	1876, Oct. 10 and 11	Lt. Tillman	do	6, 32	Lee.
79	Castle Peak	Cal	47 D	3	9013. 6	C. B.	1877, July 19	Lt. Macomb	Camp 18, 1877		
80	Cedar Hill, Tank I	Nev	47 D	2	6532. 8	C. B.	1876, Nov. 1	Lt. Symons	Camp near C. and C. shaft.	7, 34	Seckels.
81	Cedar Hill, highest point	Nev	47 D	3	7303. 9	C. B.	1876, Nov. 10	do	165 G street, Virginia City.	7, 34	Do.
82	Cedar Hill Cañon, spring at head of	Nev	47 D	2	7044. 8	C. B.	1876, Nov. 17	do	do	7, 34	Do.
83	Churchill Butte	Nev	47 D	6	6009. 0	C. B.	1876, Sept. 10	Lt. Birnie	Camp 2	6, 35	Cowles.
84	Dayton	Nev	47 D	4	4369. 1	C. B.	1876, Nov. 13, 14, 20, and 22.	Lt. Macomb	Carson City	6, 32, 33	DuBois.
85	Donner Lake	Cal	47 D	1	5884. 8	C. B.	1876, Nov. 1	Lt. Tillman	Camp 37	6, 32	Lee.
86	Mount Davidson	Nev	47 D		7941. 2	C. B.	1876, Sept. 17 and Nov. 7.	Lt. Symons	165 G street, Virginia City.	7, 34	Seckles.
87	Empire City	Nev	47 D	1	4592. 6	C. B.	1876, Nov. 13	Lt. Macomb	Carson City	6, 32	DuBois.
88	Elliott's Ranch, old stage station on Henness Pass road.	Cal	47 D	D. m.	6297. 6	C. B.	1876, Oct. 28 to 30	Lt. Tillman	do	6, 32	Lee.
89	Emma Mountain	Nev	47 D		6439. 4	C. B.	1876, Sept. 9	Lt. Symons	Camp on Carson River.	7, 34	Seckles.
90	Franktown	Nev	47 D	2	5053. 9	C. B.	1876, Nov. 8 and 9	Lt. Macomb	Carson City	6, 32	DuBois.
91	Genoa	Nev	47 D	1	4801. 8	C. B.	1876, Nov. 11	do	do	6, 32	Do.
92	Glendale	Nev	47 D	2	4452. 6	C. B.	1876, Nov. 22 and 23	do	do	6, 32	Do.
93	Geiger Grade, trestle-work below Raystown mines.	Nev	47 D	1	6163. 0	C. B.	1876, Nov. 10	Lt. Symons	165 G street, Virginia City.	7, 34	Seckles.
94	Geiger Grade, toll-gate	Nev	47 D	1	6479. 1	C. B.	do	do	do	7, 34	Do.
95	Geiger Grade, Five-Mile House	Nev	47 D	2	6367. 5	C. B.	1876, Nov. 14	do	do	7, 34	Do.
96	Geiger Grade, second summit	Nev	47 D	2	6732. 9	C. B.	do	do	do	7, 34	Do.

97	Geiger Grade, first summit	Nev	47 D	2	6651.4	C. B.	do	do	do	7, 34	Do.
98	Geiger Grade, big bend near Brewery	Nev	47 D	1	6253.5	C. B.	1876, Nov. 15	do	do	7, 34	Do.
99	Half-way House	Nev	47 D	1	5006.4	C. B.	1876, Nov. 20	Lt. Macomb	Carson City	6, 33	DuBois.
100	Haskell's Peak	Cal	47 D	5	8126.4	C. B.	1876, Oct. 11	Lt. Tillman	Camp 24	6, 31	Lee.
101	Johnson's Ranch, Bresser Creek	Cal	47 D	D. m.	5643.1	C. B.	1876, Oct. 30 to Nov. 10.	do	Carson City	6, 31	Do.
102	Junction House, on Reno and Susanville road near Beckworth's Pass.	Cal	47 D	......	4639.2	C. B.	1876, Sept. 10	do	do	6, 32	Do.
103	Lake Tahoe and Little Valley, divide between.	Cal	47 D	2	7960.3	C. B.	1876, Nov. 8 and 11	Lt. Tillman and Macomb.	do	6, 31	Lee & DuBois.
104	Little Valley and Mill Station, divide between.	Cal	47 D	1	6939.0	C. B.	1876, Nov. 9	Lt. Macomb	do	6, 32	DuBois.
105	Lewis Ranch, near Loyalton	Cal	47 D	2	4949.4	C. B.	1876, Oct, 13 and 14	Lt. Tillman	do	6, 31	Lee.
106	Long and Sierra Valleys, divide between, on Reno and Loyalton new road.	Cal	47 D	1	7075.4	C. B.	1876, Oct. 14	do	do	6, 31	Do.
107	Loyalton and Truckee toll-road, at toll-gate.	Cal	47 D	2	5415.4	C. B	1876, Oct. 22 and 23	do	do	6, 31	Do.
108	Lyon Mountain	Nev	47 D	9	8793.5	C. B.	1877, Nov. 7	Lt. Macomb	Winnemucca	....	
109	McKenney's, on Lake Tahoe	Nev	47 D	4	6231.8	C. B.	1876, Oct. 21 to 23	do	Carson City	6, 32	DuBois.
110	Mineral Pass divide	Nev	47 D	1	6968.9	C. B.	1876, Nov. 18	do	do	6, 33	Do.
111	McClellan's Cove	Nev	47 D	1	5892.2	C. B.	1876, Nov. 25	do	do	6, 33	Do.
112	Milton	Cal	47 D	1	5845.2	C. B.	1876, Oct. 24	Lt. Tillman	do	6, 31	Lee.
113	McClellan Mountain	Nev	47 D	4	7531.6	C. B.	1876, Sept. 7	Lt. Symons	165 G st., Virginia City	6, 34	Seckels.
114	Omega Mill, junction 6 and 7 mile cañons (near).	Nev	47 D	1	5350.7	C. B.	1876, Oct. 3	do	Biddeman's Ranch	6, 34	Do.
115	"Old Kentuck" Ranch, Sutro Tunnel road.	Nev	47 D	1	5683.8	C. B.	1876, Oct. 5	do	do	6, 34	Do.
116	Ophir water-tank	Nev	47 D	3	6509.1	C. B.	1876, Oct. 20	do	C. C. shaft, Virginia City.	6, 34	Do.
117	Poeville Mine (camp 3, 25 feet above mine).	Nev	47 D	8	6388	C. B	1876, Sept. 8 and 9	Lt. Tillman	Carson City	6, 31	Lee.
118	Peavine Ranch	Nev	47 D	4	4951.8	C. B.	1876, Sept. 9 and 10, Oct. 14 and 15.	do	do	6, 31	Do.
119	Peavine Peak	Nev	47 D	12	8274.8	C. B.	1876, Sept. 9, Oct. 15	do	do	6, 31	Do.
120	Peytona Mine	Nev	47 D	2	6638.8	C. B.	1876, Nov. 17	Lt. Symons	165 G st., Virginia City.	6, 34	Seckels.
121	Ruins of Jackson	Cal	47 D	1	5979.6	C. B.	1876, Oct. 25	Lt. Tillman	Camp 32	6, 31	Lee.
122	Rose Mountain	Nev	47 D	......	10820.3	C. B.	1876, Nov. 7 and 14	do	Carson City	6, 31	Do.
123	Race-course near Virginia City	Nev	47 D	2	6157.1	C. B	1876, Nov. 13	Lt. Symons	165 G st., Virginia City.	6, 34	Seckels.
124	Raw Mountain	Nev	47 D	11	8403.8	C. B.	1876, Sept. 5 and 6	do	Camp on Carson River.	6, 34	Do.
125	Reno	Nev	47 D	7	4484.2	C. B.	1876, Sept. 7 and 8, Oct. 16 and 18.	Lt. Tillman	Carson City	6, 31	Lee.
126	Shirdevant's Ranch on Truckee River.	Nev	47 D	......	4302.9	C. B.	1876, Sept. 9 and 10	Lt. Macomb	do	6, 32	DuBois.
127	Colorado Springs (cabin)	Colo	62 A	......	5945.9	C. B.	1876, Nov. 27–30	Lt. Bergland		....	Niblack.
128	La Junta	Colo	62 D	......	4093.8	C. B.	1876, Dec. 9, 10	do		....	Do.
129	Lake House, on slope Pike's Peak	Colo	62 A	......	10107.7	C. B.	1876, Dec. 1–3	do		....	Do.
130	Pisgah Peak	Colo	62 A	......	10487.2	C. B.	1876, Sept. 17	do	Denver	....	Do.
131	Pisgah Peak, Little	Colo	62 A	......	10026.7	C. B.	1876, Sept. 15	do	do	....	Do.
132	Turkey Creek (crossing road from Pueblo to Cañon City).	Colo	62 A	......	4947.4	C. B.	1876, Sept. 11	do		....	Do.
133	Twin Creek, ½ mile east of Florissant.	Colo	62 A	......	8184.2	C. B.	1876, Sept. 25, Oct. 5	do		....	Do.
134	Stone Ranch on Canadian River	N. Mex	70 C	......	5844.2	C. B.	1876, Dec. 6, 7	Lt. Morrison		....	Dunn,

List of altitudes of prominent points supplemental to those found in Volume 2 of the quarto reports—Continued.

Number.	Name or locality.	State or Territory.	Atlas-sheet.	Number of observations.	Altitude, in feet.	Derived from—	When observed, year and date.	Executive officer.	Reference station.	Original records.	Observer.
135	Los Gallinas and Dry Creek, divide between.	N. Mex.	70 C	......	7447.9	C. B....	1876, Dec. 5..........	Morrison	....	....	Dunn.
136	Los Alamos	N. Mex.	70 C	......	6789.0	C. B....	1876, Dec. 3, 4........	....do	....	....	Do.
137	Ross Fork Indian Agency............	Idaho...	32 C	M.	4544.7	C. B....	1877, Sept. 28, 29.....	Lt. Young	Salt Lake City.........	40, 95	
138	Divide between Montpelier and Soda Springs Village, on main road.	Idaho...	32 D	1	6388.0	C. B....	1877, July 18	Lt. Tillman	......do	40, 94	
139	Soda Springs	Idaho...	32 D	M.	5778.3	C. B....	1877, July 19–22, Aug. 3–5.	....do	Ogden	40, 94	
140	Mount Sherman	Idaho...	32 D	9	9572.0	C. B....	1877, July 23	....do	Camp 27	40, 94	
141	First divide between Bear Lake and Salt River, on road to Mormon Salt Works.	Idaho...	32 D	1	7496.8	C. B....	1877, July 26	....do	Salt Lake City.........	40, 94	
142	Second divide between Bear Lake and Salt River, on road to Mormon Salt Works.	Idaho...	32 D	1	7692.9	C. B....	....do	....do	......do	40, 94	
143	Salt Creek, ¾ mile below Mormon Salt Works.	Idaho...	32 D	2	6597.5	C. B....	1877, July 26, 27	....do	Ogden	40, 94	
144	Oneida Salt Works....................	Idaho...	32 D	1	6341.2	C. B....	1877, July 30	....do	......do	40, 94	
145	First divide between Salt Creek and Lane's Fork.	Idaho...	32 D	1	6337.9	C. B	....do	....do	......do	40, 94	
146	Lane's Fork, crossing emigrant road..	Idaho...	32 D	M. 2	6635.4	C. B	1877, July 30, 31	....do	......do	40, 94	
147	Lane's Butte	Idaho...	32 D	3	7822.8	C. B....	1877, Aug. 6	....do	......do	40, 94	
148	Fork Snake River, half way between mouths of Gray's and Day's Rivers.	Idaho...	32 D	3	5510.6	C. B....	1877, Aug. 10, 11	....do	......do	40, 94	
149	Mount Pisgah, or Caribou Mountain ..	Idaho...	32 D	8	9694.6	C. B....	1877, Aug. 12	....do	......do	40, 94	
150	Crossing of Blackfoot River on mail road.	Idaho...	32 D	2	6077.0	C. B....	1877, Aug. 18, 19	....do	......do	40, 94, 95	
151	Barton's Ford, Bear River, Gentile Valley.	Idaho...	32 D	2	4916.5	C. B....	1877, Aug. 21, 22	....do	Salt Lake City.........	40, 95	
152	Robbins's Ford, Bear River	Idaho...	41 B	13	4620.7	C. B....	1877, Aug. 22, 24	....do	......do	40, 95	
153	Trout Creek, on Soda Springs road....	Idaho...	32 D	6	4887.0	C. B....	1877, Aug. 27, 29	....do	......do	40, 95	
154	Sedgwick Peak..........................	Idaho...	32 D	7	9207.2	C. B....	1877, Aug. 31	....do	Ogden	40, 95	
155	Mule Spring, head of Gentile Valley ..	Idaho...	32 D	3	5245.3	C. B....	1877, Sept. 1, 2	....do	......do	40, 95	
156	Ten-Mile Spring	Idaho...	32 D	6	5547.9	C. B....	1877, Sept. 2–4	....do	......do	40, 95	
157	On Lincoln Creek, 3½ miles above Fort Hall.	Idaho...	32 B	3	5142.2	C. B....	1877, Sept. 8, 9	Lt. Young	Salt Lake.............	40, 95	
158	Fort Hall, 10 feet below adjutant's office.	Idaho...	32 B	M. 9	4752.1	C. B....	1877, Sept. 9, 10, 21–24	....do	......do	40, 95	
159	Divide on road between Malade and March Valleys.	Idaho...	32 D	1	5690.7	C. B....	1877, Oct. 19..........	....do	......do	40, 95	

160	Fountain Peak (north side)	Idaho	32 D	2	8900.1	C. B.	1877, Oct. 20	...do	Camp 78	40, 95
161	Mount Putnam	Idaho	32 D	9	8905.3	C. B.	1877, Sept. 12	Lt. Birnie	Fort Hall	42, 96
162	Meade Peak	Idaho	32 D	2	10540.9	An.	1877, July 16	Lt. Tillman	Camp 24	40, 94
163	Fly Spring	Idaho	32 C	6	5912.3	An.	1877, July 29, Aug. 1.	Lt. Birnie	Ogden Observatory	42, 96, 97
164	Cedar Peak	Idaho	32 C	3	7586.5	An.	1877, July 30	...do	...do	42, 96, 97
165	Switzer's Ranch, Rock Creek	Idaho	41 A	2	4513.8	An.	1877, Aug. 1, 2	...do	...do	42, 96, 97
166	Badger Peak	Idaho	32 C	3	6389.0	An.	1877, Aug. 3	...do	Camp 24	42, 96, 97
167	Lane's Ranch, Marsh Lake	Idaho	32 C	5	4322.6	An.	1877, Aug. 25–27	...do	Salt Lake City	42, 96, 97
168	Basin Point	Idaho	32 C	3	5791.1	An.	1877, Aug. 26	...do	Camp 35	42, 96, 97
169	McCrae's Ranch	Idaho	32 C	3	4331.1	An.	1877, Aug. 29, 30	...do	Ogden Observatory	42, 96, 97
170	Toponce Ranch	Idaho	32 C	M. 8	5071.5	An.	1877, Sept. 2–4	...do	...do	42, 96, 97
171	Deep Creek Mountain	Idaho	32 C	M. 4	8817.5	An.	1877, Sept. 3	...do	Ogden Observatory, Camp 42.	42, 96, 97
172	Fountain Spring	Idaho	32 C	7	5234.6	An.	1877, Sept. 4–7	...do	Ogden Observatory	42, 96, 97
173	Bannock Peak	Idaho	32 C	4	8358.9	An.	1877, Sept. 5	...do	...do	42, 96, 97
174	Ross Fork Indian Agency	Idaho	32 C	M. 2	4544.7	An.	1877, Sept. 9, 10	...do	Salt Lake City	42, 96, 97
175	Blackfoot stage station	Idaho	32 C	M.	4446.8	An.	1877, Sept. 18, 19	...do	...do	42, 96, 97
176	Shadow Lake	Idaho	32 C	2	4309.8	An.	1877, Sept. 25, 26	...do	...do	42, 96, 97
177	Ross Fork, 5 miles below Indian agency	Idaho	32 C	2	4364.7	An.	1877, Oct. 13, 14	...do	...do	49, 97
178	Port Neuf River, 7 miles from mouth	Idaho	32 C	5	4262.8	An.	1877, Oct. 14–16	...do	...do	42, 97
179	Summit of road between Toponce Ranch and Malade Spring.	Idaho	32 C	1	6461.4	An.	1877, Oct. 24	...do	...do	42, 97
180	Malade Spring	Idaho	32 C	2	5149.9	An.	1877, Oct. 24, 25	Lts. Birnie and Young.	...do	42, 97
181	Elkhorn Village (2 houses)	Idaho	32 C	7	4949.9	An.	1877, Oct. 29–Nov. 1.	Lt. Birnie	...do	42, 97
182	Old beach mark, Great Salt Lake, near Elkhorn Village.	Idaho	32 C	1	5243.6	An.	1877, Oct. 31	...do	...do	42, 97
183	Summit of Sublett road, between Malade Spring and Deep Creek Valley.	Idaho	32 C	1	6557.7	An.	1877, Nov. 3	...do	...do	42, 97
184	Pillar Butte	Idaho	32 C	3	5301.1	An.	1877, Sept. 27	...do	...do	42, 97, 98
185	Snake River, opposite Fall Creek	Idaho	32 C	1	4280.9	An.	1877, Oct. 1	...do	...do	42, 97
186	Malade City post-office, 4 ft. above camp.	Idaho	41 B	M.	4663.0	C. B	1877, Oct. 16, 17	Lt. Tillman	...do	40, 95
187	Paradise	Utah	41 B	1	4862.8	C. B	1877, June 9	...do	...do	40, 94
188	Box Elder Peak	Utah	41 B	9	9541.8	C. B	1877, June 11	...do	...do	40, 94
189	Beach line, back of Wellsville	Utah	41 B	1	5216.1	C. B	1877, June 12	...do	...do	40, 94
190	Mendon	Utah	41 B	1	4553.3	C. B	...do	...do	...do	40, 94
191	Logan River, above bridge, between Mendon and Logan.	Utah	41 B	3	4415.3	C. B	1877, June 12, 13	...do	...do	40, 94
192	Logan	Utah	41 B	M.	4533.1	C. B	1877, June 13	...do	...do	40, 94
193	Smithfield	Utah	41 B	1	4623.1	C. B	...do	...do	...do	40, 94
194	Naomi Peak	Utah	41 B	6	9951.0	C. B	1877, June 15	...do	...do	40, 94
195	Richmond	Idaho	41 B	1	4655.7	C. B	1877, June 16	...do	...do	40, 94
196	Cone Butte, ¾ mile west of Franklin	Idaho	41 B	6	5215.5	C. B	1877, June 17	...do	Camp 7	40, 94
197	Beach line on Cone Butte	Idaho	41 B	1	5179.9	C. B	...do	...do	...do	40, 94
198	Webster's shop, Franklin	Idaho	41 B	1	4585.4	C. B	1877, June 19	...do	Salt Lake City	40, 94
199	Crossing, Franklin and Soda Springs road, Mink Creek.	Idaho	41 B	12	5236.4	C. B	1877, June 19–21	...do	...do	40, 94
200	Divide between Bear and Cache Valleys, on Liberty road.	Idaho	41 B	1	6780.5	C. B	1877, June 21	...do	...do	40, 94
201	Liberty	Idaho	41 B	1	6104.7	C. B	1877, June 22	...do	...do	40, 94
202	Camp 10½ miles up cañon from Paris	Idaho	41 B	2	6073.5	C. B	1877, June 22, 23	...do	...do	40, 94

List of altitudes of prominent points supplemental to those found in Volume 2 of the quarto reports—Continued.

Number.	Name or locality.	State or Territory.	Atlas-sheet.	Number of observations.	Altitude, in feet.	Derived from—	When observed, year and date.	Executive officer.	Reference station.	Original records.	Observer
203	Bloomington, corner of store	Idaho	41 B	1	6076. 3	C. B	1877, June 23	Lt. Tillman	Salt Lake City	40, 94	
204	Bloomington Peak	Idaho	41 B	8	9353. 6	C. B	1877, June 25	do	Camp XI	40, 94	
205	Castle Rock	Idaho	41 B	7	9610. 9	C. B	1877, June 26	do	do	40, 94	
206	Saint Charles, corner of store	Idaho	41 B	1	6057. 4	C. B	1877, June 29	do	Salt Lake City	40, 94	
207	Bear Lake, Camp 10*	Idaho	41 B	M. 2	5960. 0	C. B	1877, June 29, 30	do	do	40, 94	
208	Laketown, Walstrom's shop	Utah	41 B	1	5993. 0	C. B	1877, June 30	do	Ogden	40, 94	
209	Lake shore	Utah	41 B	1	5955. 7	C. B	do	do	do	40, 94	
210	Kimball's Peak	Utah	41 B	10	7777. 7	C. B	1877, July 1	do	do	40, 94	
211	Divide, between Bear Lake and Logan Cañon, on Saint Charles road.	Idaho	41 B	1	8400. 8	C. B	1877, July 2	do	do	40, 94	
212	Divide, on trail between Logan Cañon and Meadowville.	Utah	41 B	1	8011. 7	C. B	1877, July 6	do	Salt Lake City	40, 94	
213	Lake Butte, near Laketown	Utah	41 B	4	6345. 8	An	1877, July 7	do	do	40, 94	
214	First divide between Meadowville and Bear River, on Evanston road.	Utah	41 B	1	7202. 7	C. B	1877, July 8	do	Ogden	40, 94	
215	Montpelier co-operative store	Idaho	41 B	1	5935. 9	C. B	1877, July 14	do	do	40, 94	
216	Beach line on Bear River, near Cottonwood Creek.	Idaho	41 B	1	5274. 7	C. B	1877, Aug. 22	do	Salt Lake City	40, 95	
217	Beach line near Head's Ranch, Cache Valley.	Idaho	41 B	3	5151. 5	C. B	1877, Aug. 26	do	Ogden	40, 95	
218	Oxford Peak	Idaho	41 B	5	9386. 0	An	1877, Oct. 18	Lt. Young	Camp 77	40, 95	
219	Boundary stake between Utah and Idaho, on Corinne road.	Idaho	41 B	1	4563. 0	C. B	1877, Nov. 1	do	Salt Lake City	40, 41, 95	
220	Weston	Idaho	41 B	2	5011. 1	C. B	1877, Nov. 2, 3	do	do	41, 95	
221	Salt Spring Ranch	Utah	41 B	2	4634. 4	C. B	1877, Nov. 3	do	do	41, 95	
222	Emigrant Ford, Bear River	Idaho	41 B	3	4323. 7	C. B	1877, Nov. 5–7	do	do	41, 95	
223	Samaria	Idaho	41 B	2	4560. 5	C. B	1877, Nov. 9, 10	do	do	41, 95	
224	Toponce Ranch	Utah	41 B	5	4583. 1	C. B	1877, Nov. 18–20	do	do	41, 95	
225	Deweyville	Utah	41 B	5	4414. 9	C. B	1877, Nov. 22–24	do	do	41, 95	
226	Warm Spring, near Samaria	Idaho	41 B	2	4506. 5	C. B	1877, Nov. 14, 15	Lt. Birnie	do	42, 97	
227	Saw-mill, near Samaria	Idaho	41 B	2	4530. 3	C. B	1877, Nov. 16, 17	do	do	42, 97	
228	Stahn's Ranch	Idaho	41 B	3	4403. 3	C. B	1877, Nov. 21, 22	do	do	42, 97	
229	Hansel Pass, summit of Old Emigrant road.	Utah	41 A	1	5137. 9	C. B	1877, Nov. 20	do	do	42, 97	
230	Dilley's Ranch, Hansel Spring	Utah	41 A	6	5043. 5	C. B	1877, Nov. 17–20	do	do	42, 97	
231	Curlew	Utah	41 A	M.	4396. 7	C. B	1877, Nov. 10, 11, June 17, 18.	do	do	42, 97	

232	Beach-mark No. 3, 1¼ miles south of Barry's Ranch.	Utah ...	41 A	1	5060.8	C. B	1877, Nov. 10..........	....do	......do	42, 97	
233	Beach-mark No. 2, 1 mile southeast of Barry's Ranch.	Utah ...	41 A	1	5113.3	C. B	....do	....do	......do	42, 97	
234	Beach-mark No. 1, near Barry's Ranch.	Utah ...	41 A	1	5132.5	C. B	....do	....do	......do	42, 97	
235	Barry's Ranch, on Black Pine Creek...	Utah ...	41 A	2	5114.4	C. B	1877, Nov. 9, 10.......	....do	......do	42, 97	
236	Antelope Peak	Idaho...	41 A	3	7282.3	C. B	1877, Nov. 8...........	....do	......do	42, 97	Lt. Birnie.
237	Twin Springs	Utah ...	41 A	8	5207.5	C. B	1877, Nov. 3–7.........	....do	......do	42, 97	
238	Rice's Ranch	Idaho...	41 A	2	4722.8	C. B	1877, July 21–23, Aug. 12, 13.	....do	......do	42, 66, 97	
239	Switzer's Ranch	Idaho...	41 A	M.	4509.3	C. B	1877, Aug. 5–7, 10–12.	....do	......do	42, 95	
240	Divide between Raft River and Rock Creek, on Old Emigrant road.	Idaho...	41 A	1	6386.7	C. B	1877, July 27..........	....do	......do	42, 95	
241	Hitching's Ranch	Idaho...	41 A	4	5205.4	C. B	1877, July 23–25.......	....do	......do	42, 95	
242	Black Pine Peak	Idaho...	41 A	M. 5	9386.0	C. B	1877, July 17, 19......	....do	......do	42, 25	
243	Emigrant Springs	Idaho...	41 A	2	5270.6	C. B	1877, July 13, 14......	....do	......do	42, 95	
244	Raft River stage station...............	Idaho...	41 A	3	5040.8	C. B	1877, July 8, 9........	....do	......do	42, 95	
245	City of Rocks	Utah ...	41 A	2	6077.7	C. B	1877, July 6 and 7.....	....do	Ogden Observatory ...	42, 96, 97	
246	Cache Peak	Idaho...	41 A	......	10451.2	C. B	1877, July 5, 6, 7	....do	Ogden Observatory, and Salt Lake City.	42, 96, 97	
247	Summit of trail between Muddy Creek and Raft River.	Idaho...	41 A	1	7373.9	C. B	1877, June 29..........	....do	Salt Lake City.........	42, 96, 97	
248	Clear Creek Peak.......................	Utah ...	41 A	4	9132.1	C. B	1877, June 28..........	....do	......do	42, 96, 97	
249	Mouth of Alder or Big Cañon	Utah ...	41 A	5	6440.9	C. B	1877, June 23–25.......	....do	......do	42, 96, 97	
250	Ten-Mile House.........................	Utah ...	41 A	2	5086.4	C. B	1877, June 19, 20......	....do	Camp 6	42, 96, 97	
251	Pilot Springs..........................	Utah ...	41 A	2	4704.0	C. B	1877, June 18, 19......	....do	......do	42, 96, 97	
252	Kelton	Utah ...	41 A	D. m.	4222.2	C. B	1877, June 15–21.......	....do	Salt Lake City.........	42, 96	
253	Great Salt Lake, surface of water	Utah ...	41 A	1	4195.2	C. B	1877, June 15..........	....do	......do	42, 96	
254	North Promontory Peak..................	Utah ...	41 A	5	7131.4	C. B	1877, June 12..........	....do	Camp 5	42, 96	
255	Salt Wells.............................	Utah ...	41 A	16	4203.2	C. B	1877, June 11–15.......	....do	Salt Lake City.........	42, 96	
256	Summit Promontory Range road	Utah ...	41 A	1	5337.4	C. B	1877, June 11..........	....do	......do	42, 96	
257	Skeen's Ranch..........................	Utah ...	41 A	10	4266.2	C. B	1877, June 9–11........	....do	......do	42, 96	
258	Tibball's Ranch	Utah ...	41 A	2	4204.1	C. B	1877, June 8, 9........	....do	......do	42, 96	
259	South Promontory Mountain..............	Utah ...	41 C	5	7459.7	C. B	1877, June 10..........	....do	Camp 3	42, 96	
260	Eyrie Peak.............................	Utah ...	41 D	7	9458.3	C. B	1877, June 8...........	Lt. Tillman	Camp 2	40, 94	
261	Mouth of North Ogden Cañon	Utah ...	41 D	......	4890.1	C. B	1877, June 5–7.........	Lt. Birnie.......	Salt Lake City.........	42, 96	
262	Co-operative Store, North Ogden........	Utah ...	41 D	1	4509.0	C. B	1877, June 7...........	....do	......do	42, 96	
263	North Willard..........................	Utah ...	41 D	2	4275.7	C. B	1877, June 7, 8........	....do	......do	42, 96	
264	Brigham City	Utah ...	41 D	1	4475.6	C. B	1877, June 8...........	....do	......do	42, 96	
265	Big Dam Springs........................	Utah ...	41 D	1	4316.9	C. B	1877, Nov. 24	....do	......do	42, 97, 98	
266	Big Butte	Idaho...	32 B	4	7658.7	C. B	1877, Sept. 22	....do	......do	42, 96, 97	
267	Under Big Butte (side Camp A)..........	Idaho...	32 B	......	5682.6	C. B	1877, Sept. 21, 22	....do	......do	42, 96, 97	
268	Devil's Corral	Idaho...	31 D	2	3601.1	C. B	1877, Aug. 15, 16	....do	Camp 28	42, 96, 97	
269	Rice's Ferry, Snake River, Camp 34 (17 feet above river).	Idaho...	31 D	8	4192.4	C. B	1827, Aug. 22–25	....do	Salt Lake City.........	42, 96, 97	
270	Side Camp A, on Snake River, ½ mile below Rice's Ferry.	Idaho...	31 D	2	4187.3	C. B	1877, Aug. 14, 15	....do	Side Camp J	42, 96, 97	
271	Summit Station (stage road)............	Utah ...	40 B	3	5945.1	C. B	1877, Aug. 18, 19	....do	Ogden Observatory ...	42, 96, 97	
272	Hildreth's Ranch.......................	Utah ...	40 B	2	4307.9	C. B	1877, Aug. 16, 17	....do	......do	42, 96, 97	

* Arbitrarily changed.

List of altitudes of prominent points supplemental to those found in Volume 2 of the quarto reports—Continued.

Number.	Name or locality.	State or Territory.	Atlas-sheet.	Number of observations.	Altitude, in feet.	Derived from—	When observed, year and date.	Executive officer.	Reference stations.	Original records.	Observer.
273	Ouray, 20 feet below post-office	Colo	61 C	D. m.	7766.3	C. B	1877, July 27–29	Lt. Bergland	Denver		
274	Alder's Junction	Colo	61 C	D. m.	8904.5	C. B	1877, June 26, 30	do	do		
275	Divide on trail from Lake City to Ouray.	Colo	61 C	4	12641.8	C. B	1877, July 2	do	do		
276	Forks of road near Hot Springs	Colo	61 C		6987.7	C. B	1877, July 29, 30	do	do		
277	Second divide on Del Norte and Lake City road.	Colo	61 C	1	11776.5	C. B	1877, July 1	do	do		
278	Wagon-wheel Gap	Colo	61 D	5	8372.1		1877, June 25	do	do		
279	Saguache	Colo	61 D	5	7620.4		1877, Nov. 13–15	do	do		
280	Star Ranch	Colo	61 D	2	7326.7		1877, Nov. 15, 16	do	do		
281	Leon Peak	Colo	52 C	2	11218.4		1877, Aug. 28	do	Camp 39		
282	Summit of Hardscrabble Pass	Colo	62 A	1	9163.4	C. B	1877, May 31	do	Denver		
283	Ranch on Pine Creek (Camp 7 B)	Colo	62 A	3	6876.2	C. B	1877, June 3 and 4	do	Camp 7		
284	Rosita (previously used)	Colo	62 C				1877, May 30	do			
285	Hay Station, Deer Range	Colo	62 C	3	9612.9	C. B	1877, June 2	do	Camp 7		
286	Fort Garland (railroad levels)	Colo	62 C		7937.0						
287	Rocky Butte	Colo	61 B	2	8508.3	C. B	1877, June 3	do	Camp 7		
288	Reed's Ranch	Colo	61 B	3	7971.7	C. B	1877, Nov. 6, 7	do	Denver		
289	Continental Divide, ½ mile south of Marshall Pass.	Colo	61 B	1	10996.4	C. B	1877, Nov. 9	do	do		
290	Forks of Tomichi Creek	Colo	61 B	2	8195.5	C. B	1877, Nov. 8, 9	do	do		
291	Saw-mill on Poocho Creek	Colo	61 B	3	8258.6	C. B	1877, Nov. 11, 12	do	do		
292	Carson Lake	Nev	48 C	2	3883	C. B	1876, Nov. 19, 20	Lt. Birnie	Camp 27	63.5	Cowles.
293	Houston's Wells	Nev	48 C	2	4148.5	C. B	1876, Nov. 20, 21	do	Carson City	63.5	Do.
294	Painted Mesa	Nev	48 C	1	6026.6	C. B	1876, Nov. 21	do	do	63.5	Do.
295	Lee's Mill, Mason Valley	Nev	48 C	4	4349.7	C. B	1876, Nov. 23–25	do	do	63.5	Do.
296	Sinkwater Peak		48 C	4	7511.2	C. B	1876, Nov. 17	do	Camp 25	63.5	Do.
297	Patterson's Ranch	Nev	48 D	D. m.	5212.8	C. B	1876, Sept. 28–Oct. 2	do	Carson City	63.5	Do.
298	Anton's Ranch	Nev	48 D	6	6516.7	C. B	1876, Oct. 2–4	do	do	63.5	Do.
299	Chalk Wells	Nev	48 D	6	5754.8	C. B	{ 1876, Sept. 25, 26 } { 1876, Nov. 6, 8 }	do	{ Camp 8 } { Carson City }	63.5	Do.
300	East Gate	Nev	48 D	2	5291.1	C. B	1876, Nov. 26, 27	do	do	63.5	Do.
301	Desatoya Peak	Nev	48 D	2	9921.3	C. B	1876, Oct. 3	do	do	63.5	Do.
302	Moore Campbell's Ranch	Nev	48 D	2	6266.8	C. B	1876, Oct. 5, 6	do	do	63.5	Do.
303	Mount Airy	Nev	48 D	2	6786.5	C. B	1876, Oct. 6, 7	do	do	63.5	Do.
304	Emigrant Pass Peak	Nev	48 D	6	7876.4	C. B	1876, Oct. 11	do	do	63.5	Do.
305	Birchin's Ranch, Reese River	Nev	48 D	D. m.	5742.7	C. B	1876, Oct. 8, 10	do	do	63.5	Do.
306	Austin City	Nev	48 D	1	6593.5	C. B	1876, Oct. 13	do	do	63.5	Do.
307	Mount Prometheus	Nev	48 D	3	8151.1	C. B	do	do	do	63.5	Do.

308	Silver Age Station	Nev	48 D	2	6014.1	C. B.	1876, Oct. 15, 16	do	do	63, 5	Do.
309	Captain John Thomas Ranch	Nev	48 D	2	5886.6	C. B.	1876, Oct. 16, 17	do	do	63, 5	Do.
310	Elkhorn Ranch	Nev	48 D	4	6123.1	C. B.	1876, Oct. 17–19	do	do	63, 5	Do.
311	Cowles Peak	Nev	48 D	4	9980.1	C. B.	1876, Oct. 23	do	do	63, 5	Do.
312	Washington Cañon	Nev	48 D	8	6992.2	C. B.	1876, Oct. 20–22, 24–26.	do	do	63, 5	Do.
313	Toyabe Peak	Nev	48 D	4	10144.2	C. B.	1876, Oct. 11, 12 do	do	Camp 11 Carson City	63, 5	Do.
314	Kingston Cañon, near head of	Nev	48 D	4	8089.9	C. B.	1876, Oct. 16–18	do	do	63, 5	Do.
315	Bunker Hill Peak	Nev	48 D	2	11404.5	C. B.	1876, Oct. 17	do	do	63, 5	Do.
316	Schmidtline's Ranch	Nev	48 D	2	6219.6	C. B.	1876, Oct. 18, 19	do	Camp 14	63, 5	Do.
317	French's Peak	Nev	48 D	1	10778.7	C. B.	1876, Oct. 25	do	Carson City	63, 5	Do.
318	Dyer's Ranch	Nev	48 D	2	6037.1	C. B.	1876, Oct. 31 to Nov. 1	do	do	63, 5	Do.
319	Peterson's Ranch	Nev	48 D	4	6136.9	C. B.	1876, Nov. 1–3	do	do	63, 5	Do.
320	Birchin's Peak	Nev	48 D	3	10343.9	C. B.	1876, Oct. 21	do	do	63, 5	Do.
321	Geneva Peak	Nev	48 D	2	11077.1	C. B.	1876, Oct. 12	do	do	63, 5	Do.
322	Cold Spring	Nev	57 A	7	4200.1	C. B.	1876, Nov. 10–13	do	do		Do.
323	Dead Horse Well	Nev	57 A	4	4117.2	C. B.	1876, Nov. 12–14	do	do		Do.
324	Lodi Peak	Nev	57 A	2	6485.6	C. B.	1876, Nov. 8	do	do		Do.
325	Basalt Peak	Nev	57 A	2	6599.2	C. B.	1876, Nov. 13	do	do		Do.
326	Indian Agency, Walker River	Nev	57 A	4	4120.3	C. B.	1876, Nov. 19–22	do	do		Do.
327	McMahon's Ranch	Nev	57 B	10	6552.4	C. B.	1876, Oct. 26–31	do	do		Do.
328	Ione	Nev	57 B	M.	6844.2	C. B.	1876, Oct. 27, 28 1876, Oct. 31–Nov. 1	do	Camp 18 Carson City		Do.
329	Mount Davies	Nev	57 B	1	11755.7	C. B	1876, Oct. 29	do	do		Do.
330	Ellsworth	Nev	57 B	9	6871.1	C. B.	1876, Nov. 3–7	do	do		Do.
331	Antelope Spring	Nev	57 B	6	6444.8	C. B	1876, Nov. 1–4	do	do		Do.
332	Paradise Peak	Nev	57 B	2	8662.4	C. B	1876, Nov. 3	do	do		Do.
333	Campbell's Spring	Nev	57 B	2	7366.2	C. B.	1876, Nov. 4, 5	do	do		Do.
334	Park Peak	Nev	57 B	M. 3	8682.8	C. B.	1876, Nov. 5	do	Camp 20 and Carson City.		Do.
335	Welch's Station	Nev	57 B	4	5235.7	C. B.	1876, Nov. 7–10	do	Carson City		Do.
336	Rito Alto	Colo	61 B		13560.8	C. B.	1876, Oct. 21	Lt. Bergland			Niblack.
337	Rito Alto timber line	Colo	61 B		11816.7	C. B.	do	do			Do.
338	South Park Salt Works	Colo	61 B	15	8968.6	C. B.	1876, Oct. 15, 16	do			Do.
339	San Luis Creek, 7 miles from Villa Grove.	Colo	61 B		8070.1	C. B.	1876, Oct. 18, 19	do			Do.
340	S. Arkansas and Punch Creek, junction of.	Colo	61 B	18	7382.8	C. B.	1876, Oct. 17, 18	Dr. Rothrock			Rothrock.
341	Rocky Butte	Colo	61 B	2	8508.3	C. B.	1877, June 2	Lt. Bergland	Camp 7		Niblack.
342	Gunnison Post-office, cone near	Colo	61 B	4	8866.2	C. B.	1877, Sept. 29	do	Camp 49		Do.
343	Reed's Ranch	Colo	61 B	3	7971.7	C. B.	1877, Nov. 6, 7	do	Denver		Do.
344	Continental Divide, ½ mile south Marshall Pass.	Colo	61 B	1	10996.4	C. B.	1877. Nov. 9	do	do		Do.
345	Tomichi Creek, forks of	Colo	61 B	2	8195.5	C. B	1877, Nov. 8, 9	do	do		Do.
346	Hunt's Peak, foot of	Colo	61 B	5	10516.7	C. B.	1877, Nov. 9–11	do	do		Do.
347	Punch Creek Saw-mill	Colo	61 B	3	8258.6	C. B	1877, Nov. 11, 12	do	do		Do.
348	Villa Grove Post-office	Colo	61 B	M.	8127.1	C. B	1877, Nov. 12, 13	do	do		Do.
349	Christonia Little Peak	Colo	61 D		13189.8	C. B.	1876, Oct. 27	do			Do.
350	Christonia Little Peak timber line	Colo	61 D		12106.9	C. B.	do	do			Do.
351	Kenny's Ranch, on Dead Man's Creek.	Colo	61 D		7829.8	C. B.	1876, Oct. 28, 29	do			Do.
352	Mosca Pass (west entrance)	Colo	61 D		8171.6	C. B.	do	do			Do.
353	White Earth Creek Post-office	Colo	61 A	3	8163.1	C. B.	1877, July 8, 9	do	Camp 23		

List of altitudes of prominent points supplemental to those found in Volume 2 of the quarto reports—Continued.

Number.	Name or locality.	State or Territory.	Atlas sheet.	Number of observations.	Altitude, in feet.	Derived from	When observed, year and date.	Executive officer.	Reference station.	Original records.	Observer.
354	Upper end Grand Cañon	Colo	61 A	2	9255.9	C. B	1877, July 12	Lt. Bergland	Denver		
355	Horsefly Hill	Colo	61 A	2	10504.5	C. B	1877, July 20	do	do		
356	Los Pinos Agency	Colo	61 A	D. m.	6399.8	C. B	1877, July 31–Aug. 23	do	do		
357	Johnson's Ford, Uncompahgre River	Colo	61 A	2	5702.2	C. B	1877, Aug. 24, 25	do	do		
358	Mount Gunnison	Colo	61 A	2	12242.1	C. B	1877, Sept. 11	do	Camp 43		
359	Three-Point Block	Colo	61 A	2	12189.8	C. B	1877, Sept. 21	do	Camp 47		
360	Cone near Gunnison Post-office	Colo	61 A	4	8866.2	C. B	1877, Sept. 29	do	Camp 49		
361	Kelly's Store, Gunnison Post-office	Colo	61 A	2	7428.0	C. B	1877, Oct. 2	do	Denver		
362	Carbon Mountain	Colo	61 A	2	12078.2	C. B	1877, Oct. 3	do	Camp 50		
363	Marcellina Peak	Colo	61 A	1	11318.8	C. B	1877, Oct. 8	do	Denver		
364	Washington Gulch	Colo	61 A	D. m.	10131.9	C. B	1877, Oct. 21, 24	do	do		
365	Red Mountain	Colo	61 A	1	12610.9	C. B	1877, Oct. 22	do	Camp 56		
366	Elk Peak	Colo	61 A	3	13101.6	C B	1877, Nov. 3	do	Camp 59		
367	Dry Lake, near Bitter Springs	Colo	61 A	1	—28.3	C. B	1875, Sept. 19	do	Los Angeles		

MINING INFORMATION.

Several of the newer mining districts have been visited, and are herewith described. No exhaustive examination can well be made in a district but little developed, in which the industry has not reached an advanced and somewhat typical stage. The detailed survey and examination of the Comstock Lode, in Nevada, and its surroundings, have been prosecuted as far as time and means would permit. The contour map of the surface, with the exception of a small area, is complete. Mr. John A. Church, by whom I have been assisted, succeeded by much energy and perseverance in obtaining the underground data for cross-sections of portions of the lode, and of certain of the working and stope levels. Mr. Karl was engaged with the plane-table during a part of the season, and in tracing the plots of the underground workings of the several companies.

The companies with one accord have tendered the survey every facility in their power to render the measurements and examinations minute and complete, and the mining surveyors, Messrs. James and Wrinkle, together with Charles H. Hoffman and Alfred Craven, have assisted in procuring data of these extensive workings. Surveyor-General E. S. Davis, and his assistant, James Butler, have extended every courtesy, and I desire here to mention the good offices of Messrs. James G. Fair, William H. Patten, Charles Forman, Samuel Curtis, H. Smith, Capt. John Taylor, Frank Osbiston, Mr. Gillette, and others whose names are not now at my hand, mining managers and superintendents who have willingly tendered information and means for prosecuting the work.

This special work contemplates a detailed contour survey of the district, including the location of mills and other works, cross-sections at each 100 feet along the vein, horizontal sections of the working and stope levels, longitudinal sections of the entire lode and of the Sutro Tunnel, the geology of the district and of the Sierra to the westward, the mineralogical constituents and lithological characteristics of the vein and country-rock, methods and expenses of mining and milling, including drainage, temperatures, and ventilation, and the aggregate and annual production. As large a part of the information gathered as is practicable will be shown upon a series of maps based upon the topographical contour sheets. The underground examinations are taken up at the points in depth to which they were carried by Clarence King and James D. Hague, his assistant, and the work will thus supplement that so well begun and successfully carried forward by the former, adding permanently, it is hoped, to the mining information of the country. The different subjects will be treated in detail as each is completed. The greater part of the material for the mapping, both above and under ground, has been gathered. Mr. Church presents the results of his examination as far as he can carry it. It is expected that the special geological and mineralogical investigations may be concluded during the coming season. Collections of the country-rock and of rare rock specimens are being made, and in this matter Mr. Adolph Sutro, the projector of the tunnel that bears his name, has aided by contributions from points along the line of the tunnel.

The levels to which the contour curves are referred depend upon barometric altitudes, referred to three initial points at the astronomical monument, west end of base, and at Carson City, connected with and checked by levels of the Virginia and Truckee Railroad, they being checked in turn by the levels of the Central Pacific Railroad at Reno, Nev. The length and azimuth and angle of elevation of the line extending from the astronomical monument to a staff or bench on Cedar Hill have been established, and this may answer as a permanent line of reference in all future mining surveys.

A special line of levels has been run, joining each of the working shafts upon the lode. Connection has been made with all the stakes of the public land and mineral land surveys. The data obtained will prove sufficient for a detailed model of the lode and its surroundings, with the underground workings, the annual progress of which it is intended shall be made a subject of further record.

Rock temperatures are being recorded at certain of the new shafts in the east country-rock, and as fast as practicable it is to be hoped that they may be carried on simultaneously in the deep workings throughout the entire district. The question of ventilation, one of the most important in the further development along the lower levels of these mines, has received some study, and systematic observations affording information concerning volumes, velocities, air-temperatures, relative position of underground spaces, influence of the Sutro Tunnel, pure or foul air, friction, &c., are in prospect of accomplishment as soon as time and means shall permit. Mr. Church, in his report, gives the yield of the Consolidated Virginia, California, Ophir, Chollar Potosi, Crown Point, Belcher, and Overman Mines for the year ending December 31, 1877, as silver $17,760,702.35 and gold $16,130,995.56, making a total of $33,891,697.91 for the year. The production as given by him from the bonanza now being worked, of the Consolidated Virginia and California Mines, since its discovery and first development, shows an aggregate of $85,352,566, of which 54.2 per cent. was in silver and 45.8 per cent. in gold.

It is interesting in the history of the development of the mines of the Comstock to know that as this paragraph is being added to this report (October 22) the workings of one of the northerly mines, the Sierra Nevada, has uncovered the prospect of bonanza ore between the 2,000 and 2,200 foot level. Quartz showing low assays was met on the incline a little below the 2,000-foot level, apparently in connection with a hanging wall, dipping nearly on an angle with the incline. Upon pushing forward this incline the assays were found to increase until at a cross-cut of 12 feet, a little below the 2,100-foot level, the presence of rich ore was revealed. Ore had been discovered as far as the 2,200-foot level, and the discovery of ore over so long a vertical line at so great depth has opened an era of renewed confidence in these mines.

BODIE DISTRICT, MONO COUNTY, CALIFORNIA.

This district was discovered and organized by Mr. Bodie, in 1863, and has been worked continuously since, excepting in 1866. It is 102 miles from Carson, Nev., via Aurora, the nearest point of railroad communication being Carson. The shape of the mining area is rectangular, being about three miles long by half a mile wide, the trend being north and south.

The district was examined geologically by Prof. J. D. Whitney, in 1864, and by A. Garrard, mineralogical surveyor. The position of the mineral ledges is on the eastern slope of the foot-hills, the ore deposits lying on the ridge. The trend of the mountains is north and south. The vein varies from 4 to 8 feet in width, averaging about 5 feet; the direction is north 20° east, and the ore is a little richer on the foot-wall. Diorite and diorite porphyry constitute the country-rock, while quartzite sometimes occurs as wall-rock. In the Standard Mine the direction of the hanging and foot walls is 58° south as far as the 300-foot level, 42° from there to the 450-foot level, and thence to the bottom it is 65°. No fossils are found in the country-rock. The ores are worked wet, and yield $72 per ton; are quartz, with the gold finely disseminated, and contain no base metal, and none in the district contain silver. Water-level has not been reached in the veins.

The principal mines are as follows: 1. Standard, size of claim 1,500 by 600 feet. Its incline is 739 feet deep, and there are five levels; one at 150, one at 200, one at 300, one at 450, and one at 550, with a winze between the third and fourth. 2. Bodie, 600 by 1,500. 3. Bulwer, 100 by 1,000, and includes three ledges. 4. Becktel, 600 by 1,000. 5. Red Cloud, 100 by 1,500. 6. Smith & Olsten, 400 by 1,000, and includes four ledges. All these mines have shafts. 7. Syndicate Mine, including the Osceola and Tioga claims, 41⅓ acres, and having a tunnel 450 feet long. 8. Black-hawk, 1,500 by 100, having a tunnel 273 feet long. 9. Bullwhacker, 1,500 by 100. 10. McClinton, the oldest location, including a series of ledges. There are placer-diggings just north and south of Bodie, but there is not enough water to work them. Up to October 1 the Standard Mining Company had spent $128,000, and had taken out $381,000 worth of bullion. They extract 75 tons of ore daily, but bullion has been produced extensively only during three months; in August, 1877, of the value of $104,000, and between September 5 and 15, $81,000. There are two mills, the Standard, with 20 stamps, 750 pounds each, and 90 to 95 drops per minute, and an engine of 130 horse-power and 2 boilers, 10 pans of 5 feet diameter, and 5 settlers of 8 feet diameter; the Syndicate, with 16 stamps, an engine of 60 horse-power, 6 pans of 6 feet diameter, and 3 settlers of 9 feet diameter. The average cost per ton for mining the ore is $2.75 per ton; for roasting and milling, $2.15 per ton; mining labor per day, $4; milling labor, $3.50; average amount of ore extracted by one man per day, 6 to 7 tons; average cost per foot for running a tunnel on main veins, $2.50; and for sinking a shaft on a main vein, $5 in the Standard, dimensions 4 by 6 feet.

Hay, which is brought from Bridgeport, Cal., is $35 per ton, and grain, mostly from Mason's Valley, Nevada, is 4½ cents per pound. There is no timber within four miles of Bodie, and pine wood, at $12 per cord, is brought 6 miles on pack-mules. The Standard mill is supplied with water from Bodie Creek, west of the town, and a spring supplies the town itself. The district contains 500 inhabitants, besides 200 Pah-Ute Indians, and has good roads. There are three stores and one banking-house at Bodie. The game found consists of deer, quail, and sage-hens in abundance.

MEADOW-LAKE DISTRICT, NEVADA COUNTY, CALIFORNIA.

This district, 11 miles by wagon-road from Cisco, Cal., was discovered and organized June 6, 1863, by H. H. Hartley. It is bounded north by French Lake, east by the ridge west of Castle Peak, south by the South Fork of Yuba River, and west by Red Mountain. It is about 7 miles long north and south, and 6 miles wide—a parallelogram—and contains about one hundred ledges. The township containing this district has been publicly surveyed.

The general trend of the ledges is northwest and southeast, and their positions are on the lower ridges, or along the summits of the foot-hills. The general direction of the lodes is southeast and northwest, and the hanging-wall side is the richest. This wall is of gray granite, generally, toward the west, and has an angle of 15° to vertical. There are good walls in the vein for 140 feet. It is supposed by miners that the deposits are fissure veins. They occur in metamorphic and igneous rocks, the ores being found in basalt inclosed by the country-rock, granite. There are no sedimentary rocks in the neighborhood, and no fossils are found. It is impossible to find the age of the vast mass of gray granite forming the major part of the Sierra Nevadas.

The district has been worked at intervals only, since 1863, most of the work being done in the seasons of 1865 and 1866, with enough each year to retain hold on the claims. The ores are worked wet, and the yield has been from $3 to $37 per ton, 100 tons at one time yielding at the last-named rate, 100 at the rate of $27½ per ton, and the Excelsior Mine, in 1865, yielding $97 per ton. Water-level has not been reached. The great drawback in working the ore is the large amount of bisulphide of iron. There are galena, arsenic, some cobalt, and traces of nickel. The chief characteristics of the ores in detail are pyrite with blende, antimony, copper as sulphide, oxide, and carbonates, graphyte in small quantities, and molybdenum?. No silver-bearing ores are found.

The principal mines worked are: 1. Excelsior, having funnel and shaft 100 feet long; 2. Sunny South, a hole 20 feet square; 3. Pacific, having a shaft 72 feet deep; 4. Pittsburgh, a hole 10 feet long; 5. Keystone, having a shaft 43 feet deep, and a tunnel started to strike the vein; 6. Wisconsin, with a shaft 20 feet deep; 7. Mohawk and Montreal, having three levels on the hill-side, from 30 to 40 feet long; 8. New York ledge, with a hole about 10 feet long—very rich rock; 9. Gold Run and Phœnix, with a tunnel 140 feet long; 10. Pullman, a hole 10 feet square; 11. Bullion, with a tunnel started a few feet.

The amounts expended on these mines are as follows: Mohawk and Montreal, $228,000; Excelsior, mill and mine, $60,000; Keystone, $2,000 to $3,000; Wisconsin and Sunny South, each, $1,000; Pittsburgh, $400; and several thousand dollars on the Pacific. The total amount of bullion extracted does not exceed $125,000. At one time there were eight mills here, the Excelsior having 5 batteries of 4 stamps each; the Mohawk 10, California 8, Winton 9, Grant 8, and Culbertson's mill 10 rotary stamps, respectively, the stamps varying from 500 to 900 pounds. The amalgam was cold-strained. Batteries were lined with copper plates; there was much loss of quicksilver by granulation, and much gold ran off in the tailings. The average cost per ton, at present, for mining the ore is $2 to $3, to be stoped, and $2 on the surface; for roasting and milling, $2.50 to $5; cost of mining labor per day, $4; milling labor per day, amalgamators, $3 to $4; engineers, $4 to $5. Average amount of ore stoped per day by one man, 3 tons. The average cost per foot for running a tunnel on main veins is $32 to $35; for running a drift on a main vein, $15 to $30.

The hills and meadows on the north and east of the district are heavily timbered, but south and west is bare rock and no vegetation. The water-supply is from Meadow Lake, half a mile long and 200 to 500 yards wide. Wells are abundant, and water can be reached at 6 feet. There are now (July, 1877) only about 25 inhabitants in the district, where there were over 5,000 in 1866. The price of freight from the railroad is a half to one cent per pound. There is a saddle-train to Cisco, with fare at $3. The place has one school-house and one banking-house, and good roads. There is little stock kept. Game consists of deer, bears, foxes, martens, grouse, and quail. No Indians have ever lived in the district.

PLACERVILLE DISTRICT, EL DORADO COUNTY, CALIFORNIA.

This district was discovered and organized in 1849, and has been worked continuously. The mines are 10 miles from the railroad station at Shingle Springs. The district lies between the South Fork of the

American River and Weber Creek, in Placerville Township, the trend of its longer axis being southeast and northwest. It has been surveyed geologically by Mr. Goodyear, of the California Geological Survey, and its mining ledges lie in a cañon and along foot-hills. The nearest mountains are the Sierra Nevada, 40 miles distant, with a trend north and south. The general direction of lodes, deposits, and stratifications is northwest and southeast. The deposits are fissure veins which dip to the eastward at an angle of 45°, and the wall-rock is talcose schist. The metamorphic slates and schists of the vicinity are evidently Archæan, but the auriferous drift around Placerville is probably Post-Tertiary. No fossils are found.

The ores are worked by the wet process, and yield an average of $18 per ton. Since reaching water-level the ore becomes lighter in descending. The sulphides above the water-level are decomposed, but below they are not, and have a bluish tint, particularly in the Saint Lawrence Mine. The ores are characterized by the presence of pyrite and galena, and some native gold is found. Sulphides occur in all the ledges. The chief base metals are iron and copper. In the richest ores there is a slight sprinkling of galena, but not enough to interfere with the working. There are no silver-bearing ores in the district.

The principal mines now worked are as follows: 1. The Mount Pleasant, having a shaft worked to the water-level. 2. Crystal, with a shaft. These mines are at Grizzly Flat. 3. The Church Union, at Diamond Springs. 4. Pocahontas, at Logtown. 5. Rose; 6. Pacific; 7. Oregon; 8. Old Harmon; all at Placerville and having shafts. 9. Grass, at Placerville. 10. Saint Louis, 6 miles southeast, having a shaft. 11. Saint Lawrence, 5 miles from Placerville, having a shaft 900 feet deep, the deepest in this part of the country. 12. Rosecrans, with a shaft, at Placerville. 13. Taylor, 9 miles from Placerville, with a shaft incline 500 feet deep, and several levels. 14. Volcano, at Volcanoville, with a shaft. 15. Sliger; and 16. Cedarberg, at Greenwood, both having shafts. There are, besides, plenty of placer-diggings in the district, those at Coon Hollow being the largest. All the mines except the Saint Louis, Rose, and Crystal have mills. The Saint Lawrence has expended $300,000, and extracted $465,000; $500,000 has been taken out of the Pacific, and $100,000 out of the Oregon Mine, and $20,000 was spent in sinking the shaft and $5,000 for the mill of the latter. From the Mount Pleasant Mine, at Grizzly Flat, more than $100,000 has been extracted, and Rose Mine has realized $14,000 and spent $10,000 upon its shaft.

The Saint Lawrence mill has 30 stamps, with 85 drops per minute; an engine of 14-inch cylinder, 45-horse power, and 2½ feet stroke, and one boiler 5 feet in diameter and 16½ feet long. It has Herdy's gold concentrators, used with copper plates, rock-breakers, and self-feeders. The amalgam is cold-strained. The Nashville mill has 40 stamps run by water-power (turbine). Davidson's mill has 20 stamps, and the other mills chiefly have 10 stamps. These mills named are the principal ones in the district. The average cost per ton for mining ore is $2.50. The cost for working by steam has been about $7 per ton, but with water-power it may be reduced to $5.50. Mining labor per day is $3, and mill ing labor the same. About one and a half ton of ore can be stoped by one man per day, with a vein 3 feet wide, and about 1 ton extracted per man per day. The average cost of running a tunnel on main veins is $5 per foot, and for sinking a shaft on main veins it cost $30 per foot at the Saint Lawrence Mine. For running a drift on a main vein the cost is $3.50 per foot. The cost of hay is $20 per ton; barley, one and three-fourths cent per pound; wheat, $2 to $2.25 per 100 pounds. There is no good timber in the district, but plenty of firewood on the foot-hills about Placerville. The El Dorado Water Company's ditch runs near the town, and is used by the gravel mines in the vicinity. It is 48 miles long.

The district has 4,000 inhabitants, three stage and many freight lines. Stage-fare to the railroad terminus, Shingle Springs, is $1.50; freight is 25 cents per hundred. The district has four churches, three school-houses, twelve stores and two banking-houses. Game consists of deer, rabbits, partridges, and quail. The country roads are good. There are a few Digger Indians in the district.

WASHINGTON DISTRICT, CALAVERAS COUNTY, CALIFORNIA.

Washington district was discovered in 1869, and has since been continuously worked. It is situated 40 miles from Milton, the nearest railroad point, via San Andreas. No survey has ever been made, except of the claim by the Land Office. The mines are on the west slope of foot-hills of the Sierra Nevada Mountains, the range lying north and south, and the spurs and foot-hills in all directions. The wall-rock is dark, grayish-blue basalt, and the country-rock near bluish-mica slate. This limestone occurring on the east, north, and south of the mineral deposits, is probably Tertiary. The working of ore is by the wet process, and the ore is combined with galena, quartz, and pyrites, the principal base metals being copper, lead, and iron. Gold is also found native. There are no silver-bearing ores here.

The principal mines are the Sheep Ranch and the Chavaune. The former has a shaft 240 feet deep, and the ore is hoisted in buckets by steam. It employs at present 30 men. It has paid its way as the work progressed, never having had any working capital. Bullion worth $300,000 has been produced from this mine. A 60-horse-power engine is used. The Chavaune has a shaft 170 feet deep, and lies on the east part of the same vein. No ore has been taken out, but the mine is still being prospected. Twenty men are at work, and a 12-horse-power engine is in use. A 10-stamp mill is in course of erection by the owners of the Sheep Ranch Mine, to be run by water-power and an overshot wheel. It has now 5 stamps and a battery.

The average cost of mining and milling labor is $3 each per day. The sources of supply for hay, grain, and other produce are abundant. There is plenty of firewood, and timber in the northeast part of the district is abundant. A flume furnishes the mills with water, and the supply is limited. The district has 150 inhabitants, one school-house, two stores, and supports one stage and several freight lines. The game found consists of deer, quail, and grouse. The country roads are good. There are a few Digger Indians in the district.

CASTLE PEAK DISTRICT, MONO COUNTY, CALIFORNIA.

This district was discovered and organized in 1864 by John Till, and mines have been worked at intervals. It lies 90 miles from Carson, Nev., via Genoa, Williams Station, and a branch road. It has been examined by Prof. J. D. Whitney, geologically. The position of the ledges is on the side of a cañon, the direction of the lodes north and south, and the ore is often found in pockets. The ledges dip to the west, or into the mountain; their hanging-wall is slate, and foot-wall granite and diorite porphyry. The paying streak is from 3 to 6 feet wide. The distance between the two walls in the Dunderberg Mine is stated to be 102 feet. No fossils in the vicinity. The mean of 125 assays of Dunderberg ore was at the rate of $47.87 per ton. The roasting process has been in use. The characteristics of the ores are much pyrite, quartz, native gold, ruby silver, a little native silver, and auriferous pyrite. Gold is shown in the silver-bearing ores in the district, and the base metal is iron.

The principal mines worked are the Dunderberg and the Glen Mono, very little bullion having been taken from either, however, while $75,000 has been spent upon the former and $6,000 upon the latter. The Dunderberg has a tunnel 712 feet long, going 600 feet before tapping the ledge. It runs east and west, and at the head drifts extend north and south, the north drift being 280 feet long and the south 120. The tunnel is 6 feet high by 5 feet wide, and there is a prospecting shaft 60 feet deep. The Glen Mono Mine has a shaft 28 feet deep, and work upon it has been stopped for want of funds. There is one mill of 10 stamps, weighing 700 pounds each, and 2 batteries, 2 pans, 1 settler, amalgamation process, and hot straining of the amalgam. There is one boiler and an engine of 25-horse power.

The average cost per ton for mining ore is $2; for roasting, $10 to $12; mining-labor per day, $4; milling-labor, $4; average amount of ore that can be stoped by one man per day, 3 to 4 tons. The average cost per foot for running a tunnel on main veins is $15 to $25.

Hay is abundant, at $15 per ton, bailed; barley is 5½ cents per pound. Good timber is also abundant, and there is water near the mines, in Dogtown Creek, in sufficient quantity.

The district has about 200 inhabitants, one church, one school-house, and one store. There are several freight-lines both to Carson and Sonora, and charges are 2 to 2½ cents per pound. The stage-fare to Carson is $25. The country roads are good, and the game found in the district consists of deer, rabbits, sage-hens, and grouse. Indians in this district belong to the Pah-Utes.

ALPINE DISTRICT, ALPINE COUNTY, CALIFORNIA.

This district was discovered in 1861, and work commenced in it in 1862, since which time it has been continuous. In 1864 a part of Alpine was included in Raymond district, but put back in 1877. The distance to Carson, Nevada, via Woodford's and Genoa, is 38 miles.

The mining ledges occur both in the cañons and on the ridges, the general trend of the mountains and ridges being east and west. The direction of the lodes is north and south, while the veins dip to the east, and are supposed to be fissures. The wall-rock is diorite and diorite porphyry. The geological age of the rock in the vicinity is probably the same as that about the Comstock lode, 45 miles distant across the Carson Valley. Water-level has been reached in the veins of the Illinois California Silver Mining Company's mine. Ores are worked by both the wet and roasting process. The gangue is quartz, and the chief base metallic iron. Native gold, pyrite, ruby silver, and argentite occur, and there is gold present in the silver-bearing ores.

The principal mines now worked are as follows: 1. The Illinois California, its vein being called the Great Eastern Lode. It has a tunnel 1,296 feet long, 4 feet 6 inches wide, and 6 feet 3 inches high. It has a paid-up capital of $100,000, and has expended $60,000. Four men are at work in this mine. 2. The Galena Ledge, with a tunnel 400 feet long, on which $10,000 has been spent. 3. The Good Hope Ledge, with a tunnel 400 feet long. On this ledge $15,000 has been expended. 4. The Centennial, formerly the George Law, with three tunnels—expended, about $20,000. 5. The Silver Cloud Gold and Silver Mine, on which $12,000 has been expended, and which has a tunnel, and a shaft 90 feet deep drifted to the ledge. It has the only patent in the district. Five companies are located in the Galena Lode. In the Mount Bullion Tunnel $50,000 has been spent, and not much bullion has yet been produced in the district, as the mines are in their infancy. There is but one mill, the Pioneer, built in 1863, at a cost of $75,000, with 10 stamps, worked by water-power. A turbine-wheel has been replaced with an overshot 24 feet in diameter. There are 3 pans and 2 or 3 settlers. The amalgamation process is in use.

But little ore has been mined. The cost of mining labor is $4 per day, and of milling labor, $3.50 to $4. The supplies of hay, grain, &c., are good, and there is plenty of timber just south of the district, and some wood on the hillsides. Price of firewood, $4.50 per cord. The Carson River flows through the district, and there are flumes coming over from the mountains.

The district contains about 200 inhabitants, one church, several school houses, and two or three stores, and has good roads. There are a few Pah-Utes. Game consists of deer, rabbits, and grouse.

WEST WALKER RIVER DISTRICT, MONO COUNTY, CALIFORNIA.

This district was settled by people from Marysville, Cal., in 1862, and the mines have been worked at intervals up to and including 1875. It lies 50 miles from Carson, Nev., by Genoa Mountain House, and the Aurora road. A very small area, 4 miles long and very narrow, is covered by the croppings, the direction of which is north and south, along the ridges and foot-hills. The wall-rock is mica slate, and the vein is a fissure one. No fossils are found within 40 miles.

The chief characteristics of the ores are pyrite, white quartz, a very little silver, and not much base metal. There is some native gold, and gold in the silver-bearing ores. The wet process is used in working. The principal mines are the Napoleon and Allan's. The former has two shafts, one 50 feet deep, and two tunnels aggregating 900 feet in length, from the bottom of one of which a shaft was sunk. A sale of this mine for $60,000 failed on account of the Chicago fire. About $18,000 has been expended on it, and little bullion taken out. In Allan's mine there is a shaft 50 feet deep and 8 feet in diameter, sunk in syenite granite. One man was at work in it in 1877. There are no mills in the district. Mining labor costs $3 to $3.50 per day, and the cost per foot for running a tunnel on a main vein is less than $8, and $8 for sinking a shaft. Both shafts in the Napoleon Mine are sunk in the vein.

Hay is abundant in the district, and there is firewood on the spurs of the Sierra Nevadas. The West Walker River flows through the district and has some small tributaries, so that water is abundant. There are about 100 inhabitants and a few Pah-Ute Indians. There are one church, one school-house, and one store, and good roads. The game is rabbits, quails, and an abundance of sage-hens.

CONFIDENCE DISTRICT, TUOLUMNE COUNTY, CALIFORNIA.

This district, 47 miles from Milton, the nearest railroad station, was discovered in 1850, and has been worked at intervals and continuously since 1870. It has been investigated by the California Geological Survey; its mining ledges are on the ridges of the western foot-hills; the trend of the near mountains is north and south, and the marked spurs and ridges have an east and west trend, while the general direction of lodes, deposits, and stratifications is north and south. Granite is the wall rock, and there are fissure veins. The ores often yield as high as $200 per ton, the lowest assay giving $6 and the highest $2,800, and they are worked wet. Water has been reached in the veins. Quartz is the gangue, and the characteristics of the ores are galena, native gold, and silver.

The only mine now worked is the Confidence, having a shaft 700 feet deep. The vein is from 2 to 18 feet wide. The company own 3,550 linear feet. In October, 1877, the only work being done was pumping. About $700,000 has been expended on this mine, and bullion exceeding that value has been extracted. It has a 40-stamp mill, costing $68,000, and an engine of 100 horse-power. There are three arrastras—no pans nor settlers. The amalgamation process is used. The average cost of mining and milling labor is $3 per day for each. Four tons per day can be stoped per man, on an average.

Hay, grain, and produce are abundant, though the sources of farm produce are out of the district. Timber and firewood are plentiful, but water is scarce. A flume supplies the mine. There are 400 inhabitants, and a few Washoe and Digger Indians; one school-house and one store. The roads are good, and deer, rabbits, grouse, and quail are the principal game.

MONITOR DISTRICT, ALPINE COUNTY, CALIFORNIA.

This district, 44 miles from a railroad, was discovered and organized by Frank Jones, in 1861, and has been worked at intervals, viz, from 1861 to 1867, by prospecting and driving two tunnels, and from 1867 to 1869 the Tarshish Mine was worked. Then until 1876 but little work was done, when the Advance Mine was started, but soon suspended, the Globe Mine following a similar course in 1868. The district has not been surveyed.

The positions of the mining ledges are in the foot-hills and mainly on the sides of cañons. The mountain trend is north and south, and that of the foot-hills slightly to the northeast. The general direction of lodes and deposits is northwest and southeast. Diorite porphyry is the wall-rock, and the direction of the slopes and planes of the hanging and foot walls is eastward. The wall-rock on the east side of the Tarshish Mine is white quartzite, stained red in places; and on the west side diorite, and also basalt. No fossils are found in the country-rock.

The ores are worked by the roasting process. Their characteristics are argentite, pyrite, hexagonal crystal of quartz, and malachite and black oxide of copper occur. No ruby silver is found. The gangue is white quartz, and the chief base metals are iron and copper. The bullion contains 15 per cent. of gold from the silver-bearing ores.

The Tarshish Mine, now called the Colorado Claim, is situated on the north side of Monitor Cañon. It has two tunnels driven in the hill-side, and a winze between them. The lower tunnel is 1,860 feet long, and has four drifts from it, and the upper tunnel is 580 feet long. The average width of the vein is 75 feet; average assay of ore, $85 per ton. About $240,000 has been expended on this mine, and $25,000 worth of bullion taken out. The Advance Mine, at Bullion, on Carson River, has a shaft 200 feet deep and a tunnel on the surface 200 feet long. The Bullion Mine has a tunnel 2,300 feet long, and has expended $50,000. On mines in the district the sum of $400,000 has been spent, including $100,000 on the Globe Mine. There are two mills in the district. The

Tarshish mill has 20 stamps, and cost $75,000; they weigh 750 pounds each, and have 85 drops per minute. There are 6 pans, with metallic bottoms and wooden sides; 6 settlers; amalgamation process; engine of 140 horse-power, 18-inch cylinder, and 2 boilers. There is also a roasting-furnace—White's patent. The Advance mill, at Bullion, has 10 stamps, weighing about 800 pounds each, with 95 drops per minute. A turbine-wheel and water-power are used. The mill turns out 10 tons per day. It has a McGlew roasting-furnace turning out 5 tons per day. The Globe mill has been torn down. Cold-straining of the amalgam is in use.

The average cost per ton for mining ore is $4; for roasting, $15; for mining labor per day, $4; for milling labor, $3.50 to $4; amount of ore that can be stoped by one man in a day, 3 tons; extracted by one man, 1 ton; average cost per foot for running a tunnel on main vein, $10; for sinking a shaft on main veins, $30.

The present source of supply of grain, hay, and farm produce is abundant. Firewood costs $4 per cord. There were about 200 inhabitants in the district in 1877, and a few Pah-Ute Indians. There are one church, one school house, and three stores. The roads are good, and rabbits, quail, and grouse constitute the game.

SILVER MOUNTAIN DISTRICT, ALPINE COUNTY, CALIFORNIA.

This district was discovered by Norwegians and Swedes in 1861, and is 49 miles from railroad communication via Markleeville and Genoa. Little work was done in it until 1872, since which mining has continued pretty steadily. Seven sections include the mineral croppings, in an area of quadrilateral shape, the trend of the longer axis being north 15° to 20° west. The district has been examined by Prof. J. D. Whitney, and the township has been surveyed by Mr. L. L. Hawkins. The mineral ledges are all on top of the mountains and cross the ridge line at right angles, and the general direction of lodes is north 15° west. The lodes generally cut across the dip of the country-rock; the vein is from 3 to 7 feet wide. The wall-rock is bluish diorite and diorite porphyry, occasionally passing into feldspar porphyry, and the direction of slopes and planes of the hanging and foot walls of the veins nearly east and west, or at right angles to the strike. The veins are said to be permanent. All rocks in the vicinity are igneous and metamorphic.

The ores are roasted, and yield $15 per ton, average, though near the surface there are many tons that would yield at the rate of $200 each. In the I X L the ore grows poorer as descent is made. Water-level has not been reached. The characteristics of the ore are light and dark ruby silver, argentite, stibnite, and pyrite; no lead, copper, nor zinc. The gangue of the Exchequer is quartz of all colors, and of the I X L, white quartz. Assays show 10 per cent. of gold in the silver bullion.

The principal mines now worked are as follows: 1. The Exchequer, with £200,000 capital. It has a shaft 400 feet deep, a tunnel 960 feet long, and 4 galleries, one at every 100 feet, averaging 400 feet in length. 2. The I X L, with £100,000 capital, which has two tunnels, one 400 feet long and the other, 100 feet below it, 960 feet long, and a shaft 310 feet deep, which is being sunk further. 3. The Isabella Company's claims, on the Pine Tree, Adolphus, and other lodes in the Scandinavian Cañon—capital £150,000; there is a shaft 100 feet deep on one of the claims. 4. The Silver Mountain Mine, with two tunnels, each 100 feet long. 5. The Lady Franklin Mine, on the south extension of the Exchequer, with a tunnel on the ledge 100 feet long and a shaft 80 feet deep.

Some good ore has been taken out. 6. The Mountain Gold and Silver Mining Company's mine, near the southern end of Silver Mountain City, with a tunnel on the lode for 2,000 feet. In September, 1877, not much work was being done in these mines for want of funds. The United States mining commissioner has recommended further work on some of these mines which he examined. Including office-expenses, the sum of $200,000 has been spent on the I X L and Exchequer Mines, $3,000 on the Isabella, and $2,000 on the Silver Mountain. The first has yielded $100,000 and the second $5,719. The Exchequer mill cost $47,000; has 18 stamps, weighing 750 pounds each, with 90 drops per minute; 6 Wheeler pans, 4 feet in diameter; 4 8-foot settlers; 1 Knox clean-up pan; 1 engine with 18-inch cylinder and 36-inch stroke and 120 horse-power; 2 boilers, 50 inches in diameter and 16 feet long; 2 large retorts and a complete assay-office; and a saw-mill run by water power. It is a dry-crushing mill with a 30-ton O'Hara roasting-furnace, with a double hearth 85 feet long. The capacity is 30 tons in 24 hours; cost, $10,000. Only 5 per cent. is lost by this furnace. The capacity of the mill is 20 tons a day. The I X L mill has 20 stamps, weighing 750 pounds each, and cost $60,000. There are dry-crushers and double-discharge mortars, 8 Wheeler pans, 4 8-foot settlers, 2 large agitators, 2 Knox clean-up pans, 2 large retort-furnaces, and an engine similar to that of the Exchequer. Cold-straining of the amalgam.

The average cost per ton for mining ore is $4; for roasting and milling, $9; for mining labor per day, $4; milling labor per day, engineers, $4.50; battery-feeders and pan-men, $3.50; all others, $3. Amount of ore that can be stoped by one man per day, 3 tons; that can be extracted, 1 ton. Average cost per foot for running a tunnel on main veins, $9, and for sinking a shaft on a main vein, $30.

The source of supply of grain, hay, and farm produce is good. Wood costs about $5 per cord, and conifers are abundant on the neighboring hills. Silver Creek flows through the district. There are about 100 inhabitants, good roads, one school-house, and three stores. The principal game is quail.

IOWA DISTRICT, ONEIDA COUNTY, IDAHO.

This district was discovered by Fairchild S. Babcock and F. McCoy, and organized September 13, 1870, and a quartz district July 8, 1877. Placer-mining has been continuous since the first organization. The quartz-mining consists in prospecting ledges. The mines are 150 miles from Corinne, the nearest station on a railroad, and have a post-office, Iowa Bar, located near. Gold is always found in any of the rock containing iron, and magnetic-iron ore is found in all the placer-mines at the base of Mount Pisgah, where the Iowa placer-mines are situated. Six companies are here working, by hydraulics, about five months of the year, and the yield is about $40,000 for the five months. There are 40 Americans and 100 Chinese at the mines, and game of all kinds is found in the vicinity. Freight from Corinne is $3 per 100 pounds. The district embraces the country drained by Iowa Creek, Anderson Gulch, Eagle Creek, Jack Knife and Tin Cup Runs—an area of 15 miles north and south by 10 miles east and west. Mount Pisgah is the center of the quartz district, is 9,000 feet high, and ranges northwest and southeast. On the west it slopes to Day's Lake. The ledges on the south of the mountain have an almost perpendicular strike, and on the west a dip of about 35° to the southwest. The ores of the vicinity are iron, copper, lead, manganese, silver, and gold. These mines were visited and reported upon by Lieutenant Tillman in 1877.

COAL IN BEAR AND GREEN RIVER BASINS.

During the season, a hasty glance was taken at beds of coking and non-coking bituminous coal on Twin Creek, that enters Bear River from the east; and at croppings southeast from its head, in the basin of Green River; and at Alta, near Evanston, on the Union Pacific Railroad. These beds are all in Wyoming, north of the Union Pacific Railroad. Twin Creek joins Bear River at an approximate distance of 50 miles from Evanston, and the coking deposits are found about 2½ miles to the eastward from the road leading from the Union Pacific Railroad to the northward, along the east bank of the river. The deposits on Twin Creek near Bear River Valley (property of the Wyoming Coal and Coking Company) show croppings of a number of veins, upon one of which a tunnel has been run, developing at a short distance from the surface a vein of compact bituminous coal. The beds, sensibly parallel, have a westerly dip of over 30°, with a course slightly to the west of north. Twin Creek is about 200 yards to the southward of the hill, several hundred feet in elevation, in which the veins are found. Fair samples of coke, made from furnaces on the ground, were shown by Messrs. Smith Brothers, in charge of the mining works. The quality is excellent, with the exception of slight impurities that can, doubtlessly, be remedied by working the ore. The present development indicates that a quantity of coking coal can be obtained from two of the veins followed, and further exploration will better show the extent and thickness in depth of the several veins. The most immediate markets at present are the mines in Utah about Salt Lake Valley, and those of Eureka, Nev. The present means of communication is by wagon-road to Evanston; thence via Union Pacific Railroad and Utah Central Railroad to Salt Lake; and Union Pacific Railroad, Central Pacific Railroad, and Eureka and Palisades Railroad to Eureka. Coal from Connellsville, Pa., has mostly furnished the Utah markets, a small amount being derived from beds in Sam Pitch Valley, Utah. Eureka has depended largely upon charcoal. The presence of coking-coal in this locality, evidently in connection with the late sedimentary rocks, and in the foothills bordering Twin Creek, that near its source shows in hills of semicircular character extended beds of non-coking bituminous coal, may be considered singular. The locality should be closely studied from a geological point of view.

In traversing the valley of the creek to the eastward, the character of the rock-beds changes in coloration. A number of bold white, gray, and yellowish-tinted bluffs to the north were being explored for fossil fishes, leaves, &c., of which large numbers had been found. Near the source, a number of beds of a light, highly lustrous, pure bituminous coal were noted. A number of these have been slightly opened. The same tilt to the westward is noticed, with a dip almost northerly, and the number of distinct veins reaches eleven. Explorations cannot fail to develop a large amount of fuel-coal from these beds.

To the south and eastward, a distance of 20 to 25 miles, croppings from bluff-like sandstone walls facing the Green River drainage are found, and specimens were secured from the tunnel upon the Mammoth Vein, so called, for which a face thickness of 50 and normal thickness of 40 feet is claimed. This vein has a less dip to the westward, and apparently is persistent for a considerable distance along a nearly northerly course. These prospects, with those of the Upper Twin Creek, and others of a similar character said to be found a short distance to the northward are of themselves indications of extensive deposits along the water-sheds leading north from the Union Pacific Railroad, between the Green and Bear Rivers. No opportunity has presented itself for obtaining analyses of the specimens, and the time at disposal precluded the determination of the profiles of the beds. A hasty look was taken at the veins opened by the Central Pacific Railroad and Union Pacific Railroad at Alta, near Evanston. These beds produce large quantities easily mined, and may do so for years to come. The quality is far inferior to that of specimens near the surface from veins to the north. These mines have been, it is believed, visited and described by other government parties.

NATURAL HISTORY (INCLUDING GEOLOGY, ZOOLOGY, BOTANY, ETHNOLOGY, ETC.).

Mr. A. R. Conkling submits a geological report of his examinations along the Sierra Nevada, to the southward of areas hitherto visited by him, which is herewith forwarded. (See Appendix I.) He has also collected such number of minerals, fossils, and ores as practicable in view of the limited amount of, and difficulties attendant upon, transportation. Mr. H. W. Henshaw presents a preliminary report (Appendix J) of his season's work, that has embraced collecting in other branches than that of ornithology, to which his time was especially devoted. A report of the fresh-water fishes collected by the expeditions of 1875, 1876, and 1877, prepared by Prof. D. S. Jordan and H. W. Henshaw, is forwarded and marked Appendix K. Appendix K 1 gives a list of salt-water fishes collected off the coast of Southern California in 1875, accompanied with notes by Dr. H. C. Yarrow and H. W. Henshaw. A report upon the reptiles and batrachians collected in 1875, 1876, and 1877, made by H. W. Henshaw and Dr. H. C. Yarrow, appears as Appendix L.

Prof. F. W. Putnam has, as his professional duties have permitted, advanced toward completion his portion of the manuscript for Vol. VII, Archæology. The remainder of the manuscript, with cuts accompanying the same, it is expected will be received in season to be forwarded finally prepared for the printer as soon as proof for Vol. VI shall have been completed.

The following collections in natural history have been added during the year, viz:

LIST OF NATURAL-HISTORY COLLECTIONS MADE DURING THE FIELD SEASON OF 1877.

Mammals	specimens	8
Mammals (alcoholic)	do	6
Mammal crania	do	4
Birds	do	200
Birds (alcoholic)	do	28
Bird sterna	do	9
Birds' nests	do	16
Birds' eggs	do	665
Fishes	do	200
	lots	23
Snakes	do	8
Lizards	do	3
Arachnida	do	3
Hemiptera	do	2
Orthoptera	do	8
Hymenoptera	do	1
Shells	do	8
Diatoms	do	12
Minerals, &c	specimens	63
Mineral waters	localities from	6

The number of specimens forwarded to the Smithsonian Institution during the year, as a donation to the museum, is herewith given:

NATURAL-HISTORY COLLECTIONS FORWARDED TO THE SMITHSONIAN INSTITUTE DURING THE FISCAL YEAR 1877.

Botanical specimens, 2,100 (350 species).
Ethnological specimens, 366, approximate, including the following:

California.

Lot 1. Abalone shells (paint-cups), beads, paint, &c.
Lot 2. Twelve abalone shells (paint-cups).
Lot 3. Four stone paint-cups, and others in fragments.
Lot 4. Fifteen stone pestles.
Lot 5. Fourteen stone pipes.
Lot 6. Eleven grinding-stones.
Lot 7. Many fragments of bones.
Lot 8. Steatite vessels, in fragmentary condition.
Lot 9. Nine stone mortars (large).
Lot 10. Twelve stone mortars (small).
Lot 11. Thirty-nine steatite vessels, large and small, with many fragments.

Utah and New Mexico.

Lot 12. Four grinding-stones, 3 stone hatchets, 2 stone pipes, 4 stone implements.
Lot 13. Many fragments of ancient pottery.

Recent.

Lot 14. Six small earthen pots, 1 large, 4 bird-shaped vessels, 8 human figures.
Lot 15. One powder-horn, bullet-pouch, and game-bag, and 2 bows and quivers, 19 arrows, 3 quivers, 56 arrows, 2 fishing-implements, 1 hair lariat, 1 hair bridle, 2 beaded shirts, 1 pair pants, beaded, 1 Navajo sash, 1 pair squaw's boots, beaded, 1 saddle-bag, 1 Jemez shield.

SPECIMENS FORWARDED TO ARMY MEDICAL MUSEUM DURING 1877.

Birds and crania (alcoholic)	27
Bird sterna	10
Mammals (alcoholic)	2

Prof. J. J. Stevenson and his assistant occupy a field where the mapping has been done in advance, and of which the geology is but little known. The greater facility of traveling with this preliminary information at hand, combined with the small-sized and consequently more rapidly-moving party required, will, it is believed, render more satisfactory all observations to be made, in accuracy, completeness, and rapidity. Should the plan of dividing the allied scientific examinations from the map-work proper prove successful, the latter can proceed with more rapidity, thus satisfying earlier the wants of the War Department, and permitting the special investigations to follow as rapidly as practicable.

PUBLICATIONS.

During the year the following maps have been completed, issued, and published:

Progress map, edition of 1878, and ten topographical atlas sheets, viz: 41 B, 47 B, 47 D, 61 A, 61 C, 62 A, 62 C, 69 D, 77 D, and 84 B. The regular topographical sheets accompany the extra copies of the annual report printed for the use of this office. Land classification in colors is shown upon several of the topographical sheets, and will be added to all, as time permits.

The quarto volume number II (astronomy and barometric hypsometry) has been issued from the press, as also the catalogue of the mean declinations of 2,018 stars.

Two thousand extra copies of the Annual Report of 1877, from this office (Appendix N N, Annual Report Chief of Engineers) have been published, accompanied in separate binding by the following atlas sheets, viz: 53 C, 61 B, 61 C sub, 61 D, 65 D, 69 B, 70 A, 70 C, and 77 B.

The list herewith shows the number and titles of the several reports and maps published as results of the survey to date, and also those awaiting publication. The reports now being submitted by this office include the annual reports of operations made at the close of each fiscal year to the Chief of Engineers, and incorporated in his report, a certain number of extra copies being printed for the use of the survey; and the quarto reports authorized to be published by acts approved June 23, 1874, and February 15, 1875. The number thus far authorized by the department is seven quarto volumes, of which two thousand copies are published in pursuance of the above acts, twelve hundred copies of which are forwarded, as each volume appears, to the Senate and House of Representatives of the United States, and eight hundred to the War Department for its uses. The maps and reports placed at the disposal of this office for distribution are sent in the main to prominent libraries and institutions of learning, and learned societies at home and abroad, and to practical workers in the several scientific branches treated. The number printed is inadequate to the above requirements, and the increasing calls for the various reports attest the appreciation with which they are received. The maps prepared, issued, and published are of the regular topographical and geological series of atlas sheets, and the authorized maps of special subjects and upon various scales, of which 2,000 copies are printed of each in addition to those appearing with the annual reports. These maps, as also annual reports, are distributed largely in the areas occupied by the survey, to the Army at large, and to the various departments of the government. Experience thus far indicates that the number of reports and maps published is much less than might apparently be distributed with advantage commensurate with the comparatively slightly increased expense of printing additional copies.

It is believed that the results of the survey appear in the best shape for distribution and use as annual reports of operations, octavo, accompanied by maps issued during the year, and in special reports, authorized by the department to be prepared and issued at such intervals as the material gathered in any one branch seems to justify. It is suggested that the total number of each of the quarto reports and accompanying maps printed should be not less than five thousand. At present the same report is distributed through three sources, *i. e.*, Congress, the department, and the office of the survey. It is plain that the opportunity for duplicating in the distribution to individuals exists, and that the same plan of distribution is not pursued by all into whose hands the publications fall for this purpose.

The several quarto volumes are stereotyped as issued, and the lithographic stones belong partly to the government, and will be held in most instances for an interval not exceeding two years by the lithographer. Congress can at any moment authorize the publication of an extra number, and it is respectfully suggested that the distribution contemplated by this office can be made more complete and satisfactory were an additional number of not less than 500 allotted for its uses.

LIST OF REPORTS AND MAPS.

The following is a list of publications (reports and maps) made prior to June 30, 1878:

1. Preliminary Report upon a Reconnaissance through Southern and Southeastern Nevada in 1869. Quarto, 72 pages.
2. Preliminary Report concerning Explorations and Surveys, principally in Nevada and Arizona, &c., in 1871. Quarto, 96 pages, with maps.
3. Progress Report upon Geographical and Geological Explorations and Surveys west of the 100th Meridian, in 1872. Quarto, 56 pages, with skeleton map and five plates.
4. Annual Report upon the Geographical and Geological Surveys and Explorations west of the 100th Meridian, &c., in 1873; being "Appendix EE, Annual Report Chief of Engineers." Octavo, 11 pages, with skeleton map.
5. Annual Report of Geographical Explorations and Surveys west of the 100th Meridian, &c., in 1874; being "Appendix FF, Annual Report Chief of Engineers." Octavo, 130 pages, with progress map.
6. Annual Report upon the Geographical Explorations and Surveys west of the 100th Meridian, &c., in 1875; being "Appendix GG, Annual Report Chief of Engineers." Octavo, 196 pages, with progress and triangulation maps and 38 illustrations.
7. Annual Report upon the Geographical Surveys west of the 100th Meridian, &c., in 1876; being "Appendix JJ, Annual Report Chief of Engineers." Octavo, 355 pages, with 9 maps, 15 illustrations, and 7 separately folded topographical atlas sheets.
8. Annual Report upon the Geographical Surveys west of the 100th Meridian, &c., in 1877; being "Appendix NN, Annual Report Chief of Engineers." Octavo, 133 pages, with progress, sketch, and profile maps, and 9 separately folded atlas sheets, 7 of which are of the land classification series.

Quarto reports.

9. Volume II. Astronomy and Barometric Hypsometry. In two parts, with 22 plates and 3 wood-cuts, 566 pages, with indexes. 1877.
10. Volume III. Geology. In six parts, with 13 plates and 171 wood-cuts, 661 pages. 1875.
11. Volume IV. Paleontology. In two parts, with 83 plates and accompanying explanatory notes, 581 pages, with indexes. 1877.
12. Volume V. Zoölogy. In 16 chapters, with 45 plates, 3 wood-cuts, and separate indexes, 1021 pages. 1875.

Special reports.

13. Tables of camps, distances, lines of march, &c., surveys and explorations in Nevada and Arizona. Oblong folio, 14 pages. 1871.
14. Tables containing camps, distances, lines of march, longitudes, latitudes, altitudes, &c., explorations and surveys in Utah, Nevada, and Arizona. Quarto, 43 pages. 1872.
15. Report upon the determination of the astronomical co-ordinates of the primary stations at Cheyenne, Wyo., and Colorado Springs, Colo., &c. Quarto, 82 pages. 1874.
16. Report upon vertebrate fossils discovered in New Mexico, with descriptions of new species. Octavo, 18 pages. 1874.
17. Preliminary report upon invertebrate fossils, with descriptions of new species, &c. Octavo, 27 pages. 1874.

18. Catalogue of plants collected, with descriptions of new species Octavo, 62 pages. 1874.

19. Report upon ornithological specimens, &c. Octavo, 148 pages. 1874.

20. Systematic catalogue of vertebrata of the Eocene of New Mexico, &c. Octavo, 37 pages. 1875.

21. Logarithm, traverse, and altitude tables. Octavo, 30 pages. 1875.

22. Instructions for taking and recording meteorological observations, and for preserving and repairing instruments, &c. Octavo, 64 pages. 1875.

23. Barometric hypsometry instructions. A revised edition of the preceding. Octavo, 88 pages. 1876.

24. List of longitudes, latitudes, altitudes, &c. Quarto, 22 pages, with blank tables, being an extract from Vol. II of the quarto reports. 1877.

25. Catalogue of the mean declination of 2,018 stars between 0^h and 2^h and 12^h to 24^h right ascension, and 10° and 70° of north declination, &c. Quarto, — pages. 1878.

MAPS.

Topographical atlas.

1. Title-page.

2. Sheet of conventional signs.

3. Legend sheet.

4. Sheet of that portion of the United States lying west of the 100th meridian, showing ninety-five numbered rectangular divisions, each to appear as a separately numbered atlas sheet, indicating progress of the survey.

5. Drainage sheet, showing by colors the areas of drainage to the Atlantic and Pacific Oceans, and of the interior basins of the territory of the United States west of the Mississippi. Scale, 1: 6000000.

6. Sheet No. 41 B. Southeast corner of Idaho and part of Northern Utah. Area, 4,075 square miles; scale, 1 inch to 4 miles, or 1:253440.

7. Sheet No. 47 B. Parts of Eastern California and Western Nevada. Area, 4,178 square miles; scale, 1 inch to 4 miles, or 1:253440.

8. Sheet No. 47 D. Parts of Eastern California and Southwestern Nevada. Area, 4,228 square miles; scale, 1 inch to 4 miles, or 1:253440.

9. Sheet No. 49. Parts of Eastern Nevada and Western Utah. Area, 16,813 square miles; scale, 1 inch to 8 miles, or 1:506880.

10. Sheet No. 50. Parts of Central and Western Utah. Area, 16,813 square miles; scale, 1 inch to 8 miles, or 1:506880.

11. Sheet No. 53 C. Part of Central Colorado. Area, 4,228 square miles; scale, 1 inch to 4 miles, or 1:253440.

12. Sheet No. 58. Parts of Eastern and Southern Nevada and Southwestern Utah. Area, 17,208 square miles; scale, 1 inch to 8 miles, or 1:506880.

13. Sheet No. 59. Portions of Southwestern Utah. Area, 17,208 square miles; scale, 1 inch to 8 miles, or 1:506880.

14. Sheet No. 61 A. Part of Western Middle Colorado. Area, 4,278 square miles; scale, 1 inch to 4 miles, or 1:253440.

15. Sheet No. 61 B. Part of Central Colorado. Area, 4,278 square miles; scale, 1 inch to 4 miles, or 1:253440.

16. Sheet No. 61 C. Part of Southwestern Colorado. Area, 4,326 square miles; scale, 1 inch to 4 miles, or 1:253440.

17. Sheet No. 61 C sub. Part of Southwestern Colorado, the San

Juan mining region. Area, 1,100 square miles; scale, 1 inch to 2 miles, or 1:126720.

18. Sheet No. 61 D. Part of Southwestern Colorado. Area, 4,326 square miles; scale, 1 inch to 4 miles, or 1:253440.

19. Sheet No. 62 A. Part of Central Colorado. Area, 4,278 square miles; scale, 1 inch to 4 miles, or 1:253440.

20. Sheet No. 62 C. Part of Central Colorado. Area, 4,326 square miles; scale, 1 inch to 4 miles, or 1:253440.

21. Sheet No. 65 D. Portions of Southeastern California. Area, 4,420 square miles; scale, 1 inch to 4 miles, or 1:253440.

22. Sheet No. 66. Parts of Eastern California, Southeastern Nevada, and Southern Utah. Area, 17,587 square miles; scale, 1 inch to 8 miles, or 1:506880.

23. Sheet No. 67. Parts of Northern and Northeastern Arizona and Southern Utah. Area, 17,587 square miles; scale, 1 inch to 8 miles, or 1:506880.

24. Sheet No. 69 B. Parts of Northern New Mexico and Southern Colorado. Area, 4,373 square miles; scale, 1 inch to 4 miles, or 1:253440.

25. Sheet No. 69 D. Part of North Central New Mexico. Area, 4,420 square miles; scale, 1 inch to 4 miles, or 1:253440.

26. Sheet No. 70 A. Parts of Southern Colorado and Northern New Mexico. Area, 4,373 square miles; scale, 1 inch to 4 miles, or 1:253440.

27. Sheet No. 70 C. Part of Northern New Mexico. Area, 4,420 square miles; scale, 1 inch to 4 miles, or 1:253440.

28. Sheet No. 75. Parts of Central and Western Arizona. Area, 17,952 square miles; scale, 1 inch to 8 miles, or 1:506880.

29. Sheet No. 76. Parts of Eastern Arizona and Western New Mexico. Area, 17,952 square miles; scale, 1 inch to 8 miles, or 1:506880.

30. Sheet No. 77 B. Part of Central New Mexico. Area, 4,465 square miles; scale, 1 inch to 4 miles, or 1:253440.

31. Sheet No. 77 D. Portions of Central New Mexico. Area, 4,510 square miles; scale, 1 inch to 4 miles, or 1:253440.

32. Sheet No. 83. Portions of Southeastern Arizona and Western and Southwestern New Mexico. Area, 18,301 square miles; scale, 1 inch to 8 miles, or 1:506880.

NOTE.—The atlas-sheets, whether topographical, land classification, or geological, are uniform in size, each being 19 x 24 inches. The final atlas, as at first projected, consists of ninety-five topographical sheets, on a scale of one inch to eight miles, with a corresponding number of geological sheets, showing in color the formations, upon the topographical map as a base. The classification of lands has been shown. Maps over limited areas of regions peculiarly interesting because of their topographical, geological, or industrial relations, have been made of larger scales, as 1 inch to 4 miles, 1 inch to 2 miles, 1 inch to 1 mile, 1 inch to 1,500 feet, all to be reduced, however, finally, and to become a part of the large connected map of the area west of the 100th meridian, on a scale of 1 inch to 8 miles.

There are hereafter to be published three series of maps: (1) Topographical, (2) land classification, (3) geological. The reports intended hereafter to be submitted are: (1) Regular annual reports of operations for each fiscal year, accompanied by topographical and land classification maps issued during the year, and (2) quarto reports, authorized, upon special subjects.

Geological atlas.

1. Title page.
2. Index sheet.
3. Special sheet, embracing portions of Western Utah and Eastern Nevada, representing the location and outlines of an ancient fresh-water lake, which included the region of Great Salt, Sevier, and Utah Lakes. Scale, 1 inch to 17 miles.
4. Sheet No. 50. Central and Western Utah. Area, 16,813 square miles; scale, 1 inch to 8 miles, or 1:506880.
5. Sheet embracing half of Nos. 58 and 66, being parts of Eastern California, Southeastern Nevada, Northwestern Arizona, and Southwestern Utah; scale, 1 inch to 8 miles, or 1:506880.
6. Sheet No. 59. Portions of Southern and Southwestern Utah. Area, 17,208 square miles; scale, 1 inch to 8 miles, or 1:506880.
7. Sheet No. 67. Portions of Northwestern Arizona and Southern Utah. Area, 17,587 square miles; scale, 1 inch to 8 miles, or 1:506880.
8. Sheet No. 75. Parts of Central and Western Arizona. Area, 17,952 square miles; scale, 1 inch to 8 miles, or 1:506880.
9. Sheet No. 76. Parts of Eastern Arizona and Western New Mexico. Area, 17,952 square miles; scale, 1 inch to 8 miles, or 1:506880.
10. Sheet No. 83. Parts of Eastern and Southeastern Arizona and Southwestern New Mexico. Area, 18,301 square miles; scale, 1 inch to 8 miles, or 1:506880.

NOTE.—The geological maps show by colors—upon the topographical sheets as a base—the principal geological formations, including Archæan, Silurian, Carboniferous, Triassic, Jurassic, Cretaceous, Tertiary, Quaternary, and Basalt.

Land-classification maps,

showing, by color, upon the topographical sheets as a base, the relative proportions of agricultural (with irrigation), timber, grazing, and arid or barren lands of the regions delineated.

1. Sheet No. 61 B. Parts of Central Colorado. Area, 4,278 square miles; scale, 1 inch to 4 miles, or 1:253440.
2. Sheet No. 61 C sub. Portions of Southwestern Colorado. Area, 1,100 square miles; scale, 1 inch to 2 miles, or 1:126720.
3. Sheet No. 65 D. Portions of Southeastern California. Area, 4,420 square miles; scale, 1 inch to 4 miles, or 1:253440.
4. Sheet No. 69 B. Portions of Southern Colorado and Northern New Mexico. Area, 4,373 square miles; scale, 1 inch to 4 miles, or 1:253440.
5. Sheet No. 69 D. Part of North Central New Mexico. Area, 4,420 square miles; scale, 1 inch to 4 miles, or 1:253440.
6. Sheet No. 70 A. Portions of Southern Colorado and Northern New Mexico. Area, 4,373 square miles; scale, 1 inch to 4 miles, or 1:253440.
7. Sheet No. 70 C. Portions of Northern New Mexico. Area, 4,420 square miles; scale, 1 inch to 4 miles, or 1:253440.
8. Sheet No. 77 B. Portions of Central New Mexico. Area, 4,465 square miles; scale, 1 inch to 4 miles, or 1:253440.

Several land-classification maps will accompany the extra copies of Appendix N N, Annual Report of 1878, of which maps no description is here given.

Special sheets.

1. Reconnaissance map of parts of Nevada and Arizona; scale, 1 inch to 12 miles, or 1:760320.
2. Map of the Grand Cañon of the Colorado. Exploration of 1871.

Scale 1 inch to 6 miles, or 1:380160. (This sheet will appear as one of the illustrations of Vol. I.)

REPORTS AND MAPS IN PROGRESS.

The following are now in manuscript or in course of preparation, and await publication:

Reports.

1. Volume I (quarto), Geographical Report.
2. Volume VI (quarto), Botany (now at Government Printing Office).
3. Volume VII (quarto), Archæology.
4. Tables of Geographical Positions, Distances, Altitudes, &c., 8vo.

Maps.

1. Sheet No. 32 C. Portions of Southeastern Idaho. Area, 4,022 square miles; scale, 1 inch to 4 miles, or 1:253440.
2. Sheet No. 32 D. Southeastern portion of Idaho. Area, 4,022 square miles; scale, 1 inch to 4 miles, or 1:253440.
3. Sheet No. 38 B. Portions of Northeastern California, Southern Oregon, and Northwestern Nevada. Area, 4,075 square miles; scale, 1 inch to 4 miles, or 1:253440.
4. Sheet No. 38 D. Parts of Eastern California and Western Nevada. Area, 4,127 square miles; scale, 1 inch to 4 miles, or 1:253440.
5. Sheet No. 41 A. Parts of Southeastern Idaho and Northwestern Utah. Area, 4,075 square miles; scale, 1 inch to 4 miles, or 1:253440.
6. Sheet No. 48. Part of Western Nevada. Area, 16,813 square miles; scale, 1 inch to 8 miles, or 1:506880.
7. Sheet No. 52 D. Central Colorado. Area, 4,228 square miles; scale, 1 inch to 4 miles, or 1:253440.
8. Sheet No. 56 B. Portions of Eastern California and Western Nevada. Area, 4,278 square miles; scale, 1 inch to 4 miles, or 1:253440.
9. Sheet No. 68, in part. Portions of Colorado, New Mexico, and Arizona. Scale, 1 inch to 8 miles; or 1:506880.
10. Sheet No. 69. Portions of Southwestern Colorado and Northwestern New Mexico. Area, 17,587 square miles; scale 1 inch to 8 miles, or 1:506880.
11. Sheet No. 73. Part of Southern California. Area, 17,972 square miles; scale, 1 inch to 8 miles, or 1:506880.
12. Sheet No. 73 A. Portions of Southern California. Area, 4,465 square miles; scale, 1 inch to 4 miles, or 1:253440.
13. Sheet No. 73 C. Part of Southern California, including portion of coast-line. Area, 4,510 square miles; scale, inch to 4 miles, or 1:253440.
14. Sheet No. 74 in part. Portions of Southern California and Western Arizona. Scale, 1 inch to 8 miles, or 1:506880.
15. Sheet No. 77. Portions of Western New Mexico. Area, 17,952 square miles; scale, 1 inch to 8 miles, or 1:506880.
16. Sheet No. 78 A. Part of Northern Central New Mexico. Area, 4,465 square miles; scale, 1 inch to 4 miles, or 1:253440.
17. Sheet No. 80 A. Part of the area within the coast-line of Southern California. Scale, 1 inch to 4 miles, or 1:253440.
18. Sheet No. 84. Part of Southwestern New Mexico. Area, 18,301 square miles; scale, 1 inch to 8 miles, or 1:506880.
19. Sheet No. 84 B. Part of Central New Mexico. Area, 4,554 square miles; scale, 1 inch to 4 miles, or 1:253440.

20. Special sheet of portions of Eastern California and Western Nevada, the Lake Tahoe region of the Sierra Nevada. Area, 2,232 square miles; scale, 1 inch to 1 mile, or 1: 63360.

21. Special sheet of the vicinity of the Comstock lode of the Washoe mining district of Nevada. Area, 119 square miles; scale, 1 inch to 1,500 feet, or 1: 18000.

NOTES UPON THE FIRST DISCOVERIES OF CALIFORNIA.

An article upon the first discoveries of California, relative to its supposed insular form, and the origin of its name, by Prof. Jules Marcou, by request for its publication contained in a letter from the Chief of Engineers, of August 6, 1878, appears as Appendix M of this report. Without claiming to be exhaustive, it contains highly valuable information relating to the early period of history of a peculiarly interesting section, embraced by the region under survey.

HISTORY OF OPERATIONS.

The yearly expeditions organized for the prosecution of field-work of the survey commenced in 1869, and have continued to and include the present season, with the single exception of 1870. Initial points for the reconnaissance of 1869 in Southern and Southeastern Nevada were established along the Central Pacific Railroad, and in the interior as far as the telegraph had penetrated. The expedition of 1871, despatched from Washington, covered more extended areas in California, Utah, and Arizona, adding to the number of astronomically determined points. The act of 1872 authorized the "establishment of an astronomical base" in addition to the prosecution of "military and geographical" surveys west of the 100th meridian. This act was based upon a plan for topographically surveying and mapping the territory of the United States west of the 100th meridian, in a systematic and economic manner, submitted in April, 1872, by Lieutenant Wheeler to the Chief of Engineers, by him to the honorable the Secretary of War, approved by both, and laid before Congress, by which body it was adopted as indicated by the act approved June 10, 1872, from which the above quotations are made. Without restriction as to the limits for annual occupation, these surveys have been continuously prosecuted in connected areas in the territory lying west of the 100th meridian to the present time. In pursuance of the approved plan, main astronomical stations were established during the years 1872, 1873, and 1874 at important points along the Union and Central Pacific Railroads. These points have proved of great benefit, not alone in the after prosecution of this work, but also that of other surveys. The expeditions of 1871, 1872, 1873, 1874, 1875, 1876, 1877, and 1878 have traversed and surveyed areas connecting with that of 1869, and developed the work in all directions until the areas entered embrace portions of fourteen of the fifteen States and Territories, a part or all of which lie west of the 100th meridian of longitude. Where work of the Pacific Railroad and military and geographical surveys west of the Mississippi and the lines of the survey of the public lands could be made available, the same have been incorporated.

This work, especially in its earlier stages, may be considered as supplemental to, binding together and developing systematically over completed areas the surveys for the Pacific Railroad and those for military and geographical purposes west of the Mississippi, suspended at the outbreak of the late war, and appropriations for which, except during the above interregnum, have been made almost yearly from 1852 to the present time.

Triangulation methods were introduced to some extent in 1872, and more generally in 1873. In 1874 the work was developed into a completely connected geodetic survey, depending upon initial astronomical points, measured and developed bases, and points determined by triangulation or trigonometrically. The geodetic work is kept slightly in advance of the topographical and allied portions, with the ultimate intention of obtaining by small parties data for a preliminary or skeleton map in advance of the regular occupation of the region for purposes of detailed topographical and geological investigations.

In 1875 the expedition was for the first time organized into a number of small and comparatively independent parties, having but few if any rendezvous in common, and this plan has since been pursued, the size of each party being dependent upon the class or classes of work that it is required to perform. The number of experienced observers increases year by year, and as means are made available the present organization can prosecute with certainty its labors in areas commensurate with the means allotted. The personnel of the expeditions has been composed of officers of the Corps of Engineers, of the Ordnance and Medical Departments, and of the artillery, cavalry, and infantry, and enlisted men of the general and regular services of the United States Army; of assistants scientific and technical, and employés, as packers, guides, laborers, teamsters, blacksmiths, &c.

Escorts were required for each party up to and including the year 1873, since which date the size of the parties in disturbed or hostile regions has been made sufficient that each may guard itself.

The area covered, including the season of 1877, is 332,515 square miles, distributed in the following political divisions:

	Square miles.
California	54,751
Nevada	62,181
Utah	38,969
Arizona	61,816
Colorado	33,041
Wyoming	231
New Mexico	71,427
Oregon	1,242
Idaho	8,877

Initial points only were established up to the close of 1877 in Kansas, Nebraska, Texas, Montana, and Washington; the latter, however, being visited for the first time in 1878.

While observations in the astronomical, geodetic, topographical, and barometric branches of the work, needed for the construction of the map, have been prosecuted with the greater force, still investigations in the branches of mineralogy and mining, geology, paleontology, zoology, botany, and archæology, such as are deemed necessary in the present stage of development of the regions visited, and without too greatly increasing the expense, have been included, as evidenced by the number of publications upon those subjects. (See list of reports and maps.)

In 1875, the field operations of the survey were divided into two sections, denominated the "Colorado" and "California," since which the Utah section has been added. A field-office and rendezvous have been established at Ogden, Utah, and a second recommended at Denver, Colo. It is suggested that if funds are made available parties can be engaged north of the Pacific Railroads in the spring, summer, and fall, and near the Mexican border during the winter months, thus keeping an expedition continuously in the field until the data for the map of the entire area of 1,443,360 square miles shall have been obtained.

CONCLUSION.

The area proposed for occupation during the season of 1878, that is rendered short on account of the lateness of appropriations, is greater than that surveyed for a number of years, exceeding in amount 40,000 square miles. The season, prolonged as late into December as practicable, will, it is believed, admit of the completion of the amounts allotted to each party, with the exception of the double party numbered one of the California section. In order to establish the necessary initial triangulation stations, this party will be compelled to occupy points along the Cascade Range outside of the area assigned. The routes followed to and from the triangulation points will furnish that amount of preliminary information well calculated to facilitate the more thorough working, at a later period, of the timbered regions of this portion of Oregon.

Methods commensurate with the accuracy of the topographical work being settled upon in advance, the endeavor has been to secure, in their pursuance, the best possible results at the least possible cost. The average amount per square mile thus far expended is, as a matter of course, in deficit of that required to prosecute a topographical survey with the detail necessary for a map, as, for instance, of a scale of 1 inch to one mile, but has proven sufficient for the survey requisite for a map upon a scale of 1 inch to eight miles, as experience proves, since no sheets have been projected on a lesser scale, and much area is represented on scales proportionately larger in the ratio of two to one, as 1 inch to four miles, 1 inch to two miles, 1 inch to one mile.

The number of military posts or stations now in existence within the area already surveyed is thirty-three, all of which have been visited, as well as others now abandoned, and aid and supplies in inappreciable quantities drawn therefrom. The opportunities for co-operation by the supply branches of the Army thereby extended have been authorized to be availed of, in view of reduced appropriations, and all material and supplies furnished at these points *en gros* are delivered, it is safe to infer, at lesser rates for first cost and that of transportation, than those for which smaller quantities for special wants could be placed upon the same ground.

The number of military establishments now in existence within the area west of the one hundredth meridian is 90. The total number on and west of the Mississippi River is 130. These posts in the interchange of troops and the various military operations intercommunicate, and it is of no little value that the government should be informed of the shortest and most available routes between them, and from each to the nearest railroad points and termini, or to other interior points of importance. This among other subjects receives attention in a topographical survey, and the maps, placed at once in the hands of officials of the War Department, either as published originals or re-delineated upon the generalizèd maps more commonly in use by the Army, are of service to the troops, whether actively engaged in scouts, in pursuit of or in action with the hostiles; the movements of the latter during the past few years having shown a generalship regardless of areas set apart as Indian reservations and often of the geographical limits of extended military departments. The number of Indian campaigns of the past ten years, in which want of knowledge and accuracy in the existing maps must have been felt, surely point to the advantages that at least may hereafter ensue from the use of accurate and detailed maps from original data. The aggregate of expense for the completed topographical map should be but little considered as compared with the space of time in which the force that can be brought into the field shall be able to complete the work. I have before invited attention to the possibility of prosecuting the survey at the southern portion of the area during the colder season, and have again to suggest that winter parties can be kept engaged along the Mexican border, thus prosecuting field-work throughout the year, should the annual estimates submitted be appropriated for in full. The constant use of maps to which the Army on the frontier in its service becomes accustomed, frequent consultation of them being a part of its practices, and, in consequence, the most immediate application of such results finding its exponent in the War Department, would seem to justify the consideration of the estimates for the survey in connection with the Army bill.

I have again, therefore, to suggest the desirability of estimating for this work among the regular Army estimates, the appropriation bill therefor usually receiving action by Congress earlier than the sundry civil or miscellaneous act. The objections to limiting to a fiscal year the funds for works of the character of a general topographical survey, incomplete until the proposed area is covered, are so patent that doubtless Congress would prefer to make an indefinite or permanent appropriation of the amount necessary to complete the work, from estimates carefully made, the department being authorized to allot the amount required to carry on the operations for a year in accordance with projects submitted in detail. I shall have the honor to again revert to this subject, should I be called upon to make further estimates for the work now under my charge.

ESTIMATE.

For continuing the geographical survey of the territory of the United States west of the 100th meridian, the supply branches of the War Department aiding as heretofore, being for field and office work, and for the preparation, engraving, photolithographing, and printing of the maps authorized for the entire area on such scales as are required for geographical and geological representations, and of the charts, plates, cuts, photographic and other illustrations for reports; and for the pay of the necessary number of assistants and scientists, in addition to such number of the Corps of Engineers and other officers and enlisted men of the Army as may be available, hereby authorized to be detailed; for temporary office-room in the field of survey and the purchase at nominal rates of sites for connecting-stations, for the fiscal year ending June 30, 1880, to be immediately available	$120,000
As follows:	
For expenses of parties in the field, including pay of assistants and employés	47,500
For office expenses, including pay of assistants	9,500
For transportation, including purchase of animals	9,000
For material for outfits	7,500
For subsistence of the expeditionary parties	5,500
For forage, winter herding, fuel, storage, erection of temporary shelters, &c.	7,500
For purchase of instruments	6,000
For repair of instruments	1,000
For temporary office-room at points remote from Washington, D. C.	1,250
For the erection of observatories, connecting-stations, and monuments at astronomical and geodetic stations	4,250
For purchase of sites for connecting-stations	1,000
For engraving and printing maps, charts, plates, cuts, photographic and other illustrations for reports	9,000
For contingencies (field and office)	4,500
Total	120,000

FINANCIAL STATEMENT.

Amount expended from appropriation for the fiscal year ending June 30, 1878	$49,589 67
Amount remaining unexpended July 1, 1878, from appropriation for continuing the geographical survey of the territory of the United States west of the 100th meridian for fiscal year ending June 30, 1879	50,000 00

Respectfully submitted.

GEO. M. WHEELER,
First Lieutenant, Corps of Engineers, U. S. Army, in charge.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. Army.

APPENDIX A.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT ERIC BERGLAND, CORPS OF ENGINEERS, ON THE OPERATIONS OF PARTY NO. 1, COLORADO SECTION, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., April 20, 1878.

SIR: I have the honor to submit the following report of the operations of party No. 1, Colorado section, during the field season of 1877:

The party, organized at Fort Lyon, Colo,. in May, consisted of the following persons: Lieut. Eric Bergland, Corps of Engineers, in charge, executive officer and field astronomer; Louis Nell, chief topographer; E. T. Gunter, assistant topographer; William C. Niblack, meteorological recorder; J. M. Harris, odometer recorder; three packers, one teamster, and one cook.

The special area assigned to the party for this season was that included within atlas-sheet 61 A, besides the occupation of certain points in atlas-sheets 62 B, 69 B, 61 D, and 61 C, in order to complete the data for the publication of these atlas-sheets.

The party moved from Fort Lyon up the Arkansas River to South Pueblo, thence, via the Hardscrabble Cañon, to Rosita, where several points were occupied as triangulation stations, an azimuth line established for the benefit of mining engineers, and the mines and reduction-works visited.

From Rosita the party moved to Fort Garland, via the Sangre de Cristo Pass, reaching that place June 11. At the request of the commanding officer, a sun-dial was erected there, and after obtaining additional supplies the journey was continued along the Trinchera to its mouth, across the Rio Grande by ferry near the mouth of the Trinchera, thence to the headwaters of the Alamosa, La Gata, and Piedra Pintada Creeks, in order to complete the data for the drainage of this section. At Del Norte the Rio Grande was gauged on the 22d of June.

The river was then near its highest stage, and the result of the measurement gives nearly the maximum volume. Owing to the high stage of the river, the water was not confined to a single channel, a considerable portion flowing through a branch to the north of the main stream. The measurements were made a short distance above the Loma bridge, the velocity being determined by means of surface floats. The following results were obtained:

Main stream.

Width, 182 feet.
Maximum depth, 7 feet.
Area of section, 692 square feet.
Mean velocity, 5.229 feet per second.
Volume, 3,618.468 cubic feet per second.

North branch.

Width, 94 feet.
Maximum depth, 3.125 feet.
Area of section, 196.5 square feet.
Mean velocity, 5.43 feet per second.
Volume, 1,067 cubic feet per second.

Hence the total volume of the Rio Grande River at this point, when nearly at its highest stage, is 4,685.5 cubic feet per second. The water at this time carried a great deal of sediment, but no alkaline taste was perceptible.

From Del Norte we followed the road up the river via Wagon Wheel Gap to Antelope Springs, at which point we branched off to the right and followed the Lake City road over the Continental Divide to Lake City, which place was reached on the 1st of July.

Mr. Nell with a side party attempted to go from Lake City to Ouray via Hensen Creek and the trail over the range, but found the snow near the summit too soft and deep to make the passage, and was forced to return and follow the wagon-road.

The Los Pinos Indian Agency was reached on the 14th of July, after a delay of a week near Barnum P. O., at the junction of the Saguache and Uncompahgre roads, from which point a number of topographical stations were occupied to obtain the drainage and topography of the country to the east, as far as the old Los Pinos Agency.

From the new agency the party moved westwardly to the San Miguel River, returning by way of the Dallas Fork and Ouray. At this latter place a side party was detached to occupy Uncompaghre Peak as a triangulation station. This was successfully accomplished July 31. The main camp was established at the agency, while the surrounding country was explored and mapped. During this time a series of observations were taken to ascertain the amount of evaporation, and hourly readings of the barometer for ten days were taken to obtain data for the horary correction.

Ouray was found to be an enterprising town of about 500 inhabitants, singularly moral and quiet for a mining town of that size. It is picturesquely situated within a natural amphitheater, at the junction of Cañon Creek with the Uncompahgre River. Numerous hot springs in and near the town afford excellent facilities for bathing. But little work was being done in the mines, as works for the profitable reduction of the ores had not been erected. A good toll-road connects the town with Uncompahgre Park, and another toll-road was under way from the town to the summit to connect with the Hensen Creek road to Lake City. This, when finished, will shorten the distance to the latter place by seventy miles, and will permit the transportation of the rich ores from the summit for reduction when works for that purpose shall have been established at Ouray. Potatoes and other vegetables are grown in abundance below the town on the bottom-lands of the Uncompahgre, and the park and foot-hills adjoining afford good grazing for horses and cattle. At the agency irrigation has been tried to a limited extent, but thus far with indifferent success. The fall of the river and the supply of water are favorable for irrigation, but the soil near the agency, which contains a large percentage of clay, dries quickly when the water is turned off, and the surface is converted into a dry, hard crust. In the vicinity of the Indian chief Ouray's house, seven miles below the agency, the soil is more favorable for vegetation, and cereals are grown without irrigation.

The bottom lands along the river are very productive, and large crops of potatoes, melons, beets, radishes, and corn were raised last summer near the agency.

During the summer the toll-road from the Lake Fork of the Gunnison to the Uncompahgre Valley was completed. This is an excellent road, with moderate grades throughout, having bridges over all the larger streams, and assures easy and quick transportation from Saguache to the Uncompahgre Valley, when the road is not obstructed by snow.

From the agency the party moved northwardly to the Gunnison River, which then became the base of our operations. The country north of the river was thoroughly explored to the northern limit of our area and westwardly to the western line of the atlas sheet, as well as south of the river to the southern line. All streams of any importance were meandered and measured with the odometer when possible, otherwise by time meander. Topographical stations were made on all peaks which gave a commanding view of the country, and the topography and drainage of the whole area were carefully determined. Triangulation stations were made on the principal peaks to connect with the system of triangles to the east and south.

The town of Gunnison, the county seat of the county of that name, was reached October 2. This town consists of a few houses scattered over the valley at the junction of the Gunnison and Tumichi Rivers. The altitude of the valley at this point is about 7,480 feet, and has a width varying from two to six miles. All of this area east of the Indian reservation line is taken up by settlers, whose principal pursuit is hay and stock raising. The hay-crop is abundant, and finds a ready sale at Lake City, distant some 56 miles. Although the altitude is not too great for their cultivation, vegetables are often killed by early frost, so that no dependence can be placed on any crop except hay. Last fall the frost killed all vegetables so thoroughly that not a potato was grown in the valley in this vicinity.

Mining is carried on to a limited extent on the southern slope of the Elk Mountains; but as no reduction-works have been built in the valley, only ore of the richest quality can be profitably transported to Lake City for reduction. Gulch-mining in California

Gulch is still prosecuted during the summer season. Coal in great quantities and of excellent quality is found on the southern slope of the Elk Mountains. A considerable quantity has been taken from the mines at Carbon Mountain, near Ohio Creek, for use at Lake City. The vein at this locality is about 6 feet thick and nearly horizontal.

Gunnison River and its tributaries are well stocked with speckled trout. Near the mouth of the Uncompahgre River a number of so-called Colorado salmon were caught. These seemed to belong to the same species which I had previously found in the Colorado River between Stone's Ferry and Fort Yuma. The foot-hills and mountains on both sides of the Gunnison abound with bear, deer, mountain sheep, elk, and smaller game.

On November 5 the Gunnison River was gauged about two miles above the mouth of the Tumichi and below the mouth of Ohio Creek. The results obtained were as follows:

Width, 75 feet.
Maximum depth, 3.4 feet.
Area of section, 154.17 square feet.
Mean velocity, 1.57 feet per second.
Volume, 242 cubic feet per second.

The Tumichi was gauged on the same day, some two miles above its mouth, giving the following results:

Width, 64 feet.
Maximum depth, 1.8 feet.
Area of section, 50 square feet.
Mean velocity, 2.63 feet per second.
Volume, 131.57 cubic feet per second.

Consequently the volume of the Gunnison below the mouth of the Tumichi was approximately 373.5 cubic feet per second.

During the spring while the snow on the mountains is melting the volume of both streams greatly exceeds that given above; and at extreme high-water it becomes dangerous to ford the Gunnison River.

Cold weather and snow came early in the fall and interrupted and delayed our work greatly. From the 4th of October snow fell nearly every day for three weeks, during which period the higher peaks were almost constantly enveloped in clouds, making it impossible to continue our triangulation work. Finally, on the 2d of November, by taking advantage of a couple of days of clear weather, West Elk Peak was occupied, after a long and wearisome march through fallen timber and deep snow. This completed our topographical work within atlas sheet 61 A, and the march to the eastward was begun. The route selected was up the Tumichi Creek to its head, crossing the Continental Divide at Marshall Pass. The lowest temperature, 10°.5 below zero, was experienced at our camp near the forks of the Tumichi during the night of November 8. From camp near the summit of Marshall Pass the ascent of Hunt's Peak was made in order to connect it with our system of triangles. Thence the journey was continued down Puncho Creek, over the Puncho Pass to Saguache, and from this place, via the Star Ranch and the San Luis Lakes, to Fort Garland, which place was reached on the 17th day of November. Here the party was disbanded and the property stored with the post quartermaster.

The field season was a remarkably successful one. The area assigned was thoroughly explored and full data obtained of its topography and economic features. Neither men nor animals were disabled during the season; the expense of feeding the latter was inconsiderable, as grass was abundant throughout nearly the whole area traversed. During the field season 7 main triangulation-stations were occupied; 103 scondary triangulation-stations, 1,502 meander-stations, 172 cistern-barometer stations, and 1,075 aneroid-barometer stations were occupied. The variation of the needle was determined at 136 different points; 1,367 miles of route were meandered, besides 1,277 miles traveled and not meandered. The highest altitude noted was 14,408 feet.

The following table gives the result of the observations made to determine the amount of evaporation at Los Pinos Agency. The tin pan containing the water was placed on the sun-dial post, about three feet above the ground, and was not covered or shaded; consequently the amount shown must somewhat exceed the rate of evaporation from the surface of the ground. In the "remarks" the amount of clouds is given in numbers from 0 to 10, inclusive, the former indicating a clear sky and the latter the whole visible sky overcast with clouds. The figures which follow "wind" indicate its estimated velocity in miles per hour.

Observations to determine the amount of evaporation at Los Pinos Agency, 1877.

Date.	Hour.	Water in pan.		Evaporation since previous observation.	Thermometer in shade.		Remarks.
		Depth in inches.	Temperature.		Dry.	Wet.	
Aug. 9	10. 00 a. m.	2. 729	59. 0	....	77. 0	54. 5	Water in tin pan placed on sun-dial post, in sun.
	4. 45 p. m.	2. 312	77. 0	. 417	89. 0	55. 2	Clouds 5. Wind 8.
10	9. 00 a. m.	2. 000	72. 0	. 312	78. 0	58. 2	Clouds 7. Wind 2.
	10. 00 a. m.	1. 948	80. 5	. 052	77. 0	60. 0	Clouds 8. Wind 2.
	11. 00 a. m.	1. 760	76. 0	....	81. 0	59. 0	New filling. Clouds 9. Wind 2.
	5. 30 p. m.	1. 510	70. 0	. 250	82. 0	60. 0	Clouds 10. Wind 2.
11	9. 30 a. m.	1. 323	73. 0	. 187	74. 0	58. 0	Partly cloudy during night, cloudy morning. Wind 2.
	2. 00 p. m.	1. 223	72. 0	. 100	82. 0	59. 8	Clear. Wind 2.
	6. 30 p. m.	1. 115	65. 5	. 108	78. 0	59. 0	Cloudy. Wind 2.
12	9. 00 a. m.	. 968	67. 0	. 147	71. 5	58. 5	Cloudy. Wind 1.
	11. 00 a. m.	. 937	90. 0	. 031	77. 0	60. 0	Partly cloudy. Wind 0.
	11. 00 a. m.	2. 349	72. 5	....	77. 0	60. 0	Partly cloudy. New filling.
	6. 00 p. m.	2. 114	65. 5	. 235	75. 0	58. 0	Clouds 8. Wind 12. Sprinkling.
13	9. 00 a. m.	1. 906	79. 0	. 208	71. 5	58. 5	Clouds 0. Wind 12.
	11. 00 a. m.	1. 843	90. 0	. 063	78. 0	57. 0	Clouds 0. Wind 12.
	11. 00 a. m.	2. 444	81. 0	....	79. 0	58. 0	New filling.
	7. 00 p. m.	2. 093	62. 0	. 351	79. 5	63. 0	Clear. Wind 12.
14	9. 00 a. m.	1. 827	77. 5	. 166	76. 5	59. 0	Partly cloudy. Wind 8.
	11. 00 a. m.	1. 750	84. 5	. 077	80. 5	58. 5	Partly cloudy. Wind 4.
15	11. 00 a. m.	1. 463	78. 0	. 287	75. 5	59. 0	Showers during afternoon of 14th. Pan not covered.
	11. 00 a. m.	2. 479	60. 0	....	75. 5	59. 0	New filling. Clear. No wind.
16	11. 00 a. m.	1. 943	86. 0	. 536	77. 5	56. 0	Clouds 4. Wind 2.
	6. 00 p. m.	1. 583	64. 0	. 360	76. 0	55. 0	Clouds 10. Wind 3.
17	11. 00 a. m.	1. 318	78. 0	. 265	76. 0	58. 0	Clouds 6. Wind 2.
	7. 35 p. m.	1. 026	59. 0	. 292	72. 0	58. 0	Clouds 5. Wind 0.
	7. 35 p. m.	2. 354	65. 0	....	72. 0	58. 0	Clouds 5. Wind 0. New filling.
18	7. 35 a. m.	2. 219	57. 0	. 135	64. 5	57. 0	Clouds 10. Wind 0.
	6. 30 p. m.	2. 385	58. 0	....	63. 0	58. 0	Clouds 9. Wind 0. Rain during day, pan uncovered.
19	9. 00 a. m.	2. 447	71. 0	....	65. 0	59. 0	Clouds 3. Wind 0. Rain during night, pan uncovered.
	6. 00 p. m.	2. 172	68. 0	. 275	71. 5	58. 5	Clouds 4. Wind 0.
20	8. 00 a. m.	2. 094	63. 5	. 078	64. 0	55. 0	Clouds 0. Wind 0.
	6. 30 p. m.	1. 729	60. 0	. 365	69. 5	52. 5	Clouds 2. Wind 0.
21	8. 30 a. m.	1. 646	58. 0	. 083	62. 0	50. 0	Clouds 5. Wind 4. Windy during night.
	6. 30 p. m.	1. 208	58. 5	. 438	74. 0	51. 0	Clouds 1. Wind 0.
	6. 30 p. m.	1. 865	60. 5	....	74. 0	51. 0	Clouds 1. Wind 0. New filling.
22	8. 30 a. m.	1. 635	65. 0	. 230	68. 5	52. 0	Clouds 0. Wind 1. Windy during night.
	6. 30 p. m.	1. 214	61. 0	. 421	76. 0	51. 5	Clouds 0. Wind 0. Warm day.
23	8. 30 a. m.	. 943	69. 0	. 271	68. 0	52. 5	Clouds 0. Wind 10. Night clear, windy toward morning.
	8. 30 a. m.	2. 562	65. 0	....	68. 0	52. 5	Clouds 0. Wind 10. New filling.
24	8. 00 a. m.	1. 740	65. 0	. 822	75. 0	50. 0	Clouds 2. Wind 3. Windy night and morning.

By omitting the doubtful observations, or those during which showers occurred in the interval between observations, we obtain for the period in question a mean daily evaporation of 0.5537 inch. The table also shows that (approximately) 70 per cent. of this evaporation occurred during the day, or between sunrise and sunset, and 30 per cent. during the night, or between sunset and sunrise.

In conclusion, I take pleasure in acknowledging the faithful and valuable services of Mr. Louis Nell, the chief topographer, and Mr. Wm. C. Niblack, the meteorological recorder, as well as those of the other members of the party, and would express my thanks to the Indian agent at Los Pinos Agency and the officers at Fort Garland for their courtesies and assistance.

Very respectfully, your obedient servant,

ERIC BERGLAND,
First Lieutenant of Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX B.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT SAMUEL E. TILLMAN, CORPS OF ENGINEERS, ON THE OPERATIONS OF PARTY NO 1, UTAH SECTION, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., May 21, 1878.

SIR: I have the honor to submit the following report upon my labors and the operations of the party under my charge during the field season of 1877, with a summary of office work since return from field.

I left Washington, May 16; stopped one day in Omaha on public business; reached Cheyenne, May 19, where I was detained several days in conjunction with Capt. Gillis, A. Q. M., purchasing mules for the use of the expedition. I arrived at Ogden, Utah, May 23, and was placed in charge of the Utah section of the survey. The two parties of this section were organized at Ogden and took the field June 5. In the field operations I directed the movements of Party I, and Lieut. Rogers Birnie, Thirteenth Infantry, had charge of Party II. The area for work was divided and assigned by yourself and I exercised no authority, after leaving Ogden, except in my own party. Lieutenant Birnie planned and executed his own work.

Party I, after organization, consisted of myself, in charge, Mr. Gilbert Thompson, principal assistant and topographer, Mr. John A. Hasson, meteorologist, Mr. William Looram, odometer recorder, two packers, a man-of-all-work, and a cook. The party had the usual allowance of instruments, viz, one triangulation instrument, to topographer's transits, two cistern barometers, two aneroids, two psychrometers, two odometers, one maximum, one minimum thermometer, two pocket-thermometers.

The country given my party to map is situated between the meridians of 111° and 112° 20′ west from Greenwich and the parallels of 41° 45′ and 43° 10′, and is partly in Utah and partly in Idaho, contiguous on the east to the Territory of Wyomong.

After leaving Ogden, Party I moved to the northward through North Ogden Cañon. On the 2d day out, the ascent of North Ogden or Willard's Peak was made in connection with Lieutenant Birnie and the topographers of the two parties for triangulation purposes. The pack-mule bearing the instrument on this trip was lost. Though lightly loaded he fell and rolled about 500 feet, being completely disabled. My march was continued along the road into the south end of Cache Valley, such points being occupied as were necessary to extend our triangles from the measured base at Ogden. Arrived at Logan the regular topographical work was begun. The movements of the party carried it along the western base of the Bear River Mountains, the range being ascended when necessary for triangulating or topographical purposes. At Franklin I loaded the mules with the month's rations forwarded to that point and continued to the northward, crossing the Bear Mountains by the Liberty road into Bear Lake Valley. The party then moved slowly to the south along the eastern base of the Bear Mountains, made a complete circuit of Bear Lake and returned to the western side of it. As the two lines of travel along the eastern and western base of the range were not deemed sufficient to give the topography accurately, the party then crossed into Logan Cañon and descended it to its mouth at Logan City, in Cache Valley. This cañon, for the greater portion of its length, runs nearly north and south, being formed by a fault in the limestone strata of this range, and enabled us to complete the topography of these mountains up to the road by which we had crossed them from Cache Valley.

After several days' work in this cañon, the party left it at a point about twenty miles from Logan City, and moved nearly directly east to the south end of Bear Lake, thence across the low range of hills between the lake and Bear River on the east. We struck Bear River near the Wyoming line, about the parallel of 41° 47′. Mr. C. J. Kintner joined the party shortly after it had crossed the Bear River Range, and acted as assistant topographer or meteorologist as occasion demanded. The movement from Logan Cañon to Bear River, on the east, was nearly along the southern limit of my work. The party now moved northward along the eastern base of the range of hills which had been skirted on the west in the circuit around Bear Lake. These hills were ascended frequently for topographical purposes. The general course of the river was followed until we arrived at Montpelier, which lies directly across Bear River from Liberty, the point it will be remembered at which we descended from the Bear Mountains in crossing from Franklin. A glance at the map in connection with the above description will show that, between the western base of the Bear River Mountains and the Wyoming boundary, five lines of survey were run extending from the parallel of Logan to the parallel of Montpelier or Liberty. These lines were about 8 miles apart. From Montpelier the party continued along Bear River to Soda Springs, which is situated at the most northern bend of the river. Soda Springs was reached July 19. Two months' rations had been forwarded to this point. Resupplying the party, Bear River was crossed at its most northern bend and the topography of the Bear Mountains obtained down to Liberty—this connected with the work already done on the western side of the range. Bear River was again crossed at Montpelier, and after passing to the eastward over the divide which separates the waters of Snake and Bear Rivers, a general northern line was followed, nearly coinciding with the eastern boundary of the work. After passing the divide between Bear and Snake Rivers, by the road up Montpelier Creek, the first water reached is a tributary of Salt River called Crow Creek. The line just mentioned lay along this creek until it joined Salt River, then along Salt River until it is joined by Salt Creek flowing from the west. Salt Creek was then taken as the course of march, leading us nearly west. After crossing a mountain ridge which separates the waters of Salt and Blackfoot Rivers, a parallel line to the south was taken up. This direction was continued until reaching the parallel of Soda Springs, when it was changed to the westward, and brought us back to the springs a second time, August 3. Procuring a new supply of rations, the march was resumed in a line nearly due north until reaching the south end of Day's Lake, then eastward to the Wyoming line, then northward to Snake River.

In crossing from the basin of Day's Lake the route lay along Tin Cup Run to its junction with Salt River; then along Salt River to Snake or Mad River, as it was called by Mr. Astor's party in 1811. This being the northern limit of the work, movement was made to the east, then south again to Day's Lake. Having connected with the outward line from Soda Springs, the party moved a few miles to the west and turned again to the north until reaching the limit in this direction, the parallel of 43° 10′. Passing to the west until the Blackfoot was reached the party turned again to the south, following up this stream to the point at which we had crossed it in the outward trip from Soda Springs. Soda Springs was again visited August 20, and the remaining rations procured. As all the topography to the east and north of Soda was now obtained, a movement was made down Bear River. The work on this trip being connected with that done before the first passage of the Bear Mountains was made, the party moved farther to the west and turned again northward. This line took the party across the basaltic flat, which separates Bear and Port Neuf Rivers. The Port Neuf was examined as far down as the mouth of the Upper Cañon. The march was then continued up this stream to its head. The party then passed to the westward to Fort Hall, which point was reached on September 10.

I have above attempted to give only a very general description of the movements of the main party. These movements were directed so as to give the topographers opportunity to see all the country mapped. No mention is above made of the numerous trips, on foot and horseback, of the members of the party in procuring the greater part of the data for the projection of the map.

It will be observed that numerous parallel lines of travel were run across the area in a nearly north and south direction. The proximity of these lines will be seen by observing a map in connection with what has been said. When it is remembered that frequent transverse lines were run and numerous points occupied, from which complete sketches were made and full angles taken, an idea of the accuracy of the work can be obtained.

A storm set in immediately after the arrival at Hall, and nothing was accomplished until the 16th of September, when the party again set out. I was ordered to leave my party here in charge of Lieutenant Young, Corps of Engineers, and proceed to Fort Ellis, Montana, for objects hereinafter to be named. Lieutenant Young reported to me September 15, and took charge of the party on the 16th.

As I directed no further the movements of the party, I will here summarize what had been done, and add a few descriptive remarks of the region thus far visited.

Eight triangulation stations had been occupied; 86 three-point topographical stations from which complete sketches were made; 1,546 miles traveled, of which 1,046 were meandered; 1,674 meander stations occupied, of which 1,468 were also barometic stations.

In this connection I cannot speak too highly of my principal assistant, Mr. Gilbert Thompson. His appreciation of topographical details is quite remarkable. His zeal and energy are equally commendable. He and I ascended the triangulation points together. He usually made sketches while I measured angles. The same method was followed with many of the topographical stations. This was the usual arrangement because of Mr. Thompson's superior facility in sketching, and not because he was less expert than myself in measuring angles. In the collection of the indispensable material for a map, I consider that Mr. Thompson cannot be surpassed.

Of the country above located it may be said that it is traversed by distinctly marked, though not continuous, mountain ranges, whose axes are nearly north and south. The eastern spur of the Northern Wasatch may be considered as extending from North Ogden Peak to Mount Putnam near Fort Hall. Farther to the east is the parallel range of the Bear River Mountains, growing less imposing to the northward, and terminating in what is locally known as the Blackfoot Range. Still farther to the east is found a low range of hills increasing in importance to the northward and culminating in Mount Pisgah or Cariboo Mountain, just south of Snake River. Between these spurs or ranges exist valleys of greater or less extent. Bear River flows nearly due north along the western boundary of Wyoming, crosses the low range of hills just mentioned at about 42° 10′; continues then north to 42° 39′; cuts through the Bear River Mountains, and turns abruptly to the south. It then flows for sixty miles between the two ranges first mentioned, and finally cuts through the western one and continues on to Great Salt Lake. The Blackfoot River rises in the hills near and to the south of Mount Pisgah, flows to the south for fifteen miles, makes a great bend to the north, passes the Blackfoot range of hills, and enters Snake River Desert. The southern bend of the Blackfoot is only about twelve miles from the northern bend of Bear River at nearest points. The rim which separates the two rivers is very low. The highest point of the divide is but 87 feet above the Blackfoot at the bend. This point is in horizontal distance four miles from the bend in the Blackfoot.

After passing the divide it is three miles until we again reach the level of the Blackfoot. Such a gentle rise leads the unaided eye to suppose that the Blackfoot might almost cross to Bear River in time of floods. By artificial means it could easily be made to empty into Bear River. The Port Neuf River rises in the hills between Mount Putnam and the Blackfoot Range, flows first to the south, crosses the western spur of the Northern Wasatch, and turns north to Snake River. The South Fork of Snake River enters the northeast corner of my area just after emerging from Snake River Mountains, but soon leaves it in making its course northward.

Salt River and Gray's River enter the Snake from the south only about three miles apart. The 111th meridian crosses the Snake between the mouths of these two rivers at the parallel of 43° 10′. This includes the principal water-courses in my section. Between the mountain ranges and along the streams there are necessarily valleys or flats of greater or less extent. The largest of these is just west of the Bear Range of mountains. It may be said to extend all along Bear River to its northern bend, then over a lava flat to the head of the Port Neuf. This valley is well cultivated and contains numerous settlements. Bear Lake Valley also contains several little villages, and along the eastern base of the mountains affords arable land. Although there is good grazing and occasional level areas are found all along the rivers mentioned, there are only a few ranches outside Cache and Bear Lake Valleys. The altitude is too great. There is timber in the mountains, pines and firs. It is rather difficult to obtain, but is sufficient for the requirements of the population.

The valleys nearly all give evidence of having once been the basins of lakes, and the lake and river terraces attract the attention on all sides. When Lake Bonneville existed Cache and Gentile (north end of Cache) Valleys were bays, connected by a strip of water along the course of Bear River.

I took particular care to make examination for any possible outlet to this ancient lake. There is certainly none to the north and east of Red Rock. My attention had already been called to this point by Mr. G. K. Gilbert. I had left the party before they reached Red Rock, but informed them of Mr. Gilbert's discovery. The profile run through the pass, in connection with observations at beach-marks, leaves no doubt that Mr. Gilbert is right. That bodies of water have existed in many of the present valleys is clearly shown. That the valleys have resulted from faults can hardly be doubted when the features of the country are considered. The former extensive channels of the rivers show that they have been growing more narrow. Where Snake River leaves the upper cañon its ancient beds are beautifully shown. The present is its third distinctly marked channel. Bear Lake is situated at an altitude of 5,955 feet above the sea-level, is about 20 miles long and 6 to 8 wide. I was informed that a line of soundings had been run across it along the boundary-line between Utah and Idaho, and that it nowhere exceeded 175 feet in depth. This lake, according to the neighboring inhabitants, has its monster. That the statements made to me in regard to the monster were in good faith I have no doubt, and the fact that these people have been deceived into their present belief is quite as remarkable as would be the discovery of a large and unusual animal. There are several marshes or sloughs in the lava flat north of Soda Springs, the most extensive being what is called Day's Lake.

The mountain masses are composed of alternate strata of quartzite and limestone, entirely similar to that described by King in the Northern Wasatch. Tilting and displacement have often changed the original order, sometimes placing one formation at the summit, then another. In the Bear River Mountains the thickness of the limestone strata probably exceeds 1,200 feet. The granite core of the mountain is evidenced by exposure in Upper Logan Cañon. As we should naturally expect, when continuous limestone strata have been thus confused, numerous caves, subterranean channels, and crevices were found. Streams of great volume were frequently seen gushing boldly from the mountain sides. One of these springs, about twenty miles above the mouth of Logan Cañon, is worthy of mention. It boils up at the back of a cavern in the rock, and the water fills a basin about five feet deep and twelve feet radius until it overflows. The cavern is roofed by a natural arch in the solid limestone. About 75 cubic feet of water per second were discharged from this spring at the time of my visit. A cave of considerable extent but no great interest was visited at a point about 15 miles above the mouth of the cañon. Mr. Thompson also discovered a funnel-shaped hole, into which a falling stone descended for five seconds before striking. It was then heard to rebound for five more. This opening was situated nearly east of the little Mormon settlement of Hyde Park, and east of the summit line of the mountains. The limestone or quartzite or both were displayed in all the hills and mountains. In the valleys south of Bear River no lava was seen, but to the north it may be said to floor all the lower areas. The lava is found along the western base of the Northern Bear Range and south of the river. It extends here to Mink Creek. It was seen south of Bear River in only one other place, and that was in the low hills between Bear Lake and the Wyoming boundary. It comes to the surface at the highest point of these hills and is evidently not an overflow from elsewhere. I was not, personally, on this point, but derived my information as to the lava from Mr. Thompson. All along the courses of the Blackfoot and Port Neuf Rivers the lava, a black basalt, protrudes. Several of the ancient outlets were visited in the vicinity of Soda Springs. From the northern bend of Bear River the lava can be traced in an almost unbroken layer to the Great Snake River Desert. Standing on the hills east of Fort Hall the most desolate view imaginable is open to the observer. I can conceive of no more dreary prospect than that desert affords, stretching far to the westward until its monotonous blackness mingles with the purplish hue of the horizon. It was in this region that the trading company of Mr. Astor met with such suffering in 1811, and Bonneville much later.

On the tributaries of Salt River (Salt and Crow Creeks) are situated two establishments for manufacturing salt. The one on Crow Creek is in latitude 42° 27′, and about four miles west of the 111th meridian. It is a small affair, and is operated by Mormons living in Montpelier. The salt is obtained by evaporation from spring-water. The water appears to be saturated, and the salt is said to be very pure. The evaporation is conducted in large pans, the fuel for heating coming from the mountains. The Oneida salt-works are much more extensive, and are owned by parties in Malade. The process of obtaining salt is the same as already given. These works are on Salt Creek, a few miles above its junction with Salt River, about 25 miles north of the works on Crow Creek. Salt was seen as an efflorescence on several of the flats between these works, and could undoubtedly be obtained in large quantities in this vicinity. The Oneida works are operated annually between the 1st of April and 1st of October. The salt is transported by freight to Idaho and Montana. Four hundred and fifty tons were shipped during 1876. Snow prevents freighting except between dates specified.

During the season numerous thermal and mineral springs were seen. These springs, as a rule, are located along the southern edge of the lava flow. We discovered none at any great distance from the lava. Such springs were found along the course of Bear River, from Mink Creek to Soda Springs, on the head of the Blackfoot, on Salt Creek, and along the Port Neuf River. Several of these springs are situated near the junction of Salt River and the creek of the same name. These springs have been once much more extensive. The warmest of them reached 145°, the highest temperature our thermometers would record. $S\ S\ H_2$ and $C\ O_2$ were evidently present in the water. From the deposition of the mineral held in solution the springs have formed little cones, looking at a distance like Indian wigwams.

The other and most remarkable springs are the Soda Springs. I shall only refer to one fact, which I have not seen mentioned. Around several of the springs, when the air is still, the carbonic-acid gas accumulates in such quantities that birds alighting near them are poisoned. It was found that less than two minutes were required to render grasshoppers unable to escape from the poisonous depressions. Birds were also experimented upon, but they were released too soon and escaped entirely. The waters are pungent and pleasant to the taste, and were there sufficient accommodations at the place it could be recommended and might become a summer resort. There is good fishing and hunting also within a day's ride. The springs are 60 miles from the terminus of the Utah Northern Railroad, by a good road. In the cañon of the Port Neuf River the works of extinct mineral springs are very extensive. The river is now cutting through the rocky chambers of these dead springs. The large, circular, and shell-like formations give rise to numerous basins of deep, clear water, in which fish delight to sport.

To give a general idea of the climate of this section during the months of June, July, and August, I append the following table:

Month.	Mean of daily maximum temperatures.	Mean nightly minimum.	Highest day temperature.	Lowest day temperature.	Lowest night temperature.	Mean daily range.	Highest nightly minimum.
	°	°	°	°	°	°	°
June	73	36	89	54	30	37	42
July	74	30	90	57	8	44	48
August	80	31	90	75	12	49	48

Continuous readings for temperature were not generally taken throughout the entire day. As a rule, the temperatures were recorded at 7 and 10 a. m., 12 m., 2 and 4 p. m. The day temperatures here given were not taken outside these hours. The camps were continually changed, and of course the conditions varied with the altitude and location of places of observations. The table, however, shows the immense daily range of temperature. The nights in June were less cold than in either July or August, probably because of more moisture in the air. The lowest temperatures given are exceptional cases, arising from altitude or passing storm.

Indications of deer were seen in all the mountains, but the larger game, elk and deer, are nowhere abundant except in the northeast section, between Soda Springs and the upper cañon of the Snake River. A few antelopes were seen in the hills east of Bear Lake. Prairie chickens, timber grouse, and sage hens abound generally. In the upper waters of the Blackfoot salmon trout exist in great numbers and are taken with incredible ease. In the tributaries of Salt River they were also found in unusual numbers, but in no other of the streams. Fishing is carried on extensively in Bear Lake by the inhabitants around the southern border. The immense herds of buffalo which once ranged the Bear River Valley and that of the Port Neuf are now no more. The hunting grounds which so delighted Bonneville and his companions are marked only by the disappearing trail or an occasional skull bleaching in the sun.

In separating from the party at Fort Hall, I was directed to proceed to Fort Ellis, Mont., there to measure and develop a base-line, and, if possible, to carry a system of triangles south to connect with those carried northward from the Ogden base. I was accompanied by one enlisted man, a cook, and a packer. I left Fort Hall September 18 and arrived at Ellis September 28. The locality was found very unfavorable for the purpose intended. I remained in the vicinity of Ellis until October 27. During this period there were only eighteen days that could be employed in work. A base-line over 4½ miles long was measured. It was connected by triangles with the astronomical monument at Bozeman, and also with the post of Fort Ellis. The complete development of the base was not accomplished, owing to heavy fall of snow in the mountains. As it was perfectly evident that nothing more could be accomplished in the mountains, I started from Ellis, on my return, October 27, and reached Hall November 7. At this point I received orders to turn over my party to Lieutenant Birnie or Young and proceed to Washington. In compliance with this order, I left Ogden November 15 and reached Washington November 20.

Upon reaching the office I was directed to take charge of all the computation work, to have it conducted in the order best calculated to meet the requirements of the topographers. In the geodetic work, Dr. Kampf and Mr. Rock were my assistants and associates. These two gentlemen were already engaged in the reductions at the time of my arrival. Upon the return of Mr. Kintner from the field, he also became a valuable addition in this branch. During the two months that this gentleman was with me in the field, he displayed great energy and interest in the work, and was available as an assistant in either the astronomical, topographical, or meteorological branch.

The amount of work required in the reduction of such a mass of observations as is annually brought in from the field is enormous. When it is remembered that the country is unknown, that the mountain peaks are unnamed, that each party has, at the outset, to adopt a nomenclature of its own, and, finally, that the observations at first must be largely multiplied to avoid probable misconnection, a faint idea can be formed of the material to be sifted. Dr. Kampf's vast experience rendered him a most valuable assistant in this class of work. He displayed his usual interest and energy in the work up to the date of his final sickness. The necessities of the topographical work have kept the geodetic branch on a continual strain, and the earnest efforts of the gentlemen in this branch cannot be too highly commended.

The geographical positions of 219 points have been determined up to the time of writing, May 4.

In the meterological branch, Mr. Frank Lee and Mr. George Dunn have been the principal assistants. Mr. John Hasson and Mr. Jay Cooke have done some work in this department. Owing to the unusually large number of hypsometric observations of the past season and the limited force for reduction, I felt it necessary to introduce some abridgments in this work. Including the cistern and aneroid stations of the past season, there were over 10,000 points whose altitudes were to be determined.

In the cistern barometric reductions the following corrections were consolidated in tabular form; the ordinary formula, Plantamour's, being used:

The correction for difference of gravity in various latitudes.

The correction for decrease of gravity acting on density of mercury.

The correction for decrease of gravity acting on density of air.

It can be easily shown that a table embracing these corrections for each party can be so constructed that the maximum error which can ever occur will be utterly insignificant when compared with the labor now required to avoid it .Tables giving the correction for the humidity have also been constructed when the sum of the relative humidities does not exceed unity. These tables have been used, where the reference station is constant, for all except the most important points. Abridgments in the work of running the profiles have been introduced also. These profiles are run with a constant temperature, intended to be the mean temperature, or rather average temperature, of the day. The temperature correction has the same sign throughout each day. The correction for temperature is cumulative so long as the vertical direction of the profile is the same. When the average temperature is above 32°, these corrections increase the difference between stations; when below, the reverse. A little consideration will show that the maximum error, which would result from omitting the temperature corrections entirely, could never exceed the sum of the corrections which would accumulate while the vertical direction of the profile was the same. When the vertical direction of the profile changes, the errors in altitudes of stations would begin to decrease, and would be equal to the excess of the sum of corrections, while the profile had one vertical direction over the sum of the corrections in the opposite vertical direction. It then appears that where the ascents are about equal to the descents in a profile and the changes frequent, the temperature corrections may be omitted without sensible errors in such work. In order to introduce this abridgment, the profiles were carried to the first approximate difference of altitude, then each one separately examined, and the errors which might occur roughly estimated. This correction was omitted where the error would be inappreciable.

As the temperature corrections are obtained by multiplying the difference of altitude between stations by a constant factor, a table has been constructed from which the corrections are taken directly. This table gives the corrections for all stations whose difference of altitude does not exceed 300 feet, and for an average daily temperature falling between 50° and 90°.

At the present writing (May 4) the computations in this branch are drawing to a close. The altitudes have all yet to be transcribed. As common points are occupied in different seasons, it is a matter of continual vigilance to keep the records in order. From what was stated in regard to the data collected during the season of 1877, no remarks need be made as to the amount of work which Messrs. Lee and Dunn have accomplished. Besides the expertness of these gentlemen in the work of reduction, their familiarty with what has been done in the office has rendered their presence almost a necessity in this branch. Mr. Hasson has worked diligently while employed in this branch; as also has Mr. Cooke, when his health permitted.

In conclusion, I can assert that the progress in the work of reducing observations has been all that could be expected, the relations between all the members of the division entirely cordial and pleasant. The results of last season's work, of my own party, will soon appear upon Mr. Thompson's completed plots. He has already, in the most beautiful and accurate manner, delineated more than one-half the area visited. An inspection of these maps will render intelligible the party movements above described, and will of themselves give a correct impression of the physical features of the country.

I have the honor to be, very respectfully, your obedient servant,

S. E. Tillman,
First Lieutenant Corps Engineers.

Lieut. G. M. Wheeler,
Corps of Engineers, in charge.

APPENDIX C.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT THOMAS W. SYMONS, CORPS OF ENGINEERS, ON THE OPERATIONS OF PARTY NO. 1, CALIFORNIA SECTION, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., May 7, 1878.

SIR: I have the honor to submit the following executive and descriptive report of party No. 1, California section of the United States Geographical Surveys West of the 100th Meridian for the field season of 1877.

Under orders from these headquarters, I proceeded from Washington, D. C., to Carson City, Nev., at which place I arrived May 28, 1877, and took charge of the organization of the parties of the California section, which were to be as follows: Party No. 2, under Lieut. M. M. Macomb, Fourth United States Artillery, a regularly-organized topographical and geological party, to work to the south and west; a "Virginia special" party, under Mr. Anton Karl, to continue the detailed work about Virginia City and the country adjoining the Comstock; a party under Mr. J. E. Weyss, to finish the topographical work about Lake Tahoe, commenced last year by Lieutenant Macomb, and a regularly-organized triangulation and topographical party to be conducted by myself.

On May 31 Mr. Karl and his party, consisting of Louis Seckels, meteorologist and general topographical assistant, and John Rafferty, cook, were sent to American Flat, where they established a camp near a small station ranch, very centrally located for their work. They were furnished with three mules, and their transportation was afterward increased by an ambulance team and driver.

Transportation was provided for Mr. Weyss, who was not to start until some three weeks later. Three selected mules were left at Carson from the herd sent up from Camp Independence and four more were ordered from Ogden.

We were fortunate in securing the services of Messrs. B. P. French and Charles Howell, two old, experienced, and perfectly reliable packers and cargodores, who were immediately upon my arrival put to work, with the requisite assistance, repairing and stuffing the *aparejos* and making such new rigging as was required.

At the rendezvous camp at Treadway's ranch full sets of meteorological observations were taken from the time camp was formed until the parties left for the field. The assistants were given instructions about the care of their instruments and the methods of repairing and adjusting them when broken or damaged in service. All were practiced in reading the barometers and in setting the aneroids. The odometer vehicles were run several times over a measured distance and the proper values for the wheel-revolutions determined. I sent my commissary stores other than those to be carried with the party to four points in the territory which I was to occupy, namely: Susanville, Lassen County, and Eagleville, Alturas, and Camp Bidwell, Modoc County, California. On June 2 Mr. Spiller was sent to American Flat to assist Mr. Karl in locating some points for his work, and to give him such instructions as were necessary to carry on the work successfully afterward. He returned to the rendezvous camp on the 5th.

The country assigned to me was that embraced within the atlas sheets 38 B and 38 D, and the portion of the atlas sheet 47 B left unfinished the preceding year by Lieut. S. E. Tillman, consequently our topographical work did not commence until we reached the valley of Honey Lake. In order to carry on our triangulation in a satisfactory manner, it was necessary that Tutib and the northeast base mountains should be reoccupied and Tobakum and State Line Peaks occupied outside the area of our topographical work. To do this work, on June 7 Mr. Spiller with Mr. Dunn, meteorologist, Frank Collins, packer, and Patrick Brinley, cook, started for a trip to the east and north, with instructions to meet us after the work was finished at McFadden's Ranch, in Honey Lake Valley.

My party was provided with a new 10-second triangulation instrument, made by Fauth, of Washington, two 6-inch topographical transits, three cistern-barometers, three aneroid barometers, three psychrometers, one maximum and minimum thermometer, three odometers, and one odometer vehicle, pocket thermometers, small compasses, steel tapes, and other minor instruments. I was also provided with a sextant, artificial horizon, and the necessary books and tables to enable me to work up such observations for time and latitude as I might take in the field.

Arrangements were made by Lieutenant Macomb and myself to start on the 9th of June, on which day we both left the rendezvous camp. The usual scenes were witnessed with the wild, unruly mules when first saddled and loaded, and it was not until about twelve o'clock, after infinite trouble, that we filed out through the western gate of "Uncle Tread's" ranch and across the valley, and through the foot-hills of the Sierras took our northward way.

My party, taken altogether, at this time consisted of the following persons: Second Lieut. Thomas W. Symons, Corps of Engineers, executive officer and field astronomer; Mr. J. C. Spiller, topographer; Mr. H. W. Henshaw, naturalist; Mr. George M. Dunn, meteorologist; Mr. Jay Cooke, jr., assistant topographer; Mr. Theodore H. Simpson, odometer recorder; Benjamin P. French, chief packer; Frank Collins and Henry Sayre, assistant packers; Delancy Wilson, chief cook, and Patrick Brinley, assistant cook. We were provided with 12 riding mules, 13 pack mules, 2 extra mules and 1 bell mare, in all 27 animals; of the above, 4 men and 7 animals were away with Mr. Spiller, as before stated.

The first day we marched 13¼ miles and encamped at Winter's ranch, a short distance from the town of Ophir, in former times the seat of much wealth and industry, but now the picture of desolation and squalor. Our road skirted along the eastern slope of the Sierras, which have been almost stripped of timber to supply the voracious maw of the Comstock.

The 10th of June I sent the train on under charge of Mr. Henshaw, and went back myself by railroad to Virginia to occupy Mount Davidson and make some observations needed in our work. Returning that night by rail, I found the camp established at Seller's ranch within a mile of Reno. Steamboat Springs, on the line of the railroad, is rapidly becoming a fashionable place of resort; a fine hotel and extensive bath-houses have been erected, and many persons in ill health, especially those afflicted with rheumatism, retire here and find great relief by bathing in the heated waters. The steam rises from many places over the surface of the ground, and presents quite a wierd aspect. These springs may be regarded as a bud of promise for the future, for the action which is going on below the ground in the great fissures is probably the same as that which took place in the Comstock when its great masses of mineral wealth were deposited for our use. In the remote ages of the future, when the Comstock will have been exhausted and its existence perhaps forgotten, some hardy band of prospectors may find its double in the region below these springs. Then the Sierras will again be stripped of their forest covering and the busy scenes of to-day enacted over again in this desert land.

Moving northward from Reno, we reached, on the 15th, McFadden's ranch, where we were to await the coming of the side party then out. The road is very good and quite extensively traveled, passing through Long Valley and skirting Honey Lake, at some distance from it, however. Much fine farming land lies in the southern and western part of Honey Lake Valley. Cultivation is rendered practicable by the streams which flow down from the Sierras and furnish water for irrigation. Without irrigation nothing can be raised here, as the rains only come during the winter season. Honey Lake takes its name from the abundance of honey-dew which collects on the leaves and branches of certain plants in the adjacent country. Along the bank of the Susan River it is said to collect on a wide-leaved plant in great quantities, and hardens by evaporation until it resembles sugar. The Indians then gather the plants, and by shaking and thrashing loosen the sugar and collect it in blankets. They have been known to gather in this way hundreds of pounds of the sugar. Honey-dew from different leaves has a slightly different flavor, that from the balsam fir, on which I found it most abundant, having a nauseating taste, while that from the oak and plum has a pleasant, pungent flavor. In a great many cases it seemed to result from the puncture of insects of the genus *Aphis* in the leaves and delicate bark of the trees, while in others in which the honey abounded no such insects could be found. In the latter case it must exude itself from the pores of the plant without any aid from the insect world. This substance does not seem to be suitable for being converted into honey by the bee, for these busy insects were but rarely seen in the region where it abounded. We remained encamped at McFadden's for about one week awaiting the side party. This side party left Carson City June 7, and encamped at Sutro Springs in the Flowery Range of mountains. The next day two stations were occupied and camp was removed to Nelson tank, a well in the desert. The next camp was at Wadsworth, where permission was obtained from the railroad authorities for the use of water from the tank at Desert Station, which place was reached at night on the 9th. On a barren desert, without even sage-brush to enliven the prospect, they were compelled to make use of the telegraph-poles to fasten the mules, and the next morning three of the animals, one pack and two riding mules, were missing. Sending a packer back for them, Mr. Spiller and Mr. Dunn occupied Tutib Peak as a triangulation station.

The packer sent for the mules did not return until the following morning, having had to follow one to within a short distance of Carson, being constantly in the saddle for more than twenty-four hours, and having ridden the mules over one hundred and six miles. The party then moved down the Truckee to the Pyramid Lake Indian Agency, and then around the lake, and occupied Mount Tobakum.

Pyramid Lake, although it receives the fresh water of the Truckee River, the outlet of that gem of lakes, Tahoe, is very strongly alkaline, and the water is not good for human use, although it can be used for a short period without much inconvenience.

Moving around the north end of the lake the party took up its march to the west through Saint Emidio Cañon by Fish Springs and Fort Sage Cañon to State Line Peak, which was occupied on the 20th, and the main camp at McFadden's ranch reached on the 21st.

We left McFadden's on the 23d, and made our next camp on the Sierra Nevadas, on Thompson's Creek, under Mount Thompson, our next triangulation point, which was occupied on the 24th.

In its physical characteristics Honey Lake Valley is similar to the other valleys lying along the eastern slope of the Sierra Nevadas, being of alluvial and lacustrine formation and rendered fertile by the water which comes down from the mountains in many streams, and which, meandering through the valley, finds a resting place in the lake. This lake, one of the last resting places of the sea which once prevailed, has no outlet, and is very strongly alkaline, the water being entirely unfit for use. During some seasons of excessive drought, when there has been little rain and snow on the mountains, the lake, wasting away by evaporation, and receiving no relief, becomes gradually less and less until it resembles the mud flats of the Black Rock country. In 1863 it became entirely dry, according to the account of the inhabitants of the valley. At the present time it has an average depth of only about 18 inches. It was formerly a part of the great basin, being connected with the Black Rock deserts by the low country lying between Hot Springs and State Line Peaks.

This valley was settled by Peter Lassen and the people whom he induced to come into it, and many were the conflicts between the settlers and the Indians, who, however, never made any organized resistance. It was also at one period a refuge and stronghold for outlaws and desperadoes. Then, after the settlers were well established and their prosperity assured, came the Honey Lake war between the people of Plumas County, who claimed the valley for California and as part of their county, and the Honey Lakers, who claimed that it was outside the limits of California and not subject to jurisdiction therefrom.

Peter Lassen, who has given his name to Lassen County, Lassen Peak, Lassen Pass, &c., was a Danish sailor who obtained a Spanish land-grant of three square leagues near the mouth of Deer Creek. Being a man of no education and very little natural ability, he was soon swindled out of his property. He then moved to Indian Valley, and thence to the valley of Honey Lake, where he took up a fine ranch in a branch valley known as Elysian Valley. He first conducted emigrants over the Lassen Trail. Desiring to secure settlers for his grant and for the Sacramento Valley, he left his ranch and went across over to Humboldt, and met a party of emigrants and brought them around by the way of Surprise Valley, Goose Lake, and Pitt River, a very long journey and over a much worse road than he could have gone by the very direct way through Fredonyer's Pass, which is now the chiefly traveled emigrant-road north of the Donner Pass Trail. Lassen was killed in a battle with the Indians at Red Rock, and is buried on his old ranch in Elysian Valley under an enormous pine-tree fully 8 feet in diameter.

On June 25 we reached Susanville, the county seat of Lassen County, and the largest place in Northeastern California. It has a population of between 500 and 600, and is prettily situated where the Susan River breaks out from the mountains. The land-office of the northeastern district of California is located here, and it has telegraphic communication with the rest of the world. On our last day's march we passed the little villages of Janesville and Bunnelsburg, situated at the base of the Sierras where cool streams come down from the mountains.

Leaving Susanville we passed to the north and east of Honey Lake, and made camp in the Hot Spring Mountains. We had almost given up finding water, and were anticipating a dry camp, when, seeing some doves, we followed them and came to a little spring from which we obtained a sufficiency of water for our use. Between the mountains and the lake are some very hot springs, in which the water boils up between two and three feet above the level of the pool formed by its action. Testing the water we found it to be 210° Fahr. This, at an altitude of 4,000 feet, shows a much higher temperature than water boiling under ordinary circumstances, and indicates a confined and overheated state of the water below.

After the necessary work about the Hot Spring Mountains we moved across the northern valley and thence to Eagle Lake. This is of an entirely different character from Honey Lake, being of very clear good water and abounding with wild fowl and fish. It is situated at an altitude of about 5,130 feet above the level of the sea, and the country in the vicinity is very heavily timbered and abounds with game. It has no apparent outlet, but about a mile from the lake to the southeast large springs exist which continually cast forth great quantities of water, and which I think must be the water of the lake which thus finds an outlet beneath the surface of the ground. Without an outlet the water must become stagnant and bad, which it is very far from being. The springs above mentioned form the headwaters of Willow Creek, which flows in a southeasterly direction and sinks in Honey Lake. Its waters are largely used for irrigation purposes in the valley. A scheme was talked of while I was in the country for bringing the waters of Eagle Lake to the Honey Lake Valley to irrigate the portions of the valley not now reached by the existing streams.

A cut and tunnel were to be made through the rock separating the lake from the head of Willow Creek, and then using the channel-way of the creek for the water until a point was reached near the valley, where, in artificial channels, the water was to be deflected off to the high ground, which is not at present reached by it. By this means many hundred acres of very valuable land could be brought under cultivation. Leaving Eagle Lake the party moved down Willow Creek in a southerly direction, and then struck off across a great bend of the creek and made camp at the southern end of Pete's Valley, where the waters of this valley, when there are any, join those of Willow Creek. On this day's march, and on many others afterward, we underwent the experience of traveling over the great beds of loose lava-rocks which exist in this northern country. Loose light earth, filled and covered with rounded rocks of an average size of three to four inches in diameter, form a combination exceedingly unpleasant to travel over and very hard on the animals. This country was undoubtedly the scene of very energetic glacial action in the long ago. Evidences of it are very abundant and unmistakable.

Our next camp was at the north end of Horse Lake, a small reservoir-lake of strongly alkaline, undrinkable water, lying to the east of Eagle Lake. Here we remained two days working up the country in the vicinity.

Leaving our camp on Horse Lake we passed down by the east of the lake, and then going over to the east through Snow Storm Valley we encamped at the Secret Valley Springs. The hills are covered with grass, but there is no water. Thence we moved on down Secret Valley across Dry Valley to Mud Springs and made camp on Rush Creek. The country is a series of mesas, valleys, and ravines, born of the volcano and molded into shape by the action of water. Our poor mules found it very hard going. On the morning of the 18th of July we started for Shinn's ranch, distance about ten miles, but owing to misdirections and the difficulties of getting around we did not reach there until the evening of the 21st.

Leaving Shinn's ranch we started to cross the Madelaine Plains, intending to go to a little valley off to the north of the plains called Cold Spring Valley.

We remained encamped at Cold Spring for several days making side trips to Tuledad, Painter's Flat, and McDonald's Peak.

On the mountain peaks in this part of the country we noticed very curious mounds of rocks piled up by the hands of man. On a large rock there would be placed three to five and six rocks of a smaller size, forming a distinct pile. About the extreme summit of McDonald's Peak we found from one hundred to one hundred and fifty of these mounds. Who built them, and for what purpose, I was unable to determine.

Leaving Cold Spring we moved to the east to a place near Tuledad, where camp was made and the topographical work carried on. A party was sent to Eagleville to procure supplies, which reached us on the 31st of July. Leaving this camp we moved on over the mountains and struck one of the branches of the South Fork of the Pitt River, thence to the west and to the South Fork Peak, where an azimuth station was made. Here I recovered a mule, which had been stolen at Cold Spring, by sending some Pitt River Indians after it.

After occupying the South Fork Mountain as a triangulation station we moved over to the east and made camp on the western slope of the Sierras, or, rather, the spur called the Warner Range. Encamping in Jess's Valley, we remained several days endeavoring to make a satisfactory station on Eagle Peak, which was rendered almost impossible on account of the smoky condition of the atmosphere. We had a very pleasant camp on the banks of a pretty mountain stream alive with delicious mountain trout, on which we feasted. Thence moving north we made a camp on the head of Pine Creek, where we also were compelled to remain several days, owing to the very smoky condition of the atmosphere, caused by the extensive fires which were raging on a range of mountains to the west. We were in a very wild and unfrequented part of the country, covered with timber and brush and a goodly number of springs and mountain streams. Deer were abundant, and several were killed, and grizzly bears and bear-signs were seen.

Moving north we camped in Cedarville Pass, and thence went to Alturas, the county seat of Modoc County, situated on the north fork of the Pitt River. This is a place of about 100 to 150 inhabitants—whites, blacks, Chinamen, and Indians. The town is the center of trade for the Lower Goose Lake country and for the inhabitants of the country whose homes are on the streams which go to make up the Pitt River.

August 24 we left Alturas, and after making a detour to the east and occupying another peak of the Warner range as a triangulation station, we proceeded on our way around the west shore of Goose Lake. Numbers of very thrifty-looking ranches are clustered about the southern and southeastern borders of the lake. The lake now is merely a sink, as it has not run out by its old outlet, Pitt River, for many years. The water is very much better than the ordinary sink water, but is yet unfit for human use. From the best evidence that I could obtain, I found that it did run out through the river eight years ago.

According to the traditions of the inhabitants of the country the old Lassen trail which was traversed by emigrants to Oregon crossed over the lake, or rather where the lake now is. The old road can be distinctly traced, crossing Lassen Pass from Surprise Valley and down to the lake, where it apparently went right on where now the water is quite deep, probably eight to ten feet. It is also distinctly marked on the other side, seeming to come right out of the lake, and, ascending the bluffs, proceeds to the west across the lava-beds. There are two peninsulas jutting out from the east and west, now submerged, on which the road runs, leaving only a comparatively narrow area of the lake between them, which may have been dry when the trail was used. The only way that I can satisfactorily account for this change in the condition of the lake is that the former southern limits were these two peninsulas and the waters of the lake found an outlet through the Pitt River, and the accumulated waters of the lake were very much less in quantity than at present. In seasons of excessive freshet and in the spring when the melting snows swell the waters, the lake overflowed and spread over what is now the southern portion of the lake, below the peninsulas above mentioned. At these times great storms and tempests, sweeping down from the north, tore away the southern barrier of the lake, which was between the peninsulas, and carried it farther to the south and formed the present barrier to the outflowing of the waters through Pitt River. This being continued for year after year, the barrier becoming gradually higher and higher, the waters of the lake accumulated until they now cover the peninsulas and the old road with several feet of water, and have blocked up permanently their outlet to Pitt River; thus changing from a lake, whose waters reached the ocean, to a sink.

The lake is the home of innumerable wild geese, ducks, white and blue herons, seagulls, &c., and many fish live in its waters. These fish are chiefly trout, and at certain seasons of the year are caught in great quantities. Along the western shore of the lake the bluffs come down very close to the water in most places, and very little land is to be found which is of any value for cultivation or grazing until the north end of the lake is nearly reached.

Leaving the lake we struck off to the west and north to make an examination of Drew's Valley, Oregon, and the country thereabouts. This valley is very beautifully situated in the mountains of Southeastern Oregon, has plenty of good water flowing through it, and is just within the outskirts of the great pine forests which cover the dhills to the north. It is chiefly used for grazing purposes, as it is too high and col to be cultivated with success. The road from Goose Lake to Linkville passes through the valley. After finishing our work about Drew's Valley we moved across the grazing country north of Goose Lake and encamped in Crooked Creek Cañon. Crooked Creek is a tributary of the Chewaucan, which flows into Abert Lake and there sinks. It flows through a very pretty valley about ten miles long and from one to two miles wide. Leaving Crooked Creek we struck out across the mountains over the trail to old Camp Warner. This trail leads us through timber most of the way, up and down hills, through pretty little valleys, and finally descending a steep mountain-side through heavy pines we saw spread out before us the old camp with its houses, barracks, shops, corrals, flag-staff, &c., very much as it had been left a few years before when it was abandoned by the troops. The only persons about were a couple of sheep-herders who were attending to their flocks which were grazing in the valley below. It was a sad sight to see the old place going to ruin, but it had answered its purpose.

On September 4 we reached Warner Valley and encamped at Jones's ranch. Here the main party remained while a side party was sent off to the east to occupy Mount Warner and Beatty's Butte. Warner or Christmas Lake is in this valley, and a very large area about the lake is devoted to raising hay with which to feed the cattle in winter that in the summer find their sustenance on the hills and the remainder of the low lands about the lake. On the return of the side party we left Warner Valley and followed the old Warner road to Goose Lake Valley and came to Lakeview, the county seat of Lake County, Oregon. This small town was started only about one year before our visit, in the most convenient position for transacting the county business, and at the same time to be the commercial center of the populated portion of the country thereabout.

Our course then lay to the south along the section of the country lying between the mountains and the lake. This is a fertile section, well watered by the streams which come down from the mountains, and is well settled. Crossing over the Lake City Pass we made our first entry into Surprise Valley and proceeded north to Camp Bidwell. Here we were received with the greatest hospitality by the officers of the post, and every facility afforded us for repairing our transportation and getting things in condition for further work. Here we bade adieu to Messrs. Henshaw and Cooke, who were ordered in by Lieutenant Wheeler, and on the 27th of September we left Bidwell and moved down the west side of the valley as far as Eagleville, when we crossed over to the east and up the east side as far as 49 Cañon. Following the emigrant road as far as Massacre Flat we left the present well-traveled road and struck off to the southeast by the old and now abandoned road which leads through High Rock Cañon Our route lay for the most part through the barren sage deserts and across alkali flats

Nothing can exceed the horrid desolation of this country, where no living thing, bird, beast, or insect, is seen. The vegetation of the district, the sage-brush, simply adds to the depressing effect.

High Rock Cañon is a very long and very narrow cañon, generally from 50 to 200 yards in width, with vertical walls two to five hundred feet in height. We traveled for nearly 40 miles through the cañon, and, emerging therefrom, proceeded on to Mud Meadows, the residence of Mr. Wenner, one of the large cattle-owners of the country. This Mud Meadows lie on the borders of the great Black Rock Desert, and are the wintering place for a goodly number of cattle. Here Piute Peak was occupied as a triangulation station, and we moved on to the southwest up Little High Rock Cañon, along the face of a white, crumbling cliff under overhanging rocks, and by a little lake which forms the sink for the waters which come down from High Rock and its branch cañons; thence across the hills to a spring under Division Peak, which was next occupied.

The view from a high mountain in this vicinity presents a wonderful picture of the grandeur and utter desolation and horror of this waterless and upheaved desert. To the east rises the Black Rock Range, a very rugged, banded, and spotted line of hills made up of white, red, and black volcanic rock. Farther on another and another range rises from the desert, which is a white barren plain many miles in extent, the whole looking like black islands in a sea of milk. To the south, barren rugged mountains and alkaline lakes as far as the eye can reach. To the north and west lies the higher mountain country, covered with the brown verdure and with bunch-grass. This section is ranged over by many cattle which find excellent feed and make the finest beef in the world. Their numbers are limited by the supply of water, which is very small. We continued in this country until October 20, when we again reached Surprise Valley, going down Hayes Cañon and across to Eagleville and down to Bare's ranch, the most southerly in the valley.

Surprise Valley, lying partly in California and partly in Nevada, just at the eastern foot of the Warner range and to the west of the upheaved volcanic table-lands of Northern Nevada, is the bed of an ancient lake, vestiges of which remain in the alkaline sinks and flats, of which there are three principal ones in the valley. The northern and western portions of the valley between the mountains and the lakes are very fertile and highly cultivated, being well watered by the mountain streams. It contains about five or six hundred inhabitants, exclusive of the military detachments stationed at Bidwell. The people of the valley find the chief market for their surplus of hay and grain and the other products of the soil at Bidwell, where it is used for the supply of the garrison. I heard much about a railroad which was contemplated and which had been surveyed from Mill City on the Central Pacific Railroad through by way of the Granite Mountains, Deep Hole, Squaw Valley, &c., to Surprise, thence to proceed across the mountains and into Oregon. I am unable to see how such a railroad, of which both the construction and the running expenses must be very large, could pay expenses for a long time to come.

Leaving Surprise Valley we set out, going through the old outlet of the lake by the main road to Reno, and separating at Clark's, about 10 miles from the valley, two courses were run to the Granite Mountain, which was occupied as our last triangulation station October 26. A four days' march from Granite Mountain brought us to Susanville, passing by Wall Springs, Murphy's Salt Works, Smoke Creek, and Shafer's. Mr. Murphy has built up quite an industry in the desert. On boring a few feet into the soil, water is found which is a fully saturated solution of salt, and which by means of a windmill he pumps into inclosed spaces of the ground, and there it is evaporated and leaves the salt, which is very pure and of excellent quality. From one gallon of water he gets two pounds and ten ounces of salt. He was extending his works so as to make more salt, as he is at present unable to supply the demand.

From Susanville we moved south to Reno, and then to Verdi, on the Central Pacific Road. Here a base-line was measured and this and the Coast Survey astronomical monument established by Professor Davidson were connected with the triangulation of 1876 and 1877. The base-line is located to the east of Verdi and on a plateau above the Truckee River.

We found that the astronomical monument, which had been built of brick, had been taken up and carted off, probably to build a chimney for some one in the vicinity. We put up a granite monument as nearly in the exact spot as possible, which was well marked by the platform around it and the remains of the bricks and mortar of the monument. The base-line was laid out on the most level place we could select, where its ends could be seen from the monument and the triangulation points to be connected with. It was necessary to grub out the sage-brush and throw out large quantities of rock in order to reduce the base to a condition favorable to measure. After the line had been cleared about 6 feet wide, stakes of a length of about 6 feet were sighted in with great care at a distance of about 500 feet from each other and 6 inches from the central line. In the measurement a strong cord was drawn taut between the two consecutive stakes and made fast, and the steel tape was stretched along the central line of the base, which was thus 6 inches from the cord. The ends of the tape-lengths were marked by wooden pegs, in which ordinary toilet-pins were placed at the exact spot. After the measurement was completed the pegs were leveled and the inclined measured lengths all reduced to horizontal distances. The method of measurement did away the necessity for sighting in each tape-length and gave a basis on which the measurement could be repeated any number of times with the utmost rapidity.

A table of natural sines and cosines was used in reducing the tape-lengths to the horizontal. The record was kept and computation made in a book prepared in the following form, and which is thus explained:

Assuming the tape-length to be 50 feet, if we multiply it by 2 will give 100 feet = 100 times the radius of a table of natural sines and cosines. The difference of elevation in the two ends of the tape multiplied by 2 will give the sine of the angle of elevation or depression with a radius of 100. This divided by 100 gives the natural sine with a radius of unity. Taking from a table of natural sines and cosines the cosine corresponding to this sine, which multiplied by $\frac{100}{2}$ gives the cosine with a radius of 50′, or the horizontal distance corresponding to the inclined measurement, 50 feet or one tape-length minus the cosine thus obtained gives the reduction in length of tape corresponding to the difference of elevation. In the computation the tape is assumed to be 50 feet, whereas it is 49.908 feet nearly. When portions of tapes were used the same principle was applied.

Number of stake.	Approximate length.	Distance from end.	Reading of level-rod.	Difference of elevation.	Difference of elevation $\times \frac{2}{100} = m$.	n = natural cosine corresponding to m multiplied by $\frac{100}{2}$.	Reduction in length of tape due to difference of elevation = $50' - n$.
	′	′	′	′			
72	50	3595	2.25	.40	.0080	49.998	.002
73	50	3645	2.80	.55	.0110	49.997	3
74	50	3695	3.80	1.00	.0200	49.990	10
75	50	3745	4.00	.20	.0040	50.000	0
76	50	3795	5.00	1.00	.0200	49.990	10
77	50	3845	5.40	.40	.0080	49.998	2
78	50	3895	5.40	0	.0000	50.000	0
79	50	3945	6.48	1.08	.0216	49.988	.012

The length of the tape was accurately determined by comparison with the standard normal rods of the Coast Survey night and morning.

The base was measured twice, once by myself and once by Mr. Spiller.

The following results were obtained by my measurement:

		Feet.
Length measured		8529.163
173 pins (36 = 1 inch) half dimensions used		.200
		8529.363
	Feet.	
Reduction for level	3.873	
Reduction for overmeasure beyond end	2.970	
		6.843
Horizontal length of base		8522.520
As determined by Mr. Spiller's measurement		8522.385
Mean adopted		8522.452

On the 24th of November we left Verdi and arrived at Carson on the 26th, highly delighted to be through with our long field season. On the 28th Lieutenant Macomb and his party arrived, and the parties were disbanded and the assistants sent to Washington or discharged as the case might be. Lieutenant Macomb and myself remained in Carson making an inventory of, inspecting, and storing the property pertaining to the survey, and shipping the instruments, &c., to Washington. This took us till the 16th of December, when we started for the East, and I arrived in Washington December 26.

Since returning from the field I have been engaged on office-work, chiefly in computing the sextant observations taken last year by the officers of the survey, also in arranging and computing a list of stars for the use of observers the coming field season. I have also had the general superintendence of the reduction and plotting of work on atlas sheets 47 B and 38 D and 38 B.

I have computed, of the sextant observations, 196 time stars, 93 latitudes by Polaris, and 68 latitudes by south stars.

In conclusion I wish to thank every member of my party, who, by their cheerful good nature and intelligent devotion to duty, contributed to make of the long field season a season of pleasure to be looked back upon in after years with pride and with very few but joyous recollections.

I am, sir, very respectfully, your obedient servant,

THOMAS W. SYMONS,
Second Lieutenant of Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX D.

BRIEF EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUT. WILLARD YOUNG, CORPS OF ENGINEERS, ON THE OPERATIONS OF PARTY NO. 1, UTAH SECTION, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Ogden, Utah, February 22, 1878.

SIR: The following is a brief report of the operations of Party No. 1, of the Utah section, while under my charge during the season of 1877.

Reporting on September 15 to Lieutenant Tillman, in charge of the Utah section, at Fort Hall, Idaho, I was directed by him to take charge of Party No. 1, organized as follows: Executive officer and field astronomer, Lieut. W. Young; topographer, Gilbert Thompson; meteorologist, John A. Hasson; odometer recorder, William Looram; two packers, and one cook.

After receiving instructions from Lieutenant Tillman as to method of conducting work, area to be covered, &c., I, with the party organized as above, left the camp at Fort Hall, September 16, and moved to the vicinity of Mount Putnam. Four days were spent here in meandering roads and getting the necessary field-notes for topography, Mount Putnam and South Putnam being occupied as triangulation stations, and several minor points as topographical stations. The party then returned to Fort Hall for supplies. Rations for thirty days having been procured the party again moved to the vicinity of Mount Putnam, such additional information being gained as the meander of a new route could furnish.

Leaving the Lander road, which we had followed up Ross Fork Creek, we crossed the low divide which separates the little valley at the foot of Mount Putnam from the upper valley of the Port Neuf. In this valley and on the Soda Springs and Fort Hall road we connected with work previously done by the party under Lieutenant Tillman. Turning from the road and following up an important tributary of the Port Neuf we crossed the mountain range to the south of Mount Putnam by a high pass leading into Rapid Creek Cañon on the west of the range. We succeeded in getting through this cañon without any mishaps whatever, although from its narrowness, the almost precipitous descent, thick brush, and woods we had anticipated trouble. At the mouth of the cañon we turned north along the base of the mountains, and followed the north fork of Rapid Creek to its head; then crossing the divide into the valley of Ross Fork we followed this stream to the Indian agency and post-office on the Montana stage-road. Several topographical stations were made in the group of hills bounded by the Port Neuf, Rapid Creek, and Ross Fork.

Leaving the agency September 29, we followed the stage-road to the mouth of the Port Neuf Cañon. An important tributary which enters here from the south was then meandered to its head. Several stations were made on prominent points, when we returned to the stage-road at the mouth of the cañon. On the night of October 3, while in the mountains, our thermometer registered 3° below zero, the coldest we experienced during the season. The road up the Port Neuf and through Marsh Valley to the forks at Watson's was then meandered, as also the old emigrant-road up the Port Neuf above Harkness to the foot of Sedgwick Peak. Sedgwick was reoccupied October 7, when check-readings to Mount Putnam and other points were made. From Watson's the old emigrant-road up Hawkins Creek to Malade Springs was followed. A day was spent in the hills just south of this road and north of Fontaine's Peak, where several topographical stations were made. From Malade Springs the old Montana stage-road to Malade City was followed. On the way, and at the little settlement of Elkhorn, while waiting to occupy Elkhorn Peak, we were detained four days by bad weather.

Leaving Malade October 17, the road up Devil Creek and down Marsh Valley to the orks at Watson's was meandered, and connection made with our previous work. Oxford Peak was occupied on the 18th, and Fontaine Peak on the 20th. From Watson's the Franklin stage-road was followed as far as Packer's Bridge, on Bear River, where connection was again made with work done by the party under Lieutenant Tillman.

In crossing the divide between Marsh and Cache Valleys careful barometric observations were made to determine whether the outlet to ancient Salt Lake, or Lake Bonneville, could not have been through this pass. The observations showed the present divide to be considerably lower than the highest beach-marks of the Salt Lake Basin. Indeed, beach-marks are to be seen on either side of the road over the divide, and at a considerable elevation above it. These marks seem to terminate in this direction about 2 miles north of the present divide. In Marsh Valley I could discover no beach-marks corresponding with the higher beach-marks of Lake Bonneville, although most of the valley is covered with a pebbly gravel, evidently of lacustrine origin. This, in places, is arranged into terraces, which are I think veritable beach-marks. They have no connection, however, with the beach-marks of Lake Bonneville, but are entirely local, as they are even lower than the present divide between the two valleys. The divide itself between the valleys is peculiar. There is a kind of swampy basin or lake, a mile long or more, which marks the real divide. From one end of this lake the water flows northward into Marsh Valley, and thence into the Snake River; from the other end it flows southward into Bear River.

About 2 miles north of this lake the water flowing northward breaks through a limestone ledge several hundred feet high. This ledge or spur, which marks the limits of the higher beach-marks, was the ancient divide between the two valleys. The cañon now formed through it shows unmistakable signs of powerful water-action, and this action, I think, can be referred very properly to the overflowing waters of Lake Bonneville, one of whose outlets at least was through this cañon, down Marsh Valley, and through the cañon of the Port Neuf, to Snake River. The peculiarities of Marsh Valley and of the Port Neuf Cañon below Marsh Valley would seem to favor this opinion.

Going from Packer's Bridge to Weston, and then crossing the mountains by the wagon-road through the Weston Pass, the party again reached Malade October 25. A topographical station was made in the high mountains south of Oxford Peak on the 24th. The party, on again leaving Malade, moved south, following the main road on the east of the valley to Hampton's Bridge, making on the way two side trips into the mountains to secure the topography of the range lying between Malade and Cache Valleys. From Hampton's a detour into Cache Valley was made for the purpose of meandering the most important roads there.

Mr. Hasson, the meteorologist of the party, left us at Hampton's, after our return from Cache Valley, November 7, on account of sickness, going to Ogden and thence to Washington, D. C. His duties during the remainder of the season were performed by Mr. Looram.

The old Boisé stage-road to Point Lookout, and thence to Blue Springs, was then followed. From Blue Springs we crossed over into Pokatillo Valley, and then following the Curlew and Samaria road we again reached Malade November 10. The road along the western side of the valley was then followed, and several days were spent in getting the topography of the mountain range on the west of the valley, between Samaria and Point Lookout.

While camped in Portage Cañon, November 14, we were joined by Messrs. McClure and Stone, members of the special Montana party under Lieutenant Tillman. The roads from Hampton's Bridge to Corinne and to Brigham City, on the western and eastern sides of Bear River, respectively, having been meandered, the party proceeded to Ogden, reaching there November 25. The party was disbanded there on the 29th.

Mr. Thompson, topographer, was engaged for several days in detailed surveys about Ogden. November 30 he and Private Messer, of Lieutenant Birnie's party, made the ascent of Observatory Peak.

The work of the party after leaving Fort Hall, September 16, till close of season, and including ascent of Observatory Peak and work about Ogden, may be briefly stated as follows:

Number of miles surveyed	618.599
Number of miles unsurveyed	284.742
Total travel from September 15	903.341
Number of triangulation stations occupied	5.
Number of topographical stations occupied	63.
Number of meander stations	1105.

The meteorological work was carried out in accordance with printed instructions.

Although many of our camps were made in the near vicinity of towns and of the Montana stage-road, which, during the summer months, is almost continuously traveled by freighters from Corinne and Franklin, we found it necessary to purchase forage for our animals but twice during the whole season. Indeed, the whole country traversed by the party is eminently a grazing one, with grass in abundance almost everywhere, and it is, besides, more than moderately well wooded and watered. The northern portion, lying within the Fort Hall Indian Reservation, is but little developed agriculturally, although it is capable of sustaining a considerable population. A little farming, however, is being done by the Indians at the agency, and at Fort Hall there is an excellent post-garden. South of the reservation, in Southern Idaho and Northern Utah, the country is quite thickly settled and little towns are numerous. The inhabitants are engaged in cattle-raising and general agricultural pursuits, and considerable attention is also paid to manufacturing. Mining interests in this region are little if at all developed, although rich minerals are said to have been discovered in some of the mountains bordering Cache Valley.

Too much credit cannot be given Mr. Thompson for his efficient work, to whom besides I am indebted for many timely and valuable suggestions.

Mr. Looram, too, as odometer recorder and meteorologist, was all that could be desired.

Very respectfully, your obedient servant,

W. YOUNG,
Second Lieutenant, Corps of Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX E.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT R. BIRNIE, JR., ORDNANCE DEPARTMENT, ON THE OPERATIONS OF PARTY NO. 2, UTAH SECTION, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 14, 1878.

SIR: I have the honor to submit the following report of the operations of party No. 2, Utah section, during the field season of 1877.

The party was organized at Ogden, Utah, between May 28 and June 5, 1877, under the direction of Lieut. S. E. Tillman, Corps of Engineers, in connection with his own.

By your instructions, the area embraced in atlas sheets 41 A and 32 C was to be surveyed by the party, (for boundaries of these sheets see progress-map,) except that portion in the southern part of 41 A previously surveyed under the direction of Clarence King. This left the natural boundaries of our area as follows: On the south the parallel approximately of Kelton; on the west, the meridian crossing Snake River near the mouth of Goose Creek; on the north, the parallel of Fort Hall; and on the east the meridian that cuts the point of Promontory Range where it juts into Great Salt Lake. This last also formed the division line with the area of Lieutenant Tillman's party on the east. A map compiled in the office by J. W. Ward gave a good general idea of the country. Arrangements were made to have on hand at Kelton thirty days' supply of rations; sixty days' at Sweetser's ranch on Raft River, a central point in the western part of the area; thirty days' at Fort Hall, and thirty days' at Malade. Fort Hall and Malade were both without the area, but the selection of points was confined to those at which freight could be delivered. All were on or contiguous to the two freight-roads that traverse that country north from the railroad.

The *personnel* of the party which left Ogden June 5 was as follows: J. W. Ward and Alfred Downing, general service United States Army, topographers; F. M. Lee and F. E. McCrary, meteorological observers and recorders; S. B. Cameron, odometer recorder; Private M. G. Brenholtz, Company D, Fourteenth Infantry; with two packers and one cook, and myself as executive officer and field astronomer—making ten in all. I was also acting ordnance officer, acting assistant quartermaster, and acting commissary of subsistence for the Utah section. Each member of the party was, as usual, provided with arms and ammunition, a riding mule and equipments, and tentage. The usual instruments were assigned and each one personally charged with the care of his own. Except the triangulation instrument, which was graduated only to 30 seconds, our supply was thorough for its purpose with the survey—topography and barometric hypsometry. A meander line was run from Ogden through the towns of North Ogden, Willard, Brigham City, and Corinne to Skeen's ranch on Blue Creek, near the Central Pacific Railroad. This march, which is about 50 miles, brought us to the field of our work.

North Ogden Peak had been occupied *en route*, in connection with the party of Lieutenant Tillman, to concert a plan for the field triangulation. The point did not have sufficient command to be of much value in this respect, but gave me valuable knowledge as to the points that would probably be seen by them in our country. South

Promontory, Tangent, North Promontory, Cache, Black Pine, and Elkhorn Peaks were in view.

South Promontory Peak was occupied from the camp at Skeen's ranch. I was there enabled to project a good connection with the development of the Ogden base.

ROUTE OF THE PARTY.

From Skeen's the meander followed the direct road to Salt Springs, where a halt was made for several days; North Promontory Peak occupied for triangulation, and another point in the same range near by for topography; the second road from Blue Creek was also meandered back to Cedar Springs. From Salt Springs to Kelton the road by way of Monument Point was meandered; while at Kelton a circuit was made through Curlew and by Emigrant Spring. The party then moved by short marches along the south of the Clear Creek Mountains, passing through Dove Creek Valley, and thence to the head of the South Fork of Raft River at the western border of the area. From Big Creek there was no wagon-road. The Clear Creek Range was crossed to Raft River by trail from the cañon of Muddy Creek. This trail leaves the cañon on the north a short half-mile above its mouth. Topographical work, embracing Dove Creek Valley and the southern slope of the range, was brought forward, and the highest point in the range between Dove Creek and Goose Creek occupied for triangulation.

Turning northward from the head of Raft River, and following the South Fork to its junction with the North Fork, and thence through Summit Valley, we came upon the Kelton and Boise City stage-road near the City of Rocks. This road passes along the north side of the Clear Creek Range. We followed along it toward Kelton until a connection was made at Emigrant Springs with the previous meander from Kelton. Our tents were pitched for several days at the mouth of Clear Creek Cañon near this road.

Since leaving the head of Raft River we had almost completed the survey of the course of the upper portion of the river, its tributaries, and the mountains about their heads. From Summit Valley a trip had been made to occupy Cache Peak. The ascent was made from the west and the descent on the south, along Cove Creek to Raft River. In the vicinity of the City of Rocks several topographical stations were occupied, and two detours had been made from the route into the Clear Creek Mountains. From Raft River Station the southern part of what we have called the Cliff Range was also worked. A side party made the connection at Emigrant Spring, and occupied a station near the head of Cedar Creek, completing the topography of the Clear Creek Range.

Another important detour was made from this camp to the Black Pine Mountains. Passing through the low divide (near Emigrant Spring) that separates the Clear Creek from the Black Pine Mountains, we entered this latter group from the south through the broad cañon so plainly visible from Kelton. At the head of this cañon mining operations have been conducted with a good deal of activity. We called it Miners' Cañon. The southern of the three most central and highest of the Black Pine Peaks was occupied for triangulation. Returning to Clear Creek Camp we found a good trail through the natural pass to the south of the peaks, and passed into the cañon on the west slope. Near the head of this a wood-road was found which we followed through the cañon and to the Kelton and Boisé City freight-road near Kelso's ranch. This road was meandered south to Rice's ranch and thence a cross-road taken to camp. Finally leaving this camp we followed the road near Clear Creek and Raft River to Sweetser's ranch, to which place sixty days' rations had been forwarded and now became our base of supplies through several weeks. We first made a detour to embrace the country lying between Raft River and Rock Creek, joining to the previous work in the Black Pine Mountains and carrying it north to Snake River. To do this we proceeded to Hitchings' cattle-ranch, which is situated on the west side of and near the pass that separates the Black Pine from the Sublett Mountains. The wagon-road from Curlew to Sublett passes through this pass. The pass was examined and topographical work done in the mountains near. The road was followed back to where it joins the Sublett cut-off (road), at the mouth of the Sublett Cañon. The Sublett road was now followed across the range to the Rock Creek drain; here the road was left and the drain followed to the springs that form the head of the creek in the valley, and thence the course of the creek to Snake River. We there came upon the old emigrant-road, along the south bank of the river, and followed it to Warm Creek. In the mean time numerous detours had been made from the route and a sufficient number of points occupied to carefully develop the topography of the range north from the Black Pine Mountains to the drainage of Warm Creek. This is a very short stream, and its drains, extending but a few miles from the river, were gotten from Badger Peak (a triangulation station) and a topographical station near it. The Sublett Range is continuous between the pass from Curlew Valley (which we called the Black Pine Pass) and Snake River. It runs nearly north and south, but north of the main drain of Sublett Creek is much broken into nearly parallel ridges, its drains trending generally north and south until, making an abrupt turn, they break away from the range in an east or west direction.

From Warm Creek camp we meandered the stream to near its source, and passed westerly through the foot-hills, direct to Raft River, for the most part without trail. The road along the east side of the stream was followed to Sweetser's. Mr. Ward, by a side trip, completed the topography of the Cliff Range. Mr. Downing conducted a closed meander, which followed the road from Sweetser's to Marsh Lake; thence up the stream to Marsh Basin, where the Boisé freight-road was intersected; and thence returned along that road to Cache Creek settlement. From this settlement to Sweetser's he followed a direct road, a portion of the Sublett. On finally leaving this camp a meander was run along the road on the east side of Raft River up to the bridge at the crossing of the Boisé road, and thence along this latter to Cache Creek settlement. From this place one portion of the party completed the meander of the road to its crossing of Marsh Creek. The remainder, with Mr. Ward, made a detour to get the topography of Cache Creek and its branches and the upper streams of Marsh Creek.

At Marsh Creek I divided the party. Mr. Ward with the main portion remained in the vicinity, to finish the topography of the Cache Creek Mountains and that part of the valley drainage of Goose Creek within our area. This would complete the western portion of the area north to the vicinity of the emigrant-road along the south bank of Snake River.

Messrs. Downing, Lee, Marshall, and myself, as lightly equipped as possible, proceeded to Rice's Ferry, and crossed Snake River to the desert country on its north.

The uncertainty of finding any water in the northwestern part of atlas sheet 32 C, left it for us, with our limited means of transporting this necessary article, only to make a direct march from one stream to the other. I decided to cross toward Snake River, since I was conversant with the topography of the country in its vicinity, and hence could direct the march to any desired point, while Wood River was flowing through a flat country and its locality not well known.

Our small party traveled from the ferry down the north bank of the river and along the new freight road established with the ferry. We camped near the Shoshone Falls (above) at a spring in what has been called the Devil's Corral. This name was acquired during the gold excitement at this place a few years since, and results from the natural inclosure of very black rock walls. From this point on Snake River a line nearly due north crosses Wood River in about 28 miles; this route was taken as enabling us to cross the desert in one day's march. After reaching Wood River its course was followed up in a northeast direction until latitude 43° 07′, as shown approximately by the sextant, was reached. Here the river changes its direction to the north and showed us that to follow it further would materially increase our distance from Snake River. We were, besides, near the latitude of our northern line of survey. A low point in the desert some 6 miles east of our upper camp on the river was selected and occupied as the most favorable for topography. Near the summit of this we found a monument of rough stones about 4½ feet high, but no record as to who built it. The point itself proved to be an old crater, and forms a portion of the volcanic ridge that running north and south is marked by a prominent butte some 20 miles north of the ferry (Rice's). This latter butte we had before named Wood River Butte.

Our camp on Wood River was struck at noon, and we took a direct course to reach a point on Snake River, about 16 miles above the ferry. The object was to strike Snake River as far up as possible, and thus increase the travel within the limits of 32 C. One dry camp was made and Snake River reached the following day at sundown. The distance is about 48 miles. Small extinct craters were numerously met with, indicating that this lava formation was the result of extended ebullition, rather than the flow of a few craters. But individual flows of considerable magnitude were afterward met in another part of this desert. We reached the ferry one day after Mr. Ward's arrival there with the rest of the party.

Finding that it would be necessary to return to the ferry along the north side of the river, I left there a supply for rations for fifteen days.

We now took the emigrant road along the south side of Snake River, and meandered it closely from Goose Creek to Bannock Creek. At Marsh Lake a connection was made with the previous meander from Sweetser's and at Fall Creek with that through the Sublett Mountains. A topographical station was occupied immediately west of Marsh Lake. At Bannock Creek the party left the emigrant road to meander the stream and to work the topography of the Bannock Range from Snake River to Deep Creek Peak. With this view Mr. Downing and myself had separated from the remainder of the party a short distance below American Falls, and passed across the range to meet the rest of the party on Bannock Creek. We crossed from the head of Warm Creek to Moonshine Creek and joined the others where this latter joins the Bannock. A number of stations were occupied in the vicinity of our line. The party then continued the meander of the road up the longer fork of Bannock to Toponce's Ranch, near its head. From this camp Deep Creek Peak was occupied for triangulation, &c. Turning north again we next camped at the head of the west fork of the stream. The source of this we called Fountain Springs, from the immense force and volume with which several issued from their sources—rock crevices. Bannock Peak was occupied; the topography in the vicinity completed. Shortness of rations prevented our undertaking any new work before replenishing, so we proceeded directly to Fort Hall. *En route* we retraced a part of our route up Bannock Creek and passed the Indian farms on that creek and Monsieur Creek. The Snake River road was taken up again near Bannock Creek and meandered across the Port Neuf ford to Ross Fork. From that place to Fort Hall, the upper of the two roads that branch from the Lander road along Ross Fork Creek was meandered.

While at Fort Hall, in connection with Lieutenant Tillman's party, we made an unsuccessful attempt to triangulate from Mount Putnam. The morning of September 16 we left Fort Hall to cross the Snake River and complete the survey of the desert country. At our camp at Warren's store on that evening, a sad and fatal accident occurred in the death of Mr. J. W. Ward, who was mortally wounded and died almost immediately from the effects of a shot from his own pistol; which was discharged on falling to the floor from his waist. His remains were, on the 17th, interred at Fort Hall. The party was much crippled by the loss of its principal topographer. From this time Mr. Downing had charge of the meander and topographical work, with such assistance as I could render from time to time.

From Warren's the meander was run along the Blackfoot to Snake River, and down the east bank of that stream to near the site of old Fort Hall. Several attempts were made to ford the river between these points, but no safe crossing could be found for pack animals, and none where one even felt assured to be able to cross without having to swim the animal. The crossing was made by means of small boats, in which the cargo was carried. The mules readily swam after the bell-mare, the latter swimming with a lead rope from the stern of one of the boats. A camp was established for a few days at the large springs some 6 miles from the river, on the emigrant road. This road is not used at present. The ferry at the mouth of the Blackfoot, where the crossing of Snake River was made, has been abandoned. These springs are the last water on the road until Big Butte is reached, about 30 miles from them. The old road, which, in the event of settlements on Lost River or of the success of the mining country of Salmon River, is likely to be a good deal traveled, was meandered from the old ferry to the Butte. This latter was occupied for triangulation.

A direct march was next undertaken from the springs to a small lake, reported to lie in the desert some 8 miles north of the mouth of Fall Creek. Directing our march accordingly, the lake was reached on the morning of the second day. But little lava was met with on this march, but heavy sage-brush, interspersed with good grazing grounds. The lava country was off to our north and west. The fact was developed that along the whole portion of Snake River that we followed, from the Blackfoot to below Rice Ferry, there stretches back from the river some 8 or 10 miles of good grazing land. This makes sufficient grazing to maintain a great number of cattle, and is probably also quite commensurate with the water supply, from which latter the cattle cannot go to any great distance. The little lake where at this time we were camped, is situated in the desert, some 7 miles from the river, and about it is found for miles as fine grazing as could be desired.

Mr. Downing continued one day's march without trail and came upon Snake River a few miles below the mouth of Raft River, and proceeded down the river to within a short distance of the ferry, making a connection with our previous meander to that place on the Wood River trip. The fifteen days' supply of rations at the ferry was taken up, and he turned to follow closely the north bank of the river with a view to a continuous meander of it.

In the mean time, with water and provisions for two nights, I proceeded from the lake with one man to occupy Pillar Butte for triangulation and topography. This point was reached from a "dry camp" by a walk of 4½ miles over very rough lava rock. A loose animal scarcely could travel over it. A small monument was found, but no record. The first standard parallel of the land survey south of Boisé is marked as located, and this point should not be more than 2 miles to the north of it. I returned to the lake and thence proceeded to Snake River, where I met the rest of the party nearly opposite the mouth of Fall Creek. At this point there is a little island near the north bank, and just above this island is the only safe ford we found on the river, and this only at low water. The line of crossing extends from the north bank about 100 feet above the point of the island and makes an angle of from 10° to 15° down the stream with the thread of the current. We followed the river bank as closely as possible up to the previous crossing at the boat ferry. The marshy bottom land with heavy undergrowth in many places between American Falls and the crossing prevented a continuous survey there, but a number of points were fixed, either by the meander or cross-sights. From the ferry to Ross Fork or Fort Hall Indian Agency our route crossed the bottom land. This was remarkable for the number of springs and streams; the grass was excellent, and as the summer advances forms the pasturage for the horses of the Indians at the agency. While the pack-train went directly from the agency to Fort Hall Mr. Downing meandered the road to Warren's, and I went by way of Mount Putnam. This second time I found no clouds to interfere; the night was spent near the summit, and the early morning, although very cold, gave fine opportunity for observation.

October the 12th we finally left Fort Hall, occupied a couple of stations in the low hills to the west, and camped on the little stream to the west of the divide, on the road to the agency, whence we proceeded to the agency and followed down the stream (Ross Fork). From where this enters the bottom land we crossed the latter directly to the Port Neuf, at the ford of the old Fort Hall stage-road. Here a little variety was introduced in the ordinarily monotonous march of the pack-train by several mules becoming mired, one of which had to be unloaded and helped out from a stream nearly waist deep. The meander of the Port Neuf was taken up at its junction with Snake River, and the stream followed up to the junction of its largest branch from the Pocotalla Mountains on the south. At the junction of the Port Neuf with the Snake we found the initial point (monument) used in the survey of the Fort Hall Indian Reservation. We turned up the branch above referred to into the Pocotalla Mountains, which were carefully worked. The route up this stream was in part identical with that of Lieutenant Young's party. A low pass at the head of the stream brought us into the drainage of Rattlesnake Creek, which we crossed some 5 or 6 miles above its junction with Bannock Creek. The march was continued across the country to Toponce's Ranch, where we made connection with a previous meander. The meander was continued along the west base of the Malade Mountains to the Sublett road, on which the low divide between the head of Bannock and Deep Creeks was crossed.

From Toponce's the Malade road was meandered as far as its intersection with the Sublett road, near the head of Little Malade River. As we were here traveling adjacent to the area of the other party, stations were occupied to connect with their work. At our camp at the Sublett road we found a record of the other party. As they had meandered the road thence to Malade, we proceeded directly there, to obtain a fresh supply of rations. We camped there with Lieutenant Young's party, and together arranged to complete the area about the common line.

From Malade my party moved by way of the small settlement of Big Bend to near the head of the Big Malade. A systematic survey of the Malade or West Mountains was commenced and carried north to the head of Little Malade, connecting with our previous work, the party meantime moving by slow marches along the east base of the range. From Elkhorn a peak of the same name was occupied for triangulation; this had been previously occupied by the other party. When the Sublett road was reached we turned west and followed it across the range until the meander was connected with the previous one that had left it at the head of Rock Creek drain. We remained in camp for several days at Twin Springs, on this road, detained by the weather, which since we left Malade had become systematically bad and disagreeable.

An important station was occupied in the Bannock Range, south of Deep Creek Peak. It was chosen near where the range divides into two spurs. One continuing to the south falls away in the forks of Deep Creek and Bankhead Creek; the other runs westerly toward the Sublett Mountains, and forms the low divide between the head of Rock and Bankhead Creeks. It connects with the Sublett Range at Antelope Peak. From this peak (Antelope) a spur of the Sublett Range runs south and terminates near Curlew. We crossed this spur near its base to Black Pine Creek. This is a small stream that heads about the Black Pine Pass before referred to. Our route across the spur enabled us to complete the Sublett Mountains except the Curlew Spur. From Black Pine Creek we proceeded to Curlew, there again connecting with Ward's meander from Kelton. Deep Creek Valley was followed to the head of the stream, and the topography of the Curlew Spur completed. From Deep Creek to Samaria the road from Twin Springs was taken, and meandered to near the latter place; where leaving it we passed by Warm Springs, and again to Malade. From Malade we returned to Warm Springs by the little saw-mill, situated at the junction of the waters of the springs with the Big Malade. The road to Hansel Spring, through Pocotalla Valley, was taken up and meandered through.

From Hansel Spring stations were occupied in the Hansel Mountains and to the north in the ridge that separates Deep Creek and Pocotalla Valleys. A meander was also run to the springs that are (several in number) at the east base of the Hansel Mountains, and near the dim road from Hansel Spring to Salt Springs (mentioned in the early part of the route); another meander was made to complete the survey of the roads in Deep Creek Valley, particularly to take up at Deep Creek crossing the Corinne and Curlew road. This road was now followed across the Promontory Range to the head of Blue Creek, and from that point the route via Sweetwater Spring was followed to the head of Salt Creek, on Point Lookout, Lieutenant Young's party having meandered the more direct road, via Blind Spring, between Point Lookout and head of Blue Creek. A minor topographical station was made in the Promontory Range, near the road, and two others in the ridge between Blue and Salt Creeks. The road between Point Lookout and Connor's Springs was meandered. A meander from Point

Lookout to Corinne completed the work of the party. Returning to Ogden, the route was the same as that taken going out. At Big Spring, some 9 miles from Ogden, we were joined by Lieutenant Young's party. The two reached Ogden November 25, and my party was disbanded as soon as practicable, Mr. Downing and others being retained a few days to do some detailed topography about the observatory and Weber River in the vicinity.

To economize time and at the same time to reach every portion of the area was held the principal object in view throughout. This caused the main routes of travel to be taken in broken parts, but their survey was finally made continuous and a duplication of routes of travel thus almost entirely avoided.

At Kelton, June 20, my chief packer was replaced by James Marshall, whose previous knowledge of the country we afterward traversed became of much practical benefit. At Clear Creek, July 19, the cook was replaced by Charles Harris. At Fort Hall, September 11, the assistant packer was discharged; his duties were thereafter very capably performed by Private Brenholtz. Artificer Joseph Messer, Company I, Fourteenth Infantry, joined the party at this time and continued with it to the end of the season, in the capacity of general assistant.

In Mr. J. W. Ward, who died so suddenly at Warren's, on the 16th of September, the party and the survey lost a most efficient topographer and energetic worker. This was his first season with the survey in the field, but his accurate manner of taking notes and following out the details of the work, with his brightness and capacity and determination to excel, coupled with previous experience in similar work, clearly showed his superior usefulness. Officially and personally I deeply regret the loss of this able worker and efficient assistant. To Messrs. Downing, Lee, McCrary, and Cameron I extend my thanks for their efficient aid. Mr. McCrary, at his own request, was relieved from duty in the field and left the party at Fort Hall, September 15. Messrs. Lee and McCrary deserve special commendation for their care of the delicate instruments intrusted to their charge.

The area surveyed by the party was a little over 7,000 square miles, not including the meander without it by way of the Shoshone Falls and Wood River. One hundred and seventy-three days were spent in the field. As before indicated, the triangulation was directly connected with that of the Ogden base party and Lieutenant Tillman, by occupying several points in common. My main stations were Promontory, North Promontory or Blue Creek, Clear Creek or Rosebud, Cache, Black Pine, Badger, Deep Creek, Bannock, Big Butte, Pillar Butte, Putnam and Elkhorn Peaks. The following are additional statistics of operations, viz:

Number of peaks occupied for topography	134
Number of camps (main and side)	122
Number of miles meandered	1,842
Number of meander-stations	1,959
Number of miles traversed but not meandered	1,050
Number of cistern-barometer stations	252
Number of aneroid-barometer stations	1,707
Number of variations determined by observations on Polaris	65
Number of sextant latitude-stations	32

Particular attention was paid to the plotting of drainage features in the field. By assuming a distance in the note-book to represent that between two adjacent stations (in kind) and plotting the cross-sights from these, a sufficient number of points were fixed to sketch in accurately the contours and drainage at once, so that wherever this was done the note-books represent in detached parts a map of the country. It will be readily seen that in harmonizing the scales, the relative positions of the different points in each will not be changed. When it happens that the distance between the initial points is known, having been determined by cross-sights from an odometer meander line or by a field-triangulation sketch, then the scale of the sketch can be fixed beforehand, say 2 miles to the inch. The reduction in office, as far as plan is concerned, then becomes a simple matter of transfer. The time required for this is not a serious objection, for I believe a rapid workman can plot and sketch from 25 to 30 square miles in a day far more accurately than by simple drainage sketches from a single station, and much more rapidly than by plane-table work, which it somewhat resembles. It moreover gives absolute instrumental angles to every point. This for mountain country. A meander-line through a valley or flat country, if the same principle is followed out, will give equally good and sufficient results for the portion commanded by the line.

GENERAL DESCRIPTION.

A little study of the topographical features of the country will show our area to be divided into two drainage basins, the great Salt Lake and the Snake River. The dividing line between these is a broken chain of mountains. The general direction of this divide is northeast and southwest, but the tendency of all the spurs is toward a north and south direction. This latter feature is so marked, that the most prominent ridges of the chain are found with this direction. We must, however, except the Clear Creek or Raft River Range in the southwest, which squarely interposes itself between the basins, with its crest approximately parallel to their lines of greatest depression. But following the divide from this ridge across Emigrant Pass, we come to the Black Pine Mountains, which extend to the north in the Sublett Range to Snake River. On the east and parallel to this is the Bannock Range and next the Malade Range. The Promontory Range connects with the Malade, and forms a well-defined ridge, from Promontory Point in the Great Salt Lake, that runs nearly due north and falls away at the Port Neuf Cañon. As a result of this formation, the great divide, finding its way from one to another of these north and south ridges, crosses a series of low passes. These passes constitute one of its most important features, and, until explored, formed objects of especial interest as possible outlets of Lake Bonneville.

The Promontory Range, with its extension north, formed nearly the eastern boundary of our area. Between this range and the Clear Creek we find four prominent passes.

Between the Malade and Bannock Ranges is the Deep Creek Pass. The approach to this on the south is by the east fork of Deep Creek, on the north is the south fork of Bannock Creek. The declivity of its approaches is remarkably gentle and open; its altitudes approximately 5,350 feet. No road traverses it at present, but the construction of one would be an easy matter.

The second is the pass between the Bannock and Sublett Ranges. The west branch of Deep Creek (Bankhead Creek) heads on its south and Rock Creek on its north. It is several hundred feet higher than the Deep Creek Pass, but is open and would serve as an easy means of communication.

The third is between the Sublett and Black Pine Mountains, and is called the Black Pine Pass; on its southeast side is a little creek of the same name. The drain of this creek reaches Deep Creek at Curlew, and a wagon-road from Curlew traverses the pass to Raft River Valley. So it results that Curlew is a point from which the natural ways to these three passes radiate. The altitude of the Black Pine Pass is 5,537 feet.

The fourth is Emigrant Pass, lying between the Black Pine and the Clear Creek Ranges; its altitude is about 5,290 feet. The freight and stage road from Kelton to Boise City traverses this pass. Kelton is also the most available point on the railroad to communicate with Curlew; it, therefore, comes to command the four passes.

Observing that the highest beach-mark of the old lake is less than 5,200 feet, we see that the passes are all above it, and that none of them formed a place of outlet or overflow for old Lake Bonneville.

Deep Creek is the largest stream on the Salt Lake side of the divide; it sinks at Curlew. This stream, in connection with several springs on the east side of its valley, will afford water for the irrigation of considerable tracts of land. A number of settlers are already located and engaged in stock-raising, with farming on a small scale. At Black Pine Creek is a fine stock range, but a very limited supply of water for irrigation.

Quite a number of small streams flow from the Clear Creek Mountains on the south, and through soil that would well repay cultivation. The misfortune, however, is that in the heat of summer their waters scarcely flow beyond the mouths of their cañons. A few settlers are there, but their crops are not certain.

Kelton, near the most northern point of Great Salt Lake, is well known as a station of the Central Pacific Railroad. It is about 25 feet above the level of the lake and is situated in an alkali plain; its only importance is derived from its being a transfer point for freight and passengers to Boise City, Atlanta, and vicinity, in Idaho. At Monument Point, salt is manufactured by evaporation from the water of the lake. The operation is very inexpensive. The salt is principally shipped to the mining districts in Nevada and Utah for use in the reduction of ores.

The lake side of the divide shows that a large portion of it has been covered by the waters of the lake, and the terraces are one of its most prominent features, reaching as they do to nearly 1,000 feet above the present water level. Such land is, of course, highly impregnated with alkali, and much of it is barren from this cause. The beneficial effects of some of the alkali salts in agriculture is well known, but here the absence of running water has prevented a proper admixture of soil. The slopes afford good grazing and the ground can be cultivated where it can be irrigated. But little wood is found growing below the old water-marks.

A remarkable instance of wood growth was noticed adjacent to the road leading from Curlew to Black Pine Pass. Here the road ascends from one level to another over a series of distinct terraces. On one of these about a third of a mile in width is a thick growth of cedars, apparently many years old. On the terrace above (and consequently the older of the two) a few young trees are starting. The effect of this can be best appreciated as we saw it first from Black Pine Peak, where, looking down into and across this arm of the old lake, the edges of this succession of terraces appeared as graceful curves bending up the valley, and the terraces themselves as the treads of a great stairway stretching distinctly across it. This growth of trees made one tread of green distinct in outline and in perfect contrast to the others. It would seem that the sediment deposited during the growth of this terrace contained germs of growth that were lacking in the others.

THE NORTHERN SLOPE.

On the north side of the divide Snake River separates a country traversed by numerous streams on the south from a lava desert on its north side.

The highest peak we had to ascend was Cache, the culminating point of a detached group of mountains, that give rise to Willow and Birch Creeks, Marsh Creek, and Cache, Cove, and Alamo Creeks. The first two are tributary to Goose Creek, and the last three to Raft River. The altitude of Cache Peak is 10,451 feet. The name is somewhat in doubt and its origin is unknown. This spelling has been taken from the common pronunciation of the word. A divide from this peak connects around the head of Raft River, by the west, with the Clear Creek Mountains. To the north the group falls away at Snake River, and the same is true of the Sublett and Bannock Ranges. Comprising the country north from the divide to Snake River, we have, consequently, a series of north and south mountain ridges, with their intervening valleys.

The largest of these is Raft River Valley, which is traversed by a stream of the same name. Besides the tributaries mentioned above, this stream receives the drainage of the north slope of the Clear Creek Mountains, which comprises several fine streams. In the last 40 miles of its course the fall of the stream is slight; the soil is of a spongy character, and in the heat of summer the water sinks and rises at intervals, leaving portions of the bed quite dry. In this flat portion of the valley adjacent to the stream is a large area of grass land. A quantity of hay is cured for the winter use of the large herds of cattle owned in the valley. One of our supply points was made at the ranch of Mr. Sweetser in this valley, and we are much indebted to him for his kindness and hospitality. Mr. Sweetser states that after a patient and careful trial of the soil for farming, he was compelled to abandon the purpose; the crops proved failures. This valley is the winter herding-ground for a great number of cattle. During the summer the herds are driven into the mountain valleys and the pasturage of the main valley preserved. In Summit Valley, near the head of the river, is a splendid summer range, and there are several others, including Rock Creek Valley.

About the valley, in several places where the streams emerge from the mountains, good farming land is found; nearly every one, however, takes advantage of the immense preponderance of grazing land and engages to a greater or less extent in cattle-raising. A thriving farming settlement is on Cache Creek. Yost's ranch, on a stream from the Clear Creek Range, has a promising appearance. I venture to express the opinion that settlers would do well in that vicinity and along Cove and Alamo Creeks. With the exception of Yost's ranch and one stage-station (Raft River Station), there are at present no permanent settlers in what may be called the middle valley. This valley is terminated above by the cañon below Summit Valley, and below by the little range of hills at Raft River Station. Summit Valley is too cold for cultivation. In August, a farming settlement was but just started on Sublett Creek. The altitude of this is but little greater than Cache Creek settlement, but it is doubtful if the soil is as good.

Marsh Creek is the next stream below Raft River flowing into the Snake. Well up this stream is the most thriving farming settlement we found. The place is called Marsh Basin, and is a natural valley on the north side of the Cache Creek Mountains. The freight-road from Kelton to Boise passes through the settlement. Goose Creek, the next below, is being rapidly settled. Fall Creek is a stream only a few miles long; it flows into the Snake next above Raft River. It is a very pretty stream, about 10 feet across, and near its mouth falls successively over a number of clay and calcareous cement ledges, some of them 6 feet in height. Its source is remarkable. Several large springs, near to each other, burst from the bottom of the drain and form the whole volume of the stream within 200 yards. Above these springs the dry drains extend back into the mountains 5 or 6 miles. The Sublett and Bannock Ranges throughout present this same phenomena, as evinced in the sources of Rock Creek, Warm Creek, and Bannock Creek, whose principal sources are all copious springs at the feet of the mountains or well out in the valleys. The mountain soil is loose and porous and the drains almost all dry. If we do find a spring in a cañon it soon sinks, sometimes to make its appearance again below, with re-enforcement, and sometimes to disappear altogether.

Rock Creek is the next stream of importance above Fall Creek. It drains the valley lying between the Sublett and Bannock ranges. This valley has been devoted to grazing purposes. It is proposed to establish there a farming settlement. The stream furnishes an abundant supply of water, and the experiment may well be tried.

Bannock Creek is for the most part within the limits of the Fort Hall Indian Reservation. The Indians have one farm there which seems to do well. The potatoes were fine and the grains of wheat plump. About the upper portion of the stream is fine grazing-land. The west fork, which furnishes its principal supply of water, has for its source a copious spring that issues from the foot of a mountain slope; it issues from a crevice in the rock, down which a pole could be readily forced some 8 feet. We called it Fountain Spring.

Next above Bannock the Port Neuf comes into Snake River. At its junction is the initial point of the reservation. From this point the western boundary takes a direct line to Bannock Peak.

The Indians have another farm on Monsieur Creek, a little tributary of the Port Neuf from the Pocotalla Mountains. Their largest farm is at the agency on Ross Fork, a tributary of the Port Neuf on the north.

From the mouth of the Blackfoot to American Falls the Snake River flows through bottom land. It closely skirts the desert on its north bank, but on the southeast side the bottom land is extensive. Numerous islands occur, and in places the river has three or four different channels. Cottonwood trees grow thickly along it in many places and there are thickets of undergrowth, so that we found it impracticable to meander either bank closely (at this part).

The American Falls is opposite the north end of the Bannock Range; a low lava ridge thwarts the stream, and is a part of one extending in the same line north into the desert. Below the falls the river makes its way through the southern portion or along the edge of the lava, the flow of which has been from the north. Occasionally as about the mouth of Upper Rock Creek, below Raft River, and notably where the two great falls occur, the lava is found on the south side and the river makes its way through the protruding tongues. Naturally where this occurs the river cañons, the banks are high and steep, and it is difficult and often impossible to travel close to the water's edge. But between the American Falls and Rice's Ferry the river for the most part flows through a dry-looking country, its banks generally low, with good pasture lands adjacent, especially on the north side, where, until quite recently, the country has been little grazed. The ford near Fall Creek has already been referred to.

The average fall of the river from the boat-ferry near the site of old Fort Hall to Rice's Ferry is about 1.8 feet to the mile, including the American Falls. This distance by the current is about 110 miles. The average width is not less than 200 yards; in places it approaches 300 yards.

The Indians swim their horses and can make a ford almost at any place where the approaches are good. But with the exception of the Fall Creek ford I found no place where perishable material could be safely carried over without the aid of rafts or boats, and that ford is not practicable before the middle of August.

From the American Falls to Rice's Ferry a good trail follows close along the river-bank on the north side. On the south side the emigrant-road keeps quite close to the river as far as a little below Fall Creek, and then does not approach it again until near the mouth of Marsh Creek, being about 10 miles to the south of it at the Raft River crossing.

A lava desert stretches north from the Snake River some 60 miles to the Salmon River Mountains. Below the mouth of the Blackfoot but one road crosses this desert. Formerly there were ferries at the mouth of the Blackfoot and at Fort Hall (trading post). From these points roads converge and join at large springs about 6 miles from old Fort Hall. Thence the road takes a direct course, and passes around the east base of the Big Butte. On the north side of this butte, and not far from the road, is a quite accessible spring, distant about 30 miles from the large springs. The road is somewhat rough, but could easily be made good.

The next water beyond Big Butte is Lost River. This river is quite to the north of our area, and was not visited. It flows from the Salmon River Mountains east into the desert, and sinks. Probably the best point to reach the sink of the river from the Snake, with a view to a new road, would be from the mouth of the Blackfoot, and one might be constructed on that line, but the distances between water would be greater than by the present route, and the saving of travel would not be great.

A notable feature of this country is the springs that rise adjacent to the Snake River, and appear to come from under the lava. Some of these have a great volume. Probably the rain-fall on the great extent of lava finds its way into and through the rocks, and the water makes its appearance again in the springs at the edges of the bed near the river. A series of these springs is found adjacent to and on a line with the large springs referred to. These occur at the foot of a low bluff, and range nearly parallel to the river, some 6 miles from it. Lower down the river large springs burst forth just at the bank. (It will be remembered that here the river cuts into the lava flow.) Two are found as far down as the vicinity of Raft River.

Wood River joins the Malade and flows into the Snake below the Great Falls. As before stated, we followed only along its middle portion, not reaching its mouth or the mouth of its cañon from the mountains. Between it and the Snake River above American Falls lies the greatest extent of the dry country. While much of this is covered with lava rock through which one must pick his way to travel, there is yet left a large part of it covered with fine grazing, especially near the rivers.

The roughest portions of the field lie between the Big Butte and Wood River; while, with a few exceptions, the country extending back a number of miles from Snake River is not difficult to traverse on horseback.

Along Wood River where we traveled the bottom land would generally average an eighth of a mile in width. The altitude is less than 4,500 feet, and except for its isolated position, coupled with danger from Indians, undoubtedly offers a fine field for settlers.

Game is not plentiful in this country, but bear, deer, antelope, beaver (quite numerous), and badger may be found. Ducks and geese are numerous, and an abundance of fish is to be found in the Snake River and its tributaries.

No mines are at present in operation. Good prospects in silver ores have been worked to some extent in the Black Pine Mountains and along the northern slope of the Clear Creek Range. The gold washings on Snake River about the Great Falls are now almost deserted. I was told that a few Chinamen are at work there now. Ten or twelve years ago this apparently inaccessible locality was a busy mining place and paid well.

Very respectfully, sir, your obedient servant,

R. BIRNIE, Jr.,
First Lieutenant of Ordnance, Executive Officer.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX F.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT CHARLES C. MORRISON, SIXTH CAVALRY, ON THE OPERATIONS OF PARTY NO. 2, COLORADO SECTION, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., April 1, 1878.

SIR: I have the honor to submit the following executive report of the operations of party No. 2, Colorado section, of the surveys west of the 100th meridian, for the field season of 1877, together with a brief description of the country traversed and its resources.

EXECUTIVE REPORT.

On the 16th of May I arrived at Fort Lyon, verbally encharged with the organization of the Colorado section, which having been accomplished, I sent party No. 1 into the field May 24, under Mr. Niblack, with instructions to proceed directly to Pueblo, Colo., where Lieutenant Bergland was to meet and take charge of it.

The personnel of party No. 2 was: First Lieut. Charles C. Morrison, Sixth Cavalry, executive officer and field astronomer; Assistant Engineer F. O. Maxson, topographical assistant; Mr. Thomas W. Goad, meteorological observer; Mr. C. De V. Davis, aneroid and odometer recorder; Mr. S. H. Elkins, general assistant; Juan de Jesus Martinez, José I. Martinez, and Juan Garcia, packers, and Benjamin F. Harrison, packer and cook.

My instructions were to proceed up the Purgatoire River to its head, cross the main range by the Costilla Pass, thence follow down the west side of the range to Santa Fé, from there to reach some point in 77 D, at which work was left off the previous year; to finish that quarter atlas-sheet and carry the survey over the one to the south (84 B), connecting westward with the work west of the Rio Grande done in 1873.

The party left Fort Lyon May 25, with thirty days' rations. The pack-train of 10 mules was in good condition. The route of the party was up the Purgatoire River to its head, thence across the headwaters of the Vermejo to the Costilla Pass, down the Costilla to the town of the same name; thence following the drainage of the Rio Grande to Fort Craig, where we entered upon the field proper of our summer's work. On the way down places left blank in previous years were surveyed. Of these there were several small mountain districts in the main range.

En route we encamped one day in Costilla Valley, above the narrow cañon, to post records. From there we reached Costilla. From Costilla we skirted the mountains. We were detained one day, June 6, near Los Cerros by a snow-storm, which prevented work. From Los Cerros the main road to Colorado Creek was followed; from there a trail to the mouth of that creek, keeping on the plateau; thence by a trail to Arroyo Hondo; from there, passing the old Indian pueblo of Taos, our route led through Fernandez de Taos and Ranchos de Taos; thence by a trail over the United States mountain, between the mill road and the Rio Grande Cañon road, down Pueblo Creek to the Indian pueblo of Picuris; thence by trail north of the Pueblo Cañon to El

Embudo; from there we followed the river road to La Joya; thence by the main road to Santa Fé. There we remained four days, making necessary comparisons of meteorological instruments and posting the records. From Santa Fé the route down Santa Fé Creek was followed by way of the cañon as far as La Bajada, leaving the Mesa road to the right; from this point the old stage road to Algodones and Albuquerque was followed to the latter town; thence down the east bank of the Rio Grande to Constancia; from this little town we left the river by the road leading to Cerro Montoso; thence skirting these hills, turning again toward the river, it was reached at a point opposite Socorro.

From Socorro we went to the Magdalena Mountains, having to finish the topography of that range. The northeastern portion having been surveyed the previous year, there remained but the southern and western slopes from Cañon del Agua and Cañon de la Maquina. From the latter cañon it was intended to work up the western slope of the range; with this expectation the pack-train, on the 4th of July, was directed to a small spring 8 or 10 miles from our camp, while Mr. Maxson and myself occupied a topographical station. In crossing an old lava flow they lost the trail, but faintly marked on the rock, and not knowing where the spring was, they wandered to the river, to which point we trailed them, making a march of over 30 miles after one o'clock. Celebrating thus, in a most uncomfortable manner, the Fourth, we reached camp after eleven o'clock at night. The next day we went into Fort Craig, from which point Mr. Maxson and Mr. Davis were sent to the west of Magdalena Range, returning on July 10. We left Craig July 12 and followed down the west bank of the Rio Grande, beyond San José to Las Tripas, thence diverging from the river to the Cañada Alamosa; from there to Polomas Creek, at the point where it breaks through the Sierra Negrita, we cut the Cuchilla Negra Creek 6 or 8 miles above the town of the same name; thence passed down the Cuchilla Negra to its junction with the river, and from there went to the McRae Ferry. Crossing the river here we proceeded to Toussaint's ranch; thence back to the river by the trail over the southern end of the Fra Cristobal Range, striking the river at Alamocita; thence up the Rio Grande on the east bank to Paraje Ferry, making a detour at the northern end of the range to occupy Fra Cristobal as a triangulation station. At Paraje Ferry we were occupied several days in gauging the Rio Grande; having completed which we proceeded via Annaya Spring to the San Andreas Mountains. Here we worked from July 28 to August 5, in that portion of the range almost destitute of water. From Dripping Spring we followed the main road, by way of Mound Spring, across the Mal Pais to Jaralosa Spring; thence by Nogal to Fort Stanton. Nogal Peak, at the head of the creek of the same name, was occupied *en route* as a triangulation station and Tortolita Peak for topography. While encamped at Stanton a thorough survey of the cave near there was made, a brief description of which will be given.

Having drawn rations at Stanton, and with transportation very much rested by the stay at the post, we proceeded up Bonito Creek to a point which we had reached while occupying Nogal Peak; from there we crossed over to Ruidoso Creek; thence by the Rinconado Bonito trail to the summit of the range, where, leaving the main party at Carrizo Spring, one of the heads of Carrizo Creek, Mr. Maxson and I followed the crest of the range to the high White Mountain Peak, which lacks little of being 12,000 feet elevation. After staying two nights on this peak, which we occupied for triangulation and azimuth observations, we returned to the main camp; thence followed the trail down into Rinconado Bonito. From there, skirting the western base of the mountains, we passed the Tres Rios and the Tres Cerros Springs and cut the road leading to Stanton at Nogal Creek, which we followed to that post. Rationing anew here, September 4, we followed down the Bonito past the town of Lincoln, doubled the southern end of the Capitan, which we occupied for triangulation and topography; then skirting the northern base, passing through the town of Las Tablas, we next occupied East Carrizo Cone; passing to the south of Pedernaluda and Carrizo Peaks we arrived at Carrizoso Spring. From here the portion of the belt of Mal Pais or lava flow, north of Jaralosa Spring, was surveyed. We followed up the western edge of the flow around the northern end, down again by the east side to Carrizoso Spring. While at a dry camp at the northern end, one of the packers was very ill with a congestive chill. Mr. Matthews very kindly sent a wagon to bring him from camp to the Carrizoso ranch. From here we proceeded to the Jicarilla Mountains, where we were four days engaged in the survey of this range, the greater portion of which Mr. Maxson did by short trips from the main camp at Winter's ranch. From there we went to Cerro Tecolote, which was occupied for triangulation; thence to the Western Gallinas Spring. The Gallinas Mountains having been finished, we next camped at the Gallinas Waterhole or Laguna; from here Mr. Maxson, Mr. Goad and I went to the Gran Quivira ruins, nearly due west of this point, a short description of which will be given elsewhere. Returning to the main camp the survey was carried to the north, connecting with the work of the previous year, by Mr. Maxson, to the west to Punto de Agua, by myself, at which latter point the party were again united. From here we followed along the edge of the Mesa Jumanes, camping at Chupadero Spring and ranch. From this last camp, by detour trips, the country lying between the Chupadero drain and basin of the Gran Quivira, south of the Mesa Jumanes, was surveyed; this course being necessary for the want of water. From here we traveled to Ojo del Llano, thence by way of the Cerro Colorado, which was occupied for triangulation, to the Rio Grande, which river we struck at San Pedro. Following the Rio Grande, we arrived at Fort Craig, October 14, forty days out from Fort Stanton. Here we remained three days drawing rations, shoeing the animals, and repairing transportation, refilling aparejos, &c. From Craig, San Mateo Mountain was the next triangulation point to be occupied, and a very good one it proved to be, although very difficult of ascent. Camping all night upon it, we caught the first fall of snow. From here we moved to Toussaint's ranch, thence to a dry camp southwest of the Oscura Mountains. Thence we proceeded along the western base of the Oscuras. Two more dry camps followed this one, just before reaching the latter of which a short, sharp shower thoroughly wet the grass and drenched the mules, and enabled us to fill the water-kegs. Hardly had the rain ceased before all sign of it was gone; the earth had taken it up like a sponge. It had saved us an additional 20-mile tramp, however, for we could not have longer done without it. It proved a greater benefit, for with the exception of one camp at Jaralosa Spring, we were dependent upon water-holes filled by it for the next eight days.

From the camp west of the Oscuras we doubled the northern end of the range. Mr. Maxson was sent on a sidetrip up through the Mesa country, while I carried the survey into Jaralosa Spring, where he joined the main party four days later, having gone as far north as Gallinas Waterhole. From Jaralosa we returned to the Oscura Mountains. Leaving the pack-train at a waterhole on the eastern slope, Messrs. Maxson, Goad and myself ascended the range and kept along the crest to the point where it breaks down from the Oscura Pass, thus getting the drainage lines of the whole range. We encamped at an old Indian camping ground; evidences of their former presence in the shape of pieces of raw-hide, ox-horns and lodge-poles were numerous. During rainy seasons there is undoubtedly water at the spring, then dry. Returning to Jaralosa Spring, Mr. Maxson took the east side of the lava flow, I the west, meeting two days afterward at Mal Pais Spring. From here we went to Tularosa, thence to the Mescalero Indian Agency. Here Mr. Maxson was again detached to go to Elk Spring, while with the main party I went to Dowling's Mill, and returned to the agency and back again over different routes. Mr. Maxson joined the party again and was detached to go to the southeast to Whitetail Spring, thence to come into Fort Stanton, which post we reached November 11; staid there three days and then started on our route toward Fort Union, following the main route toward the Pedernal, by way of Posos del Pino or Alkaline Holes. A detour was made from the Gallinas ranch to the Berendos Spring, at the eastern foot of the Gallinas Mountain; here we were snowed up two days; the grass being covered, our animals suffered for forage. A second detour was made from Posos del Pino, bringing us to the eastern Pedernal Waterholes from the southeast. From here we went down the Piedra Pintada Cañon, crossed the Pecos at Giddings ranch; thence by way of Los Tanos to Cuervo Peak, which we occupied for triangulation. A heavy snow-storm detained us here again. From there, passing to the east of Mesa del Pino, we plodded through the snow, crossing the Conchas above Barredera, and occupied Corazon Peak as a triangulation station; thence by way of Trementina we made a loop about the Mesas between Rincon de la Corazon and Rincon del Mesteñito, and ascended the high Mesa by the Olguin Hill; thence by Cherry Valley we traveled to Fort Union, the point of disbanding. The last seven days had been through heavy snow; the grass being entirely covered, the mules could only feed on the oak bushes, and were consequently so worn out for want of forage that marches were cut down to 10 or 12 miles. Prior to these snows the train and riding-mules had been in superb condition, as good as when taking the field, but a seven days' fast was too much for even mule-flesh. Reaching Fort Union December 3, the property was stored there and the party disbanded.

DESCRIPTIVE REPORT.

The country from Fort Lyon, Colo. to Constancia, N. Mex., on the Rio Grande, has been described in former reports. Suffice it to mention a few points of interest. The Costilla Cañon, formerly considered impassable, now has a well built road through it, and is one of the prettiest in the whole range east of the Rio Grande. The road descends from the divide north of the Costilla Peak at the head of the Vermejo, into a beautiful open valley, an amphitheater, in whose grassy glades large herds of sheep are grazing, dotting the banks, between which runs the Costilla Creek, a beautiful trout stream, from 2 to 3 feet deep; in places 4 to 6. The nicely rounded slope, clothed in its many-shaded forestry from the somber wintry green of the spruce to the bright dancing leaves of the aspen, suddenly puts on a rugged, bolder front as the cañon narrows, forcing the road from bank to bank, now avoiding some jutting trachyte point, crossing here and there but to recross, till finally it is pent up by this rushing, roaring stream which fills the cañon from side to side, leaving not even a bridle-path, with no room on either side, the stream itself impassable, the practical engineer has built a trellis-work over the bed of it. Roughly constructed of heavy pine timbers, it carries the roadway over the foaming waters beneath, till the cañon widens out and again allows the road space on the bank. There are many other cañons deeper in Colorado, but few surpassing it in beauty. It is in strong contrast to the forbidding aspect of the sandy hills at the mouth of the cañon, where Costilla is situated claiming both Colorado and New Mexico, the line running through the town.

The next point of interest is the Taos Pueblo, the most important excepting perhaps the Zuñi of the Indian Pueblos in New Mexico. With a history back to the first Spanish occupancy of the country, an existence dating indefinitely long before that date, a prominent center, in whose council chambers the plans of uprising took form in the first determined expulsion of the Spaniards from the country, it can but be regarded with interest. Here they have raised their crops, herded their goats, manufactured their pottery, lived their apparently objectless lives for hundreds of years, seemingly with no ambition other than the privilege of existing. They have not changed; they are living proofs of the truth of the Spanish reports concerning them over three hundred years ago. The same two principal houses stand which Vargas attacked in 1692, in all their quaintness, built of adobe or sun-dried bricks, five or six stories high, each story receding the depth of a room, without doors, entered from above by ladders; they are faithful witnesses of the lack of change in this section, while ruins of similar evidences point to the great changes that have taken place farther south in the Territory. We afterward passed through Picoris, an Indian town, dating back probably as far as Taos; it is smaller and more squalid-looking, but as intimately connected with Santa Fé's early history. The country west of the Rio Grande, from Magdalena Mountains to Palomas Creek, fell in the belt to be surveyed by the party. The Magdalena Range is a high abrupt range, culminating in a point over 11,000 feet elevation, which shoots up above timber line. Rather rounded on top, it required a large monument to be recognized a hundred miles. Its flanks, where not too rugged, are covered with heavy pine timber. The trend of the range is very nearly north and south. At the northwestern end, the mines of massicot, argentiferous galena and carbonate of lead, might be worked to advantage, as also, when transportation becomes cheaper, the copper and gold-bearing copper ores.

The principal waters of the range are the Cañon de Aqua, a running stream heading just east of and under the highest point of the range, the Sawmill Cañon stream, and Spring Hill Creek. Besides these there are numerous springs on the east and south, the principal of which are the Burro, Cienaga, Carrizos, and Tusas Springs.

Game is very abundant in these mountains; bears, white and black tailed deer, and turkeys are very numerous. Fine pine timber covers the slopes. About the base there is a scrub growth of piñon, pine and cedar; also a few walnut-trees along the creeks. The grazing is very good.

The country rock is metamorphosed granite at the south end, capped by limestone on the northwest. To the southeast, connecting as a spur, is a low range of hills of eruptive rock. The plain between the Magdalena and San Mateo having here and there croppings of basalt, the volcanic formation becomes more and more apparent.

The San Mateo Range, the southern end of which (though not the highest, by far the best point) was occupied for triangulation, rises abruptly from the valley plain, particularly on the south. Much broken by deep cañons, with precipitous faces, it was very difficult of ascent. The snow fortunately filled the crevices in the beds of loose rocks, enabling us to cross them, which otherwise might not have been possible.

From San Mateo stretches to the southeast the plateau country of the valley of the Rio Grande, bounded on the west by the bare black hills of plutonic rock, parallel to which run the Mimbres. Beyond these, to the southwest, lies the great interior basin of the Upper Gila, which stream breaks through its encompassing ridges between the Diablo and the Mogollóns, running in a cañon of over a thousand feet deep.

To the north of this great plateau basin, veined by its deep black cañons of eruptive rock, lies a second basin, the plains of San Agustin, with no river to encañon it. Here and there a green spot or a few thousand sheep mark its few springs.

As yet the San Mateo Range is left almost entirely to the Indian, the deer and bear, but the prospector will soon find his way there, to be quickly followed by the miner. About its base the noise of one or two cattle-ranches or an indifferent logman occasionally breaks in upon the silence of nature. The country rock is trachyte; about the base, hills of basalt, of a much later date, break up the slope into many drains, the Nogal Creek, from the southeast, being the principal one. Between the San Mateo and the Mimbres drainage is the Cañada Alamosa, a wash from three to four hundred feet deep; in places narrow, at others fully a half-mile wide. It is similar to the Cuchilla Negra drain, the Palomas, Animas, and others to the south. They are very marked features of the plateau, sloping gently from the base of the range to the Rio Grande. Between them the country is almost flat. Their presence is hardly suspected till you reach their precipitous banks, which give them more the appearance of great furrows than anything else. In the Cañada Alamosa there is a hamlet of the same name, as also in Cuchilla Negra. From the mountains to the town there is running water in these drains. South of these is the Palomas, also a beautiful stream, where the rock, cropping, brings it to the surface, as it does where the cañon breaks through the Negritas Hills. The Rio Grande Valley, from Socorro to McRae Ferry, fell in the district to be surveyed. From Peña Blanca to Parajé Ferry, land capable of irrigation and cultivation on both banks stretches, in varying widths, from 3 miles to a few feet. In some few places the river has encroached upon its banks till it has reached the base of the mesa, as between Contradera and Valverde. Still there is probably not more than one-tenth of the irrigable land now cultivated. The soil, mainly a decomposed basalt, largely feldspathic, is admirably adapted to the cultivation of grapes. Favored by the dry climate, the culture of this fruit will doubtless cause this country to rival California in its wines at no distant day. The lack of knowledge of the manner or means of handling the grapes properly seems the only difficulty. From a few miles below Parajé Ferry to McRae, the river is more or less encañoned, leaving little irrigable land, the greater portion of which lies in the vicinity of San José, a hamlet on the west bank, about 20 miles below Craig, and at Alamocita on the east bank, about 25 miles below the same post.

The Fra Cristobal Range rises abruptly from the plain of the Jornado del Muerto, the elevation above the plain on the east being about 2,000 feet, the western face, which is nearly vertical, being about 2,500 feet above the river. The formation is limestone, on metamorphosed sandstone. The strata are nearly horizontal. The point selected as a triangulation station, though not the highest, is far the best marked. The legendary origin of the name is that during the early settlements a priest by this name had been buried at the northern end of the mountain; that since then it had assumed in outlines his profile. It needs but little assistance of the imagination to trace the gigantic face as seen from Fort Craig.

It was the point of the nose, a detached mass of limestone, quite difficult of ascent, that we occupied as the triangulation station. The monument, 6 feet high, did not show as a pimple to the naked eye on the good friar's nose from the base, although easily perceptible with the instrument from triangulation stations. The Indians formerly used the point just to the north of this as a watch-tower from which to descend upon the trains crossing the Jornado del Muerto, the dreary waste stretching for 90 miles to the south. The only water on this forbidding trip was at the Ojo del Muerto, fitly named the Spring of the Dead, from the danger attendant upon any one who dared enter the cañon closely guarded by the Apache Indians. Indeed, travelers rarely went to it, preferring to keep out on the plain where the approach of Indians could be seen. Of late years the route has been safe, owing to the occupancy of the post of McRae, and water is now had at Toussaint's ranch and the Aleman, the supply of the former being brought from Annaya Spring; at the Aleman is Martin's Well. There is little chance for water in the narrow ridge of the Fra Cristobal; with the strata cut off on both sides, there is no opportunity for it to collect. At times there is a little on the western slope, about a mile and a half north of the triangulation station, which gathers in a hollow in the rocks from a dripping spring, which, drop by drop, runs perhaps two or three gallons a day in dry weather; at other seasons of the year sufficient for small herds of sheep.

At the southern end, also on the western slope, embowered in walnut-trees, is another spring giving a very little more bountiful supply; a third between Alamocita and Fort McRae. About a mile east of the road runs still more water, but it is very much impregnated with lime and a trace of sulphur. These three constitute the water supply of the Fra Cristobal Range. A few horses would keep these dry at most seasons.

The Jornado del Muerto is covered with a fine gramma grass. East of the stage-road about 4 miles, and about 20 miles from Fort Craig, is the Annaya Spring, quite alkaline in taste, but well suited to cattle. It is on the edge of the cropping of the limestone formation.

The San Andreas Range bounds the Jornado del Muerto on the east, the northern portion of which was covered by our work. It is a fit border for this broad, dry plain. Almost equally without water, it was only by taking advantage of the rainy season that we could work at all in the district. A little spring, which as most distinctive was called Dripping Spring, runs about enough water in a day for four mules or horses; this would have been the only water in 1,500 square miles, but for the rainfall which had filled the pools. The ridge breaks down in San Andreas Pass to very nearly the level of the plain, the San Andreas Mountains being to the south, the Oscura to the north, the principal point of the San Andreas being the large dome-shaped mountain which is called Salinas Peak. It is covered with timber to its top. The divide to the south is much lower, and the country breaks into hogbacks, with large cañons running to the east, well grassed but almost destitute of water. Several old indian camps were found, where they had been making mescal. East of this ridge lies the Mal Pais Basin, probably the bed of an ancient ocean which has left behind it but a small salt lake, fed by the brackish water of the beautifully clear Mal Pais Spring.

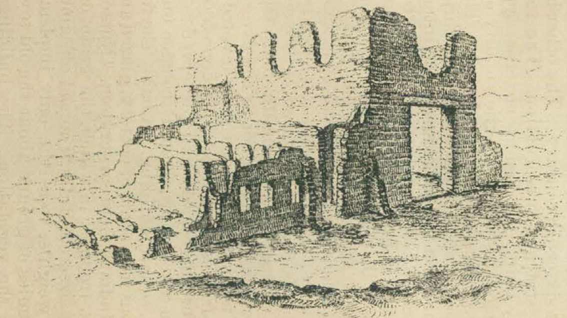
This basin, which extends from the vicinage of the Gran Quivira south nearly to

Mexico, was surveyed from an east and west line running a few miles south of Mal Pais Spring to its northern limit. It is bounded on the west by the San Andreas and Oscura Mountains and the Chupadera Mesas, and on the east by the Sierra Blanca, Carrizo, Jicarilla, and Gallinas Mountains. A great flow of comparatively recent lava has at one time in its seething, boiling blackness burst forth from a little crater at the north, and wound its way, a molten stream, for over 40 miles. An unsightly, forbidding barrier, it stretches from northeast to southwest, a natural wall, only to be crossed at two places; one about 5 miles south of Jaralosa Spring, a wagon-crossing; the other immediately abreast of it, an Indian horseback trail. Like a great black sponge, its cavities open everywhere, its surface hardly passable on foot; it is similar to, though probably rougher, than the lava-fields of California.

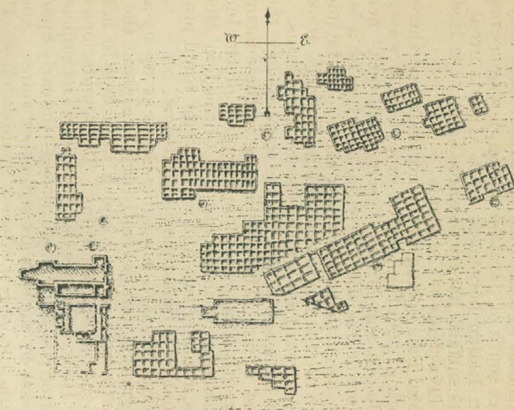
On the west side, from that point of Mal Pais Spring to the northern end there is no permanent water, excepting Mound Spring. On the east, as croppings of water from the mountains, are Carrizo, Jaralosa, Jake's, and Milagro Springs, all quite near the lava. Although holding in solution more or less alkaline salts, they furnish a bountiful supply of sufficiently good water for the cattle-ranches near them. In the midst of the barren, dismal plain west of the lava are the Lomitas or Mound Springs, of exceedingly bitter water. North of the San Andreas Pass are the Oscura Mountains. They are precipitous on the west side, almost impassably so. On the eastern slope they are covered by a dense growth of piñon and cedar. The only spring in these mountains we found dried up. It had been apparently a favorite camping place of the Indians, from the bones strewn about. Between the Oscuras and the Chupadera Mesas is another good pass. In the main drains, running east and west, water could probably be reached by sinking wells. The formation is limestone on sandstone.

North of the Oscuras are the Chupadero Mesas, a low table-land cut up by almost innumerable cañons and drains, well grassed, but perfectly dry, excepting the little water at Chupadero Spring, which has been developed and a tank dug to hold the limited supply. Here we found one of the old Spanish ruins. The foundations of the houses and the churches still remained. Here, where we now find but water sufficient for one family, formerly lived several hundred people, in stone houses—the early Spaniards and their Indian slaves. In the dry mesas to the east are still other ruins. About 15 miles to the east is the Gran Quivira ruin, the largest of these Spanish relics. Fifteen miles from water of the present day lived in this town probably several thousand people. A monument to the dead past, the churches, both over a hundred feet long (the larger being 130 feet long), built in the form of a cross, stand in silent evidence of the energy of the enthusiastic priesthood of the sixteenth century. The other houses, built with a marked regularity, are in various states of preservation. The rooms are all rectangular, and the houses very regularly built. Walled-up cisterns, apparently for the public use, were found at the crossings of streets. In the vicinity of the larger church, the buildings were better built, the rooms being much larger. The cathedral faced the east. The walls are of a limestone shale, the exterior edges chipped square, the interior being rubble. They vary from 2 feet in thickness for the interior walls to from 4 to 6 feet for exterior ones. The interior had formerly been plastered, the woodwork painted. Over the entrance had been a gallery. Some of the beams, with their Moorish ornamental work, still project from the wall. The floor of this gallery consisted of small split poles laid in juxtaposition diagonally from one girder to the next, which girders were squared beams, 11 by 13 inches, placed about 3 feet apart, the sides exposed to view being finished with the squares and circles marking the type of the best of the ornamental work. On these diagonals was a heavy, rudely woven matting or thatching of straw. On the right of the entrance was a small room. Opening from the left transept was a larger one, out of which opened a door to the exterior, also one into the corridor leading to the rooms of the monastery or rooms devoted to the residence of the priest. Many of the window-frames were intact; one door-frame, showing that the door turned on wooden pivots for hinges, was well preserved. The accompanying plates show the plan of the town and the ornamental cornice under the gallery. East of the town was a large, hollow, square building, probably the fort. Everywhere strewn over the ground were numerous fragments of pottery, glazed and unglazed, of queer designs, doubtless the work of Indians held in serfdom. Numerous arrowheads of flint or obsidian, metates or stone troughs, in which the grain or coffee was ground, and small round stones of various sizes carefully trimmed off, similar to those used by the present Pueblo Indians as weights, were the only implements found. Nothing of iron was left. Several square miles of ground about the old town had been under cultivation, as was apparent from the vegetation. The buildings seemed of two dates, those about the eastern church, which was evidently the older, being built with smaller rooms, with the streets parallel to the church, running at an angle to the east and west lines on which the better part of the town was built. The difference in preservation may have been due to having been built less substantially for the lower class, but I think the other theory more probable. Some fifteen miles to the east were the Indian ruins of the Pueblo Blanco. To the west were other ruins, both Indian and Spanish. For sketch at Gran Quivira ruin see plate opposite.

GRAN-QUIVIRA, NEW MEXICO.

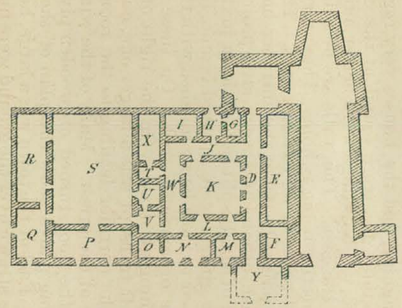


Ruins of Church and Cloister,
(From S.E.)



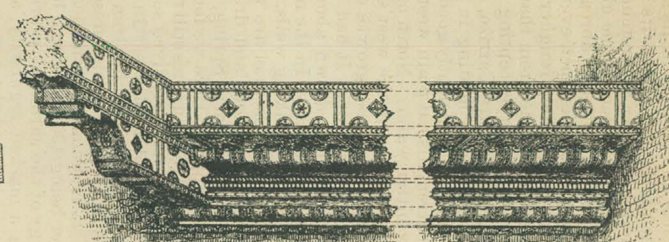
General Plan-View.

SCALE 300 Ft.



Plan of Church and Cloister,
(Restored.)

SCALE 100 Ft.



Carved Wood Cornice.
Under the Gallery.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

In all this country there is not now a drop of permanent water, such changes have three hundred years made. The country described by Juan Jaramillo, one of Coronado's captains, in 1542, as being "as beautiful as any he had seen in all France, Spain, or Italy, and watered by many streams," is to-day utterly dry, covered, to be sure, with nutritious grasses, but otherwise almost a desert. Driven from here about 1680, the country was not again occupied by the Spaniards.

The Pueblo Blanco, to the east of Gran Quivira, at the edge of the Jumanes Mesa, north of the mouth of the Gallinas Cañada, probably antedates the latter. It is undoubtedly of Indian origin, and yet at the time of Coronado's expedition and the subsequent ones to the Quivira country, the Indians are represented as living in temporary habitations, consisting of a framework of poles thatched with straw, while these buildings are of stone. There are no remains of furnaces at the Quivira, and the absence of slag, only one or two pieces of which were found, would indicate that the town was rather the agricultural center, from which the mining population gathered its supplies, than the smelting town itself, as has been surmised by many. Tradition gives this ruin as the hiding-place of fabulous wealth, and numerous parties have dug haphazard over the ground, particularly in the region of the cathedral, looking for the silver and gold fondly believed to have been concealed there when the priests were compelled to abandon their churches, the soldiery their barracks, and flee to Old Mexico, or New Spain, as it was then called. Occasionally an unheeded skull or fragment of bone has been the only treasure developed. It is of much more interest archæologically than it ever probably will be in gold or silver. The great change in its water features may be the result of the gradual rising of this section, once an interior ocean, and the filling in of this basin by the denudation of the surrounding mesas. North of the Gran Quivira little evidence of volcanic action is apparent. Farther south plutonic rocks are found, of widely different ages and lithological characteristics. The most recent is the lava-flow before mentioned. I find no mention of this lava belt in the old Spanish journals, and yet it is so marked a feature that it should hardly escape notice.

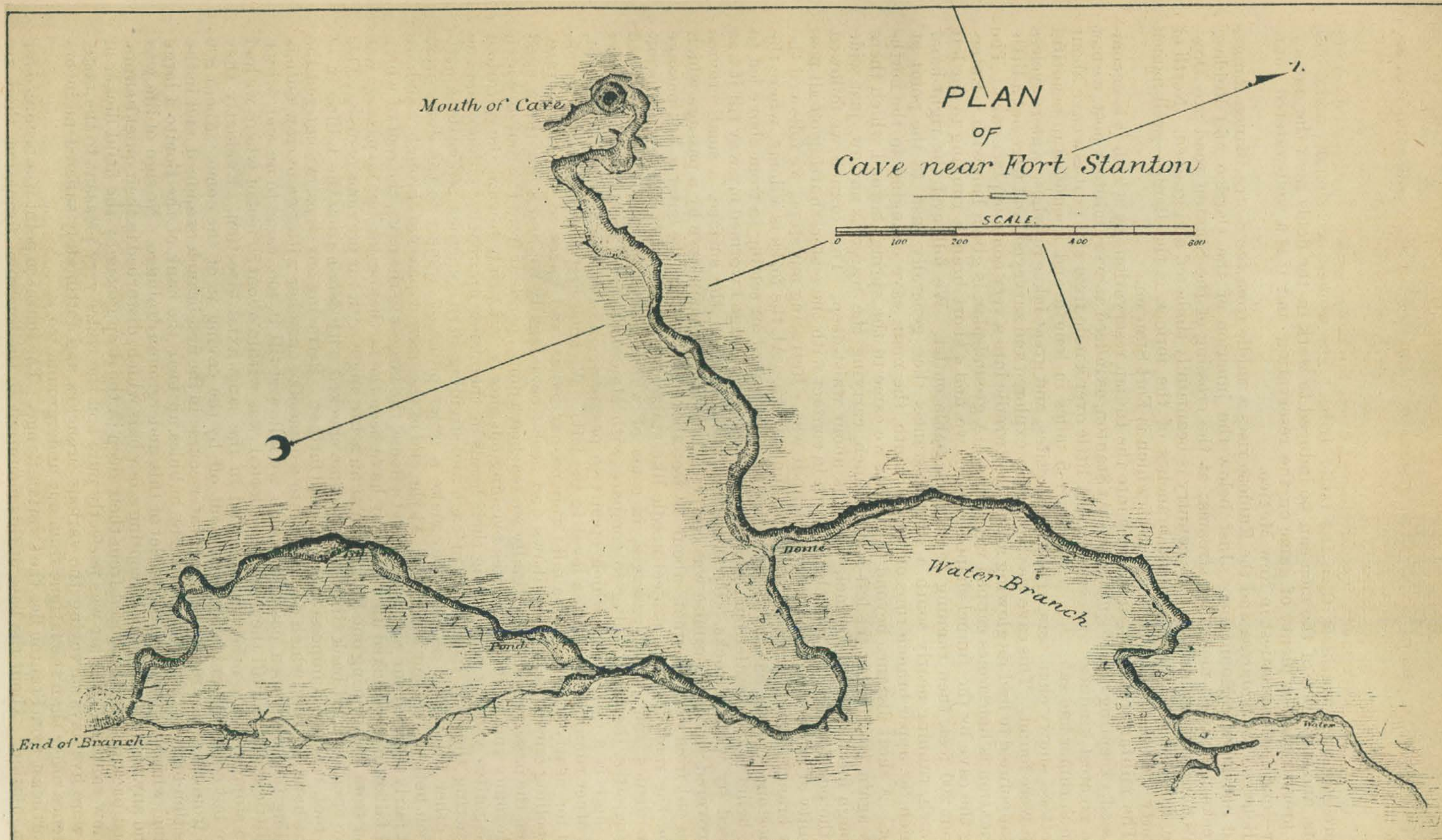
East of this great basin numerous detached ranges, from the Gallinas on the north to the Gaudalupes on the south, divide the waters of the Pecos from it. The highest of these is the Sierra Blanca, a noble mass, towering nearly 7,000 feet above the plain at its base, reaching an altitude of 11,900 feet above the sea. It is almost perpendicular on its western face. I know of no mountain in this country which presents so great a rise in so short a distance—that of nearly 7,000 feet in about 5 miles. It is a great mass of quartzite porphyry, trachyte and graphic granite, with limestone about its base, veined with mineral lodes of copper, silver, and gold. As yet the fact of its being within the Mescalero Indian Reservation has kept prospectors, to a great extent, out of the range. It is heavily timbered, particularly on the eastern slope, which is less precipitous than the western, with fine pine and spruce. Above the timber the snowy summit shoots up a thousand feet.

The Ruidosa, Eagle, and Bonito Creeks gather its waters on the east, the Nogal to the north, and the Tres Rios to the west. The short cañons give but little water in the Tres Rios and Nogal Creeks, but the others are fine streams, in the waters of both of which the speckled trout gives good sport to the fisherman. Black, cinnamon, and occasionally grizzly bear, black and white tailed deer, and turkeys, furnish abundant game to the Indian. The elk, once very plentiful in these mountains, is now very rarely seen. It is one of the best watered sections of New Mexico. The Tularosa Creek draws its waters from the northeast end of the Sacramento Mountains, a high, timbered plateau broken up by deep cañons into narrow ridges, the summits of which are nearly on a level. The town of Tularosa is on the plain, near where the stream debouches from the mountains. It is eminently a Mexican town, with its irregular streets, adobe houses, squalid idlers, ragged urchins, and full allotment of wolfish-looking dogs. Notwithstanding its proximity to the mountains, much of the wood here used is the mesquite root, which gives an intensely hot fire. Considerable grain and the staple frijoles or Mexican beans, and chili, are raised in this vicinity for trading with the Indians and to supply trains passing through, many of which, to avoid the sandy Rio Grande Valley route, follow this much drier one. It is, though farther, cheaper in the end, as they graze their oxen, while they would have to feed them in the more settled river country. At Tularosa Indian Agency we found the agent just finishing an issue of rations to the happy-looking group of Apaches, and are indebted to him for assistance in getting the list of Apache words already submitted to you, which was enlarged and revised by the assistance of Dr. Appel, the surgeon at Stanton. The Indians are very uncommunicative as to their religion, marriage ceremonies, and funeral rites. It is only by living with them and becoming almost as one of them that the true inwardness of these forms can be arrived at. The varying reports make it unsafe to venture a description of them, other than the wedding seems to be a barter arranged between the groom and the bride's parents. They bury the dead usually on hills, and cover the body with branches and stones. I was not long enough near them to arrive at any idea of the construction of their language. The fact of their using a double negative, and of the decimal system of notation, is of some importance in any effort to trace connection with other tongues. They average below the medium stature, are of scant angular frames, of larger bones, but less symmetrically built than the Navajoes, and have much less intelligent faces, are more squalid in appearance, and more generally worthless than the latter tribe. The women occasionally make baskets, and some few of the men can be induced to work in the fields near the agency. At present there is plenty of game on the reservation, and it is a well-watered country—one of the prettiest in New Mexico.

Between the Tularosa and the Ruidoso rises a saddle from the Sierra Blanca Ranges and Sacramento Mountains. Just below the junction of the Carrizo and Ruidoso Creeks flow swift mountain streams; at the crossing of the Stanton road are Dowlin's flour and saw mills. This country is beautifully timbered and grassed. North of the Ruidoso and Eagle Creeks, branches of the former, is the Bonito—well-named Pretty Creek—on the right bank of which is Fort Stanton.

The military reservation tongues into the Indian reservation, by which it is encompassed, excepting on one short side. At Stanton, as indeed at every military post, we met the greatest kindness and courtesy. A little over a mile from this post is a cave about which rumor had said that it was over 5 miles in length and abounded in beautiful grottoes, snowy chambers, crystal stalactites, and great lakes in whose waters eyeless fish were found. This cave we thoroughly explored and surveyed, and were not a little disappointed to find its glowing mysteries dwindle into a very commonplace cave. The formation is limestones capped with sand. A ground-plan is given herewith. Entering the cave by the funnel-shaped mouth, we find a short branch running to the left about 200 feet, then running to an impassable outlet. We followed the right-hand branch, running nearly south a short distance, then generally east, to the point at which the upper branch runs off to the south, the main cave changing to the northeast. A short distance beyond this point we came to the spring, beyond which there are again two forks; the left-hand branch, carrying the water, is narrow, just wide enough for the water-channel, which is about waist-deep. This branch we followed to the point where the roof closed down in contact with the water, shutting off all possibility of proceeding; and a cold tramp it was. Retracing our steps, we followed the dry branch, which again divided into short forks. At the forks is a dome, where the limestone stratum has caved through, and a current of air setting in from above led to the belief that an outlet had been found. Up this passage I wormed my way till it was closed by wedged rocks. Upon tracing the line upon the surface, a small crevice discovered that our surmise was correct. Leaving the main cave by a passage which runs out from near the roof, about 40 feet above the bottom, we enter a low passage from the roof of which project needle-like stalactites; finally this passage opens out into domes and larger passages, in some of which there are fine stalactites and stalagmites, though nothing to compare with Mammoth Cave, as claimed. Farther on there is a dome from which open two passages, one running down to the right, the other running on nearly a level to the left. We tried first this left-hand branch, and for nearly a quarter of a mile were on our hands, and knees, at times prostrate, propelling ourselves by our elbows and heels; occasionally we had a breathing spell when the passage opened. Finally we reached a dome, pendant from the roof of which were many amber-like stalactites reaching out slowly but surely toward the upturned stalagmites year by year lifting their heads in their slow approach to union, the one gathering the daily increments of each and dividing it in generous proportions with the other till, united as one, they make a great pillar of support to the dome from which both drew their strength. At the end of the narrow passage through which we had fairly wormed our way we reached a dome, the largest in the cave, the roof of which had fallen in and choked up what may have been the farther outlet, but no passage was open from it excepting one leading off at an acute angle with our previous course. This more open way led back till it also became chocked with *débris* from the falling in of the roof, making it impossible to proceed farther. Retracing our steps, we entered the right-hand branch, which decended into a dome-like chamber with two narrow outlets leading to a more open passage, which we followed till it, too, came to an end, which we little suspected, till the work was plotted, was within about 50 feet of where we had been stopped in the other passage, and in the same axial direction. Evidently they were but one communication, being cut off by the caving in of the dome. About 800 feet from the point reached on the water-course in the first branch examined, and in the direction of its axis prolonged, there bubbles up near the bank of the Bonito a large spring, which is doubtless the outlet of this underground drainage. No sign of life was found anywhere in the cave, excepting a few bats which, disturbed in their quiet haunts, flitted back and forth, roused from their sleep in the deep gloom by the fitful flicker of our few candles. The air was perfectly pure and the water very pleasant to the taste. We were five days surveying the various branches, and fortunately suffered no inconvenience other than the fatigue from our underground work.

Northeast from Stanton lies the Capitan Range. The southern point was occupied for triangulation. About the base of this mountain, in the limestone formation, there are



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many caves smaller than that near Stanton. West from the Capitans are the Carrizo and Patos Mountains, northeast of which are the Jicarillas. All of these are excessively dry, White Oak Spring, in the Carrizo, being the best water-supply. The little spring in the Jicarillas gives a supply of water for about half a dozen horses.

The placer mines have been worked over for some years with no great returns. An attempt has been made to use a dry washing-mill by which the gravel and sand is sifted out, but it has not proved a success. There is certainly gold in these mountains, but as long as they are forced to carry water 10 or 12 miles to wash it, it cannot be considered to be in paying quantities. The little Tecolote Hills, to the north, will be, some day, of importance, as having plenty of fuel-wood, piñon and cedar, about the base. Northeast of these lie the Gallinas Mountains, a densely-wooded range in which game is very abundant, and the four or five springs are a saving clause to classing the great belt of country as destitute of water. Northeast of the Gallinas some 15 miles are the Posos del Pino, sometimes called the Alkaline Wells. The country traversed between these wells and Fort Union has been described in previous reports.

The country in atlas sheets 77 D and 84 B is nearly all grazing-land, excepting such agricultural land as is found along the Rio Grande, on the Tularosa, Ruidosa, and Bonito Creeks, and in the Manzano Mountains along the streams. All the mountain districts grow timber. In the Manzanos, Gallinas, Capitan, Nogal, and Sierra Blanca Ranges there is timber suitable for lumber. The other mountains yield but fuel-timber. In the vicinity of the salt lake east of Punto de Agua and that one near Mal Pais Spring, the land is barren.

The following is a summary of the topographical work done by the party during the season:

Total area surveyed about 8,000 sqare miles.

Number of main triangulation stations occupied	12
Secondary triangulation and topographical stations	60
Three-point stations	666
Stations on traverse lines or meander stations	2,933
Points at which the variation of the needle was determined	102
Cistern barometer stations occupied	278
Aneroid barometer stations occupied	1,828
Horary curves determined	3
Rivers gauged	1
Pointings made on triangulation stations	6,590
Miles meandered	2,869
Total miles travelled	3,602

The successful accomplishing of the work allotted the party is due to the untiring energies of the assistants who individually and collectively worked to bring about the best results. I desire to thank them all. This was the second season. I was fortunate enough to have Mr. Maxson as my principal assistant, and cannot express too highly my appreciation of his intelligent energy. Mr. Goad and Mr. Davis, indeed all, in their special work, led to a harmonious whole.

I am, very respectfully, your obedient servant,

CHAS. C. MORRISON,
First Lieutenant Sixth Cavalry.

Lieut. GEORGE M. WHEELER,
Corps of Engineers, in charge.

APPENDIX G.

EXECUTIVE AND DESCRIPTIVE REPORT OF LIEUTENANT M. M. MACOMB, FOURTH ARTILLERY, ON THE OPERATIONS OF PARTY NO. 2, CALIFORNIA SECTION, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., May 1, 1878.

SIR: I have the honor to submit the following executive and descriptive report of the operations of party No. 2, California section, of the survey under your charge during the field season of 1877.

I left Washington by your orders on the 12th of May, 1877, and proceeded direct to Carson, Nev., with instructions, as acting assistant quartermaster and assistant commissary subsistence of the California section, to receipt for the necessary supplies and transportation, which, by previous arrangement, were to meet me at that point, as well as to attend to the boxing and shipping of certain stores pertaining to the survey and stored at Carson, which would be needed at the headquarters of the Utah section at Ogden.

Arriving at Carson May 19, I found Lieutenant Wotherspoon, Twelfth Infantry, with the animals which we were to use during the season. Receipting to him for 50 mules and 2 horses, the remainder, 28 mules and 1 horse, were, on the 28th, shipped to Ogden. The other property needed there was sent off soon after, and on the 25th, nearly all of our *matériel* and several members of the survey having arrived, our rendezvous camp was established. Lieutenant Symons arriving on the 28th, I reported to him, as instructed, and the work of organizing the different parties went on under his supervision. This was completed under your own eye during the first week in June, and on the 9th of that month we took the field. Party No. 2, organized for topographical and geological work, was assigned to my charge with the following *personnel:*

Lieut. M. M. Macomb, Fourth Artillery, executive officer and field astronomer; Mr. W. A. Cowles, topographer; Mr. A. R. Conkling, geologist; Mr. E. L. Vail, meteorologist; Mr. J. B. Callahan, odometer recorder; Mr. C. W. Howell, chief packer; one assistant packer, one man-of-all-work, and one cook. Total, nine men.

The transportation consisted of 11 pack and 9 riding mules, with a bell-mare and one extra animal. Total, 22 animals.

The instrumental outfit was as follows: One sextant for latitudes, two ten-second transit theodolites for triangulation, two Young & Son's topographical transits for meander lines and filling in, two Green's mountain barometers, with three aneroids, two sets psychrometers, and a maximum and minimum thermometer for meteorological work, and, lastly, an odometer and vehicle for measuring road distances.

The area assigned to the party embraces atlas sheet 56 B and certain unfinished portions of 47 D (see progress-map). It lies partly in Nevada but principally in California, including in this State all of Alpine and portions of Calaveras, Amador, Eldorado, Placer, and Nevada Counties.

This area, embracing a portion of the main crest and outlying foot-hills of the Sierra Nevada, presents topographical features exceedingly complex, but of the most striking and varied character. Vast, rugged mountain masses, culminating in numerous peaks, bewilder the eye; deep cañons cut in the solid granite open unexpectedly into grassy meadows, while numberless mountain lakes, sparkling in the sunlight, everywhere brighten the landscape.

In the winter millions of tons of snow collect in these natural reservoirs, furnishing, during the long, dry California summer, the water-supply of the parched foot-hills. The area is drained to the west and southwest by the numerous ramifications of the American, Mokelumne, Stanislaus, and Tuolumne Rivers, the two former being tributary to the Sacramento, the others to the San Joaquin. These streams flow in deep cañons separated by long, gently-sloping ridges heavily timbered, and presenting few salient points, making their location by cross-sights very difficult.

The drainage to the north and east is by the Truckee, Carson, and Walker Rivers, all of which are tributary to the great interior basin.

The greater portion of the area is magnificently timbered, principally by various species of conifers, from the stunted nut-pine on the east to the gigantic redwoods of the Calaveras Grove. Oak is also found on the long ridges as they fall away to the west, and now and then a thick growth of manzanita and white thorn, with some mountain mahogany. Thickets of quaking aspen occur on nearly all the mountain streams.

The principal routes of communication between the east and west of this section are, first, the Placerville and Virginia wagon-road, crossing the main summit at Johnson Pass; next, the Amador road, leaving Carson Valley near Woodford's and passing through Hope Valley and over the Carson Pass; then, still further to the south, the Big Tree road, crossing the Sierra at Silver Mountain Pass, running through the Calaveras Grove and connecting Silver Mountain City with Murphy's and other mining settlements in the foot-hills; and, finally, the Sonora and Mono turnpike road, between Sonora and other towns on the western slope, and Aurora, Bodie, Bridgeport, in the Mono mining country. There are no great thoroughfares running north and south, but numbers of stock-trails occur, perfectly passable for pack-animals.

To work up the above area it was decided to move the main party as follows, supplies having been forwarded to Placerville and San Andreas on the west, Silver Mountain City near the center, and Bridgeport in the east:

1. Up the Carson Valley and along the west fork of that river into Hope and Faith Valleys, then westward to Pleasant Valley, on the edge of our area, occupying all points adjacent to our route important for triangulation and topography.

2. Northward, with a month's rations, to the unfinished portion of sheet 47 D, beyond the Central Pacific Railroad, connecting with the work being done in the vicinity of Lake Tahoe by Mr. Weyss, and fixing the more important points needed by him, returning to Placerville about the end of July.

3. Eastward to Silver Mountain City and Bridgeport, with supplies for August, oc-

cupying a part of that month and all of September in the mountains to the east and southeast.

4. Westward for the last time to San Andreas, in the southwest corner of the sheet, passing over the Sonora and Mono wagon-road, and returning by the Big Tree route, connecting with the work previously done to the northwest of this road, and bringing up in Carson during the first week in November.

5. Into the Pine Nut range, occupying the rest of November in the triangulation and topography of these mountains, which would be finished about the time for disbanding.

In accordance with this plan the party left the rendezvous June 9, and camped on the Carson River, about a mile and a quarter east of Genoa. As is usual on the first march, the mules gave a good deal of trouble, especially as my chief packer was suffering from an attack of rheumatism contracted at the rendezvous camp. My assistant packer, moreover, struck for higher wages than I thought he was worth, so that I was obliged to discharge him. Fortunately, at Genoa I fell in with an ex-sailor who had had considerable experience in packing, and secured his services. We were thus able to proceed with only a day's delay, and the next camp was Woodford's, at the mouth of the Carson Cañon. Here Howell became so much worse that he was unable to walk or ride, and I therefore left him at the Hot Springs near Genoa to recuperate, with orders to join us at Placerville. His temporary absence was much regretted, as it of course interrupted to a great extent the facility and rapidity of our movements.

Moving up the Carson Cañon we camped in Hope Valley, at Stevens' ranch, from which base we occupied triangulation stations on Cary's and Stevens' Peaks. Leaving Mr. Cowles here to occupy certain points for topography, I made a detour to the north, and occupied Freel's Peak for triangulation. I then rejoined the main party, and moved by the Carson Pass into the valley of Twin Lakes, camping at Caple's ranch. From here we made a triangulation station on what is locally known as Silver Era Peak, but which is called by the United States Coast Survey "Round Top," and is one of the points in the belt of triangles which they are now running across the continent. We also occupied, for topography, a dome-shaped peak, properly called Round Top, and then moved to Tragedy Springs, on the Amador road. This spot takes its name from the fact that many years ago three men were murdered here by unknown hands, and their bodies burned. The charred remains were buried by some of the early settlers, and a rough heap of stones marks the grave, a lofty pine bearing their epitaph.

From here we made a detour to the south, occupying Mokelumne Peak for triangulation and a number of stations for topography. This work completed, we moved westward to Pleasant Valley, following the main road for about 3½ miles beyond Tragedy Springs, and then taking a branch road running along one of the long wooded ridges previously mentioned. We spent a couple of days here writing up notes and taking in supplies from Placerville, some 10½ miles to the west. We were there rejoined by Howell, who had nearly recovered from his attack of rheumatism.

June 30 all was ready for our northern trip, and, therefore on that day, taking Pyramid Peak as an objective point, we struck out on the Placerville and Virginia road, following it as far as Georgetown Junction, and connecting with last year's work. Here we left the main road, and camped at Sawyer's ranch July 2. We obtained here our first news of the special party under Mr. Weyss, and learned that they had left only a few hours before for McKinney's, on Lake Tahoe, having occupied the peak for topographical purposes. July 3 we ascended the peak, but the day was so rainy and misty that we could do no work. The 4th, however, proved more favorable, and we celebrated it by successfully completing our object. Unfortunately, the cold raw weather again laid Mr. Howell up with rheumatism, and partly on this account I moved westward into the foot-hills, camping at Hotchkiss Ranch, near Georgetown. At this town I obtained much valuable information as to the topography of the American River drainage, from Mr. Pease, superintendent of the California Water Company, who kindly furnished me with a map of this section, by Mr. Bowman, embodying the results of careful surveys made for the company.

The climate here is delightful, the air being so dry that the hottest days are comparatively comfortable, while the nights are always cool and bracing. On this account I left Howell here to complete his recovery, as it would have been folly for him to attempt going into the mountains with us.

We therefore started northward, and camped in Squaw Valley July 15, having occupied several topographical stations and fixed a number of points by cross-sights. Here we found the special party encamped, and I was glad of the opportunity of comparing notes with Mr. Weyss. We occupied the "Needle" (the point which I was unable to reach last year) in conjunction, and selected several peaks for future use. I then moved up to Summit Station on the Central Pacific Railroad, whence Castle Peak was occupied for triangulation, and then down the South Fork of the Yuba to Cisco, near which point a topographical station was made.

Traveling from here up Rattlesnake Creek, crossing the divide and passing through

Ossaville, we encamped at the old mining town of Meadow Lake. This place, now inhabited by only three or four families, was, in 1865–'66, the scene of a great "gold fever." It then claimed some 3,000 inhabitants and was, at least, large enough to sustain a theater, near the ruins of which we raised our tents. This place has an altitude of 7,377 feet, and the snow in winter sometimes entirely covers the houses. I was shown several specimens of the long Norwegian snow-shoe which is used by mail-carriers and others when other modes of locomotion are impracticable. From this base we made Mounts Lolo and Jackson, both of which have been occupied by reconnaissance parties of the Coast Survey.

Finishing here, we turned southward and occupied Red Mountain, near Cisco. This point commands a very extensive view of the great snow-shed which extends for miles east and west of it. On this account it has been recently selected by the railroad company as the site of an observatory from which to detect in their inception the numerous fires to which the structure is liable, and telegraph the news to the relief stations.

Our next camp was at Berkeley Soda Springs, which are situated just ten miles by wagon-road to the southward of the railway, and are becoming quite a place of resort for tourists and visitors from San Francisco and other cities of the State. A good horseback trail connects the springs with Lake Tahoe.

Continuing on our way southward, we crossed the drainage of the American River and camped at Hotchkiss's ranch July 31. Here we found Mr. Howell completely recovered, so that we were now able to continue the work with our full complement. Passing next through Placerville, for mail and supplies, we moved eastward to Charity Valley, lying to the south of Hope and Faith Valleys. While here we occupied several topographical stations, connecting with our previous work. The west fork of the Carson heads in Hope and Faith Valleys, while the waters of Charity are tributary to the east or main fork through Markleeville Creek. These little valleys afford abundance of excellent grass, and are occupied every summer by dairymen, who drive up their herds from the foot-hills as soon as the snow melts off.

Our next camp was Indian Valley, which drains to the Mokelumne. This we found taken up by sheep-herders, whose numerous flocks had made sad havoc with the once luxuriant grass. After occupying a point near here, a detour was made to the Blue Lakes, and a topographical station made in their vicinity. These lakes are tributary to the north or main fork of the Mokelumne River, and are used as storage reservoirs by the Amador Canal Company. They have, I understand, been spoken of in connection with a scheme for supplying San Francisco with water. Some fine grazing land in their vicinity is used as pasturage for sheep. These lakes are accessible by a mountain road leaving the Amador road near Williams's Rock. A mining hamlet, now adandoned, on the ridge between Williams's and the lakes, bears the name of Summit City.

From Indian Valley moved to Hermit Valley and then to Pacific Valley, both on Big Tree road, occupying several topographical stations, and camping August 14 in Bear Valley, near Blood's toll-house. Here and in Hermit Valley we found large herds of sheep collected for shearing, these stations being convenient for that purpose on account of being on the Big Tree road.

Our next move was to occupy some points to the southeast known as the Dardanelles, after which we proceeded to Silver Mountain City, reaching it August 18. While here we occupied the important points in the neighboring mass of mountains, that nearest the town being known as Silver Mountain. We named the loftiest point, which was one of our most important triangulation stations, Highland Peak.

From this camp we made a detour occupying from August 24 to August 31, during which time we visited Monitor, Markleeville, Mogul, and Silver King (the two latter deserted mining-camps), and studied the topography of Diamond, part of Antelope, Sluyert's, Silver King, and Bagley Valleys.

On our return to Silver Mountain a couple of days were spent in preparing a transcript of observed angles and a plot of the triangulation as far as completed, for use at headquarters. We then moved camp to near Highland Lakes, and occupied several prominent points in the vicinity for the purpose of studying the topography about the headwaters of the Stanislaus and Mokelumne Rivers. In the immediate vicinity of the lakes a number of prospect-holes attest the former presence of a mining-camp, which bore the name of Highland City, although there is not now a vestige of a house remaining.

From here we crossed into the Carson River basin, and encamped, September 5, in Golden Creek Cañon, near Dumont's wood-camp. At this point, and others in the same drainage, large quantities of fire-wood are annually cut to supply the market created by the Comstock mines. This wood is cut and corded during the summer and winter, and when in the spring the river and its tributaries are swollen by the melting snow, it is floated to its destination in the Carson Valley; most of it being collected at Empire City, on the Virginia and Truckee Railroad, and thence transported by rail to the mines.

From this camp, on September 6, Messrs. Cowles, Vail, and myself made a station on a neighboring peak in the divide between the Carson and Stanislaus. It will remain ineffaceably fixed in our memories as the scene of a sad and terrible accident to one of our party. We had finished a very successful day's work, and were completing our labors by putting up the usual monument, experiencing considerable difficulty in finding suitable material, the peak being composed of large fragments of heavy magnetic rock. In attempting to detach a small piece, Mr. Cowles loosened a heavy mass, which, slipping from its bearings, precipitated him some 15 feet upon the jagged rocks below, passing over his legs as it rolled on. Mr. Vail and myself, on hastening to his assistance, were inexpressibly shocked to find that both legs had been broken below the knee, but immensely relieved to find that he had escaped with his life. We carried him in our arms as best we might over the uncertain footing afforded by the loose rock, until we reached a spot level enough to put him down. Leaving Mr. Vail here to look out for him, I procured the assistance of some wood-cutters, who were fortunately at work about 2 miles from the scene of the disaster, and with their assistance constructed a rough litter, on which, with great labor, we bore him down the steep mountain-side to a small flat where there was a deserted cabin. Here assistance reached us from our own party, and, after working all the next day, we succeeded in getting him to our camp late in the afternoon, where we found awaiting our arrival a physician, who had been sent for to Genoa, some 55 miles away. He found that both bones in each leg had been broken in several places, but, owing to the fact that Mr. Cowles wore a heavy pair of riding-boots at the time of the accident, there was but little mangling of the flesh, and relieved our anxiety immensely by stating that he thought both legs could be saved. Meantime, before the final operation of setting could be performed, the patient would have to be taken over 50 miles to Genoa, which was the nearest point where suitable attendance could be procured. This long journey was performed September 8, in a spring wagon, which we were fortunately able to obtain. Mr. Cowles bore his injuries with remarkable fortitude, retaining full possession of his faculties, and remaining quite cheerful throughout this most severe trial. I was necessarily detained some days at Genoa, attending Mr. Cowles during the setting of his legs and providing for his future comfort. Not being able to reach you by telegram, I thought it best to carry on the work as well as might be without a topographer, until I could hear from you at our next mail-station, and accordingly, having detailed one of my men to look after Mr. Cowles until further orders, I rejoined the party September 15.

The next day I made a side trip up the Carson, camping near Stanislaus Peak, on the divide between that river and Clark's Fork of the Stanislaus. A high point overlooking Sonora Pass was occupied for triangulation, and Stanislaus Peak for topography, this latter point bearing a fine monument erected by a reconnaissance party of the Coast Survey. Looking southerly from these points, a fine view of the Sierra is obtained in the direction of its axial line, mass after mass of snow-capped peaks rising one behind the other in grand but almost inextricable confusion. Finishing here, I moved into Fish Valley, also tributary to the Carson, and camped at some soda springs near its head. This valley is naturally furnished with abundance of fine grass, but this had been almost entirely consumed by large herds of cattle which had ranged through here during the summer, and the mules eked out their scanty meal by licking industriously at the saline deposits in the neighborhood of the springs.

Remaining long enough to finish the topography of this little basin, I crossed into the Walker River drainage, passing down Silver Creek and coming out upon the Sonora and Mono road, which I followed to Bridgeport. Here the mules were shod and supplies taken for a trip to the Sweetwater Mountains, for which I set out September 27. After making several topographical stations I visited Sweetwater Peak, the highest point in the range, September 30. The wind blew a perfect gale, against which it was impossible to stand without support, utterly precluding the taking of any observations. This state of things continued until October 5, until which time I had been unable to get the required angles, although I visited the peak daily. At last, however, having taken the necessary observations, I passed down Desert Creek, the principal stream rising in these mountains, and made three additional topographical stations, and moved into Antelope Valley, camping near Coleville, an agricultural hamlet. The West Walker flows through this valley, and furnishes the main supply of water for irrigation, the principal crops being hay and barley. I next moved up the cañon of the West Walker, came out on the Sonora road, and returned to Bridgeport. Here we replenished supplies for our final trip westward, on which we started October 14. The weather, which had heretofore been comparatively good, was now growing threatening and stormy, with some snow, making the future success of our operations somewhat dubious, especially since there was not a blade of grass left by the sheep in this section, making it necessary for me to depend entirely on what forage I could carry with me.

After some preliminary work, I crossed the Sonora Pass October 18, camping near the summit. Our observations showed this pass to have an altitude of 9,660 feet, more than 1,000 feet higher than any of the others visited by the party, over which there is a wagon-road. I hoped within the next two days to be able to occupy Castle Rock, a point which I had intended using for triangulation; but the weather proved so bad that I was obliged to give it up, not having a day to spare in waiting for it to clear, since there were still three stations to be occupied in the Como Mountains. We continued to be harassed almost daily with rain and mist until we reached San Andreas. We left here on the 24th, directing our march for the Big Tree road, via the village of El Dorado. We came out upon it at the Half Way House (so called because midway between Murphy's and the Trees) and continued on to the Grove, where we camped.

It is a singular fact that the immense size of these trees does not at first strike the observer, so symmetrical are they, and, moreover, the eye is gradually accustomed to their immense size by passing through a forest of grand pines, varying from 100 to 200 feet in height. This grove is now so well known, and has been so frequently described, that I shall not attempt to go into details here concerning it. I would merely remark that the altitude of the trees is generally exaggerated some 15 or 20 feet. One of the largest, called the "Mother of the Forest," I found to be 300 feet high, while the one pointed out as the highest reached the great altitude of 315 feet.

Continuing on this road, we reached Blood's Station, in Bear Valley, October 28, and found the proprietor moving out for the winter, his stock having been driven out some days previously. The next day opened with a heavy snow-storm, and we passed on over the summit to Silver Mountain, which we reached after a hard day's march through the snow. The next day I went on to Markleeville, visiting the Hot Springs near there. From Markleeville a meander was run down the Carson as far as the site of Young's bridge, and November 1 we camped at Genoa. We found Mr. Cowles in good health and spirits, and with every prospect of being sufficiently recovered to bear the journey home when the parties should disband. Passing on to Carson, I made preparations for the Como Mountain trip, on which I set out November 5.

A number of meander-lines were run in this range and vicinity, and our triangulation for the season closed and connected with the base by the occupation of three main stations. In addition to these, five other points were occupied, especially for topography. Although delayed somewhat by unfavorable weather, I managed to close out the work and get into Carson November 28, where I found Lieutenant Symons and his party. The various employés were paid off and discharged, as their services became unnecessary, and the California section of the survey disbanded. I was occupied until December 12 in boxing, storing, and inventorying the property of the survey, which was put in a condition for shipment to whatever rendezvous might be selected for next season.

The party was in the field 173 days, during which time 1,072.5 miles were meandered and 850 traveled without meander. Fifteen peaks were occupied as main triangulation stations and for topography, and, in addition to these, 50 other important points, especially for the latter purpose. One hundred and eighty-four cistern-barometer altitudes were obtained, besides the aneroid stations along the meanders. Observations for latitude and magnetic declination were taken at 27 camps. A large number of mining districts were visited and notes made concerning them by Mr. Conkling, who also studied the geology of the region surveyed; the results of his work being incorporated in a special report. The more important road distances measured by the party with the barometric altitudes pertaining to them are submitted herewith in tabular form.

Owing to the unfortunate accident to Mr. Cowles and the impossibility of supplying his place, the topographical work of the party was greatly interrupted, and it is much to be regretted that he was unable to finish what he had so well begun.

Another misfortune was the scarcity of feed in the mountains. This was due to the fact that the country was completely overrun with vast herds of sheep, which utterly denuded the mountain valleys of grass, and in fact of nearly every green thing within their reach. This unusual influx of sheep was caused by the drought throughout Central and Southern California, the water-supply having failed on account of the light rain and snow fall of the previous winter, the average being one of the smallest on record for years.

All through the mountain country visited there are fine summer ranges, with abundance of wild grasses, on which the right to drive sheep and stock is claimed by original discovery or purchase. The men who are in the habit of summering their flocks here are known to one another, and, as a general rule, respect each other's rights. But this year there were many interlopers from the south who, rendered desperate by circumstances, respected no one's claims, and, in consequence, numerous feuds resulted whenever they came in contact with the original occupants, sometimes resulting in loss of life. In the former part of August I met a sheep-owner in the neighborhood of Carson Pass who had driven his herd all the way from San Luis Obispo, near the southern coast. The grazing having given out there, he had left in April with 10,000 sheep, which he intended to winter in the Mason Valley region.

There is much bitter feeling among the cattle-owners against the shepherds, since it is impossible for their herds to feed where the sheep are, the latter invariably driving them off. There is no doubt that if the sheep continue to be driven up into these mountains in such vast numbers the grasses will be eventually killed out and great injury inflicted on the country.

In conclusion I would say that great interest was manifested in the survey by the people of the area visited, especial thanks being due to Mr. Pease, of Georgetown, superintendent California Water Company, and to E. A. Smith, esq., of Placerville, engineer, in the employ of the El Dorado Water and Mining Company. While at Silver Mount City the party was shown great hospitality by W. P. Arnot, esq., and the Messrs. Folger of the Alpine Chronicle, these gentlemen tendering us free use of their offices during our stay and rendering us such assistance as lay in their power. I desire also to thank the various members of the party for cheerful co-operation under trying circumstances, Mr. Conkling lending a helping hand when we were short of packers, and Mr. Vail, during the topographer's absence, rendering very valuable aid by his talent for sketching.

I am, sir, very respectfully, your obedient servant,

M. M. MACOMB,
Second Lieutenant, Fourth Artillery.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX H.

REPORT UPON EXAMINATION OF THE COMSTOCK LODE BY JOHN A. CHURCH.

COLUMBUS, OHIO, *May* 20, 1878.

SIR: I have the honor to present the following preliminary report of the operations upon the silver and gold mines of the great Comstock Lode, with the examination of which I was charged during the past season.

My attention has been exclusively directed to the important questions connected with the structure of the vein, the regimen of the mines, and the high temperatures encountered in the rocks. I have found this field so extensive that it is impossible to cover it alone or in one season.

I was cordially received by the managers of the different mines, all of whom extended every facility in examination for which application was made. I desire to express my obligations to them, and to other gentlemen who are in fact too numerous to be specified, for the assistance received.

This report is necessarily somewhat fragmentary and disconnected. Many subjects connected with the mines require time for elucidation; others become hopelessly involved if a description is attempted without illustrations. For these reasons I have presented a sketch of the present condition of the mining industry with a more careful discussion of a few isolated points.

I have the honor to be yours, &c.,

JOHN A. CHURCH,
Professor of Mining, Ohio State University.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

I reached Virginia, Nev., June 11, and immediately placed myself in communication with the superintendents of the principal mines, and also with the surveyors, Messrs. James and Wrinkle, and Messrs. Hoffman and Craven. From all of these gentlemen I received immediate and substantial help.

Permission was given by all the managers to use the working maps as the basis of the survey, and by this generous aid I was able to accomplish the satisfactory progress which has been made.

The workings upon this lode are so extensive that it would require the labor of a surveying party for several years to lay them out, and it would be impossible to do this completely now. Very much of the ground on the vein is treacherous, and drifts are closed every year by the steady creeping in of the walls and roof. Even when this does not occur, the great heat encountered would defeat the efforts of any party that should undertake to remain for any considerable time in old drifts, where the air is stagnant.

After carefully examining the maps a number of mines were visited, among which were the Chollar Potosi, Ophir, Consolidated Virginia, Belcher, and Crown Point; and seeing that, from the nature of the ground, some parts of the mines which were then open would be closed to me before another year, I decided that the work of plotting the formations in the several mines should be carried forward at once, as the most immediately pressing work of the survey. In this course I was justified earlier than I expected or wished to be. In some of the mines one month sufficed to close important openings. This was especially the case in the Overman mine, where a long west drift in the upper part of the mine, which has not been worked in for some years, was closed, probably by a fall of the roof, during the time that I was examining the Crown Point and Belcher mines. In company with a shift boss, I attempted to reach its face, but the candles went out so suddenly from bad air that we were compelled to retreat when more than 500 feet from the end of the drift. I found the task of plotting the formations more difficult than was anticipated; but, after repeated trials, a system was arranged which has given uniformly good results, and which has enabled me to construct maps of each level, and also sections of the lode at any desired points.

Maps of the Belcher, Crown Point, Kentuck, Yellow Jacket, and Imperial mines, all in Gold Hill, are already made, and others of the Virginia mines are being drawn from the notes taken. When this work is finished it will afford a view of the formations of the greatest mineral vein now worked in any part of the world, as they are disclosed by one of the most extensive series of connected mining operations known.

The shafts, drifts, and winzes on this lode must present nearly 100 miles of workings in mines that are now connected, and a large amount of similar works in the numerous other mines of the district which are not connected with the principal group. This does not represent all the work done, for the extraction of the ore is mostly from great masses that are removed bodily, and not merely penetrated by drifts.

It is unfortunate that these exploratory openings are not all now available for survey. From the surface down to the 1,000-foot level the mines are almost completely closed; and it is to the lower half from the 1,000 to the 2,200 foot level that the operations of the survey are confined. As a necessary consequence many problems that could probably be solved if the record of the whole work from the surface downward were known, must now remain unexplained for lack of a sufficient area of observation. This is especially true of the characteristics exhibited by the bonanzas or great bodies of quartz and porphyry in which the ore occurs. Usually they form the most treacherous and shifting part of the lode, and not one of all these ore bodies that has been opened above the 1000-foot level now remains accessible. The ground has closed in and shut up their salient points from view.

This state of things is especially to be regretted, since the relations of these great ore bodies to the significant portions of the country rock are not likely to be solved without an extensive accumulation of facts. They present strongly marked peculiarities, the thorough discussion of which would probably lead to a knowledge of the forces which have given them their remarkable form and their extraordinary relation to the dike which forms the west wall of the lode. In fact these ore bodies, as the product of all the forces which have acted upon the lode, no doubt bear significant marks of the action, and if they could be discerned and understood the history of the vein would be written. Some of these, at least, will be the subject of discussion in the final report of the survey.

Observations have also been made with the object of ascertaining the origin of the clays which cut the rocks both in and outside the lode, and apparently at all angles. These have always been a perplexing subject of study. They vary, not only in position, but also in texture, and yet they offer but few points of significance. The character and composition of the Black Dike have also been carefully studied. It appears to be double, inclosing a sheet of propylite, which, though very thin, is maintained for thousands of feet in length with extraordinary regularity. The two sheets of eruptive dike appear to be identical in composition, but vary somewhat in condition. The eastward inclination of the dike places the eastern sheet over its fellow, and in that position it has acted as an effectual water-shed. It is much decomposed itself, being often reduced to a mere clay, but has almost always protected the western sheet, which is rarely acted upon to a marked degree, either by meteoric or subterranean waters, in the part of the lode still open to inspection.

In addition to these questions immediately connected with the formation of the lode the larger geological details of the district have also received some attention, though not so much as it is intended to give them hereafter. The form of the diorite which determines the western limit of the propylite in the Virginia section of the lode, the position and constitution of the numerous dikes which traverse the country, and the general geological history of the region, will all receive careful attention. Information has been collected concerning the dynamic movements which have produced the great mineral lode as their net result.

The present time is a period of exceptional interest in the history of this region. The deepest drain-tunnel in the world is rapidly approaching the lode which it is in a position to tap within a few months. The mines have reached such a depth that a new disposition of the points of extraction, as well as new machinery of the greatest magnitude, have become necessary, and will soon be completed. The lode itself has discovered some peculiarities that have not been recorded before. These facts, combined with the always remarkable character of the formation, indicate the value and importance of the survey at the present time.

THE STRUCTURE OF THE LODE.

The valuable labors of von Richthofen and of King have made the general structure of the Comstock Lode very familiar. The country in which it is found is mostly made up of eruptive rocks, in which diorite, propylite, trachyte, andesite, and basalt occur, under such relations as to indicate successive periods of outflow, marked by the kind of rock which was ejected. These principal vein rocks have an eastern dip varying from about 40° to 60°. The vein has been explored for about 20,000 feet in length, and from 1,200 to 2,400 feet in depth. It lies in beds of the rock which was once called greenstone trachyte, but which has been more closely defined by Von Richthoven as propylite. For about one-half its length it lies at the contact of this rock with diorite of older date, but the other half appears to be entirely inclosed by propylite. Some time ago it was announced that the portion of the lode in contact with the diorite had changed from the contact of the two rocks to entire inclosure in the diorite. But my examination shows that, while there was some foundation for this opinion, it does not correctly represent the state of things. The lode is nowhere entirely inclosed in diorite, though at some points in its course it may have penetrated the diorite mass of Mount Davidson to a considerable depth.

The causes of this action were clearly discernible, and will be presented in a final report, together with other deductions from the observations made.

West of the lode, and closely following its course, is a dike of rock which is supposed to be andesite, but which is also pronounced by observers (Mr. Mellville, Attwood, and Prof. H. G. Hanks, of San Francisco) to be dolerite. By the miners it has long been known as the Black Dike.

In the upper levels this rock was found to be very much more decomposed than it has proved to be at greater depths. It, too, is partly a contact dike, and partly inclosed in propylite alone, and from the observed facts Mr. King ventured the acute observation that it was probably the first cause of the ore fissures. He also in consequence of this decision moved the origin of the deposits from the period of trachytic eruption, where Von Richthofen had placed it, to that of the andesitic.

The Black Dike is a more prominent feature of the formation in the lower levels than it was in the upper, where its decomposed condition probably made it sometimes almost indistinguishable from others of the numerous clays which penetrate the lode and the propylite in all directions. From this better exposure I was able to confirm Mr. King's observation of the intimate relation of the lode to this dike.

ARRANGEMENT OF PRODUCTIVE PORTIONS.

The great length of the lode has given room for the growth of two towns upon it, Virginia and Gold Hill. They stand immediately over the most productive portions of the ground, being separated by the "divide," a rise of ground which forms a prominent rib upon the surface of Mount Davidson. The latter is composed of the diorite which forms the west wall of the fissures. This divide or swell in the contour of the west wall has been remarkable through the whole history of the lode, as covering the only piece of ground that may be called continuously barren in the central portion. This barren area has greatly increased in length within a few years from the giving out of large ore bodies that yielded immense quantities of rich ore in the upper levels.

The terminal portions of the lode have never been so productive as those in the central portion, and they appear to have yielded more ore from the parts that were nearest the center than from the extreme ends of the lode. This interesting phenomenon is also intensified in the lower levels. Large and valuable deposits of ore were found in the first thousand feet of depth of the terminal mines, which have not been duplicated below.

These facts might be taken to indicate that the lode is naturally divisible into two main channels, throughout which the ore was deposited and which are narrowing in depth. Mr. King, in his exhaustive discussion of the lode as exhibited in the workings above the 1,000 level, divided the whole into three instead of two of these ore channels or chambers; and while this surmise has not been sustained by subsequent developments, there is a general impression among men of long experience in these mines that the non-continuance in depth at certain points of ore bodies which appeared near the surface is indicative of a real and permanent restriction of the ground that is likely to prove profitable.

Views of this kind have been expressed about the Chollar Potosi Mine, in the upper levels of which ore bodies were discovered of such magnitude that they have continued to yield 30,000 tons of ore yearly, after being worked for a dozen years or more. The lower levels have on the contrary, been so barren that no ore has been found for

1,200 feet of vertical depth, or along a distance of toward 1,700 feet on the inclination of the lode.

But even this discouraging history does not warrant the opinion that the barrenness of the ground in this part of its length is permanent. The cause appears to be traceable to a dynamic movement in the west wall previous to the formation of the lode. The full bearings of the subject cannot be discussed at this time, but there is no doubt whatever that the existing state of things *may* change to a condition of high productiveness with the same readiness that the former change of an opposite kind exhibited. There is nothing in the cause of the altered circumstances which can lead us to maintain that it is certain to act permanently. It may cease at any point, and the old condition of things be again established. But neither can this improvement be predicted. The full action of the movement indicated can never be ascertained in any other way than by mining, but its character forbids the assumption that it is necessarily permanent.

My confidence in this opinion may lead to the inference that I have equal confidence in the future of the Gold Hill mines, which also now rest under the cloud of failure to produce ore in paying quantities. While it is true that the condition of the southern or Gold Hill portion of the lode offers no reason for discouragement and presents good ground for expecting a renewal of the productiveness that once gave glory to a long range of mines, extending from the Bullion for nearly four-fifths of a mile southward, the evidence of this is not of the same character as that which the mines north of the Bullion exhibit. The Gold Hill portion of the lode has a simpler structure than its neighbor, the Virginia section; but the forces which affect it are for that very reason more obscure. There no rigid mass of diorite stands to work important results upon the lode. The crevice through which the plastic material of the Black Dike rose to the surface is propagated for thousands of feet entirely through propylite, and the mineral deposits follow closely the same line.

In this part of the lode we have to deal with simple conditions. The filling, the decomposition of the rocks, and all the other important features of the structure, have been the result apparently of one force, the action of subterranean waters. Though the effects which these waters have produced are of the highest importance to man, and have supplied him with a large proportion of the metals and minerals useful to him, the circumstances of their action are still obscure. The rocks which were once the scene of this subterranean chemical activity have been for thousands of years the theaters of his mining operations, but the fact that this activity existed in the shape which is now confidently believed in, became a subject of general scientific credence only within a few years.

The Gold Hill mines, then, offer an example of a lode pure and simple, the product of a force acting apparently with quietude rather than with turbulence, but producing results that are immense, whatever standard we judge them by. What the significant marks of the action may be has not yet been discerned, but there is no doubt that such marks exist, and that a proper study of the subject continued through a number of years, and covering the profitable and unprofitable zones of the lode, would teach us what they are.

In this connection the present condition of these mines must be considered a very important one, for a strongly marked feature has been developed within a few years. This is the extreme thickening of the Black Dike from a dozen or score of feet to as much as 250 or 300 feet. Whether this occurrence has any significance or importance to the mines cannot possibly be learned in any way but by actual exploration. No such thickening is reported in the dike as shown in the upper levels.

The cause of this sudden thickening is doubtless correctly given by the common explanation. The crevice of a dike or vein is irregular in its course, both longitudinal and vertical. The downward inclination, instead of being produced with regularity, is occasionally interrupted by a portion which is more nearly vertical than the crevice above it or below it. If one of the walls of such a vein slides upon the other in the direction of the main inclination, the walls of this vertical portion will be moved horizontally apart. An enlarged chamber will be formed there which, when filled, presents just such a thickening as we see in the Black Dike of the Gold Hill mines from about the 1,700-foot level down.

Whether an occurrence of this kind will favorably affect the lode depends upon the condition in which it has left the rocks. If they have been fissured, the chance of ore deposition is undoubtedly increased. This may have taken place at the lower end of the vertical turn in the crevice; and the question which is just now a fascinating one to the miners of Gold Hill is whether this will prove to be the history of their ground.

The ground opposite this thickened portion of the dike has now been explored for about 300 feet in depth without results; but this may be only a small portion of its extent. Whatever the result may be, it seems quite certain that this change in the structure of the vein and its inclosing rocks is for the present to be regarded as altogether favorable. It may not have produced valuable results at the level now opened, but it is quite certain that the prospects of the lode, either immediate or future, are improved by its occurrence.

It is to be regretted that the east country-rock, opposite this particular portion of the lode, has not been explored to any great distance. This was to be done in the Crown Point Mine the past winter, and it is to be hoped that the character of the formation has been exhibited successfully.

ENGINEERING OF THE MINES.

The general mode of opening and operating the Comstock mines has not materially altered since Mr. James D. Hague published his fine description of the methods and machinery employed, in 1870. In fact the plan followed has, by the nature of the ground, been quite uniform since the true eastward inclination of the lode was discovered. Since that time the works have differed more in magnitude than in plan.

The Comstock is an example of a lode inclining to the east with a dip of from 40 to 60 degrees, and operated by vertical shafts sunk through the east country-rock. The extreme rapidity with which the ground is worked out necessitates the frequent removals of these shafts, and also the adoption of a combined system of vertical and inclined shafts, in order to lessen the frequency of the removals.

We may distinguish four general groups of works accomplished since the discovery of the lode:

1. Surface works, operated by "diggings," inclines, tunnels, and shallow shafts.
2. A number of shafts striking the lode at depths of 400 to 600 feet
3. A second line of shafts reaching the lode at depths of 1,100 to 1,300 feet. This is the system of works now in active operation.
4. A line of shafts not yet finished to the level of the lode, but which is expected to tap it at a depth of 2,000 to 3,000 feet. Only three of these shafts are under construction—the California and Consolidated. Combination, and Yellow Jacket.

Of course there are some shafts that do not fit exactly into a general summary like the above. The Overman, Julia, and Sierra Nevada all tap the lode at depths between 1,300 and 2,000 feet. Still the general statement illustrates the tremendous strides made every year in opening the ground. The vertical advance of about 1,000 feet made at each of these removals probably corresponds to a horizontal distance of nearly the same or a greater amount.

When the mines are in a bonanza the advance in depth is somewhat slower than when they are in barren ground, for the enormous extent of the ore bodies in this lode makes the yield of each level extraordinarily great. Under any less active system of mining, one of these levels would supply ore for years. But when a mine is worked with such activity as these all are when in ore, the draft upon the store of mineral wealth is such as to require unremitted attention to the task of opening new ground. The Consolidated Virginia Mine extracted last year no less than 144,400 tons of ore, or 400 tons a day for 365 days. Such an output would not shame a coal mine, and would be large even for an iron mine. The ore body from which this was taken yielded probably about the same amount to the California company.

This rapid work is the result partly of high wages, admirable organization, and the lavish use of machinery. A large number of machine drills are in use, the Burleigh and Ingersoll being both highly praised. The administrative vigor which characterizes the management of these mines has made the employment of machinery for drilling a success wherever tried. As before said, the drifts are pushed forward at the rate of 3 to 10 feet a day. The higher rate is usuallythe result of machine-work, but hand-work also produces results that would be considered extremely rapid elsewhere.

Of course this rapidity of excavation is partly due to heavy charges of powder. Black powder is very little used. For ordinary mining work dynamite, Hercules powder, and occasionally other nitroglycerine compounds, are employed in all the mines.

The character of the ground is also very favorable. Though rather hard in drilling, it blasts well, and the large powder charges shatter the face so much that good picking ground is often left. Still it was observed that the miners on the Comstock follow the practice which seems to prevail wherever rapid progress is secured, and do not attempt to push the use of the pick so far as might be done, but hasten to get the machine drills in position as soon as possible after a blast. Deep drilling is not much employed, the holes being from 10 to 30 inches for hand-work, and not often exceeding 5 feet for machine drills. In ground that is a little hard for picking, shallow holes of 2 or 3 inches in depth are sunk, and filled by a small cartridge called a *gopher* laid in without tamping. The shock of the explosion greatly increases the effectiveness of the pick. As in all successful undertakings, the excellent work done on the Comstock is largely due to the perfection of these small matters of detail; and the high rate of progress so uniformly maintained is sufficient proof that the system has, in the course of time, become well adapted to the circumstances of the region

PUMPING MACHINERY.

A more noticeable improvement is that which has taken place in machinery. The large constructions for hoisting, pumping, and compressing air are now subjects of special design in which the requirements of mine managers of long experience in this particular district are met by mechanicians of equal experience. The result of their combined efforts is seen in a series of massive and costly engines of simple type and the most durable construction. These cannot be described without illustrative drawings, which are necessarily left to a final report. Here I must confine myself to a general indication of their character.

The old geared pumping engines, described and figured by Mr. Hague, are gradually giving way to double-acting compound engines, the latest example of which has cylinders of 32 and 64 inches diameter and 12 feet stroke. These are worked with steam pressures of 100 to 110 pounds to the inch. Wooden spear-rods are used from 12 to 14 inches square, made of Oregon pine and balanced at distances of about 300 feet, a V bob being placed at the junction of the vertical and inclined shafts to transmit the motion. The pump, therefore, is single acting, the return-stroke of the engine merely raising the rod. The pumps are usually from 11 to 14 inches in diameter, and are worked at 6 to 7½ strokes per minute. At this speed they pump ten or eleven million gallons of water per month to heights of 1,600 to 1,800 feet and more. They are all supplied with the Davy differential valve-gear, with an improvement by Mr. W. H. Patton, the designer of all but one of the pumping engines of this type now at work on the lode. The valves are of the poppet form. All these engines were made by Messrs. Prescott, Scott & Co., of San Francisco, with one exception. That one was built by the Risdon Iron Works of San Francisco, and is of a type that departs from the one above described. It is a compound engine, pumping at both strokes, with pump-rods balancing each other, the weighted balance-bobs being dispensed with. The pump-rods are 8 inches square, the pump 10 inches in diameter, and the depth of the vertical shaft, in the autumn of 1877, was above 1,100 feet. This is said to be the only double-acting pump placed on the quartz mines of the West. The amount of water in the mine has never been sufficient to test its full capacity.

Hydraulic pumping engines have not yet been placed on the Comstock Lode, though designs for them have been made. Considering the importance of the pumping problem there and the usual boldness of both engineers and mine managers in matters of innovation, it is somewhat surprising that this method has been entirely neglected.

VENTILATION.

Similar uniformity is noticeable in the air-compressing machinery, which is of a type also devised in San Francisco. The air-cylinder is the well-known one of Mr. Waring, of New York, in which the valves are poppets closed by springs, and the air is cooled by water that circulates through the hollow walls of the cylinder, the piston, and piston-rod. Mr. Waring's method of combining the steam and air pistons, so that the former shall commence its stroke with the full pressure of steam just as the latter is approaching the end of its stroke and beginning to overcome an increased pressure of air, is also retained, but with a different mode of arrangement. A U-shaped horizontal bed-plate is employed, the fly-wheel being hung on the arms of the U and plying between them, while the steam and air cylinders are at the opposite or connected end of the U and lie on each side of the fly-wheel. This gives a very firm structure. Very large machines of this description have been placed at the C. & C. and Gould & Curry shafts, their air-cylinders being 60 inches in diameter. These machines are, of course, not used for ventilation. Their sole purpose is to supply force to the machine drills and the subsidiary ventilating engines, of which there are great numbers in the mines. The air-pressure obtained is about 60 pounds.

Air for ventilation is supplied by blowers of the Root and Hawkins patterns. Fan-blowers are little used on the surface, if at all. A Guibal fan was placed on the Gould & Curry Mine, but as there is no bratticed compartment in the shaft, and the managers all object to maintaining one, on account of the difficulty of keeping the shaft in good repair, the fan was found not to be adapted to the case and is not now in use. Being placed at the mouth of the drain-tunnel, several hundred feet from the shaft, it required special boilers and engines, so that the cost of working it was very high. In fact, it has been (unofficially) reported at $100 a day, which seems almost incredible.

The Guibal fan was an exhaust, and the only one on the lode of this kind. All others are forcing blowers. None of them strike the observer as being very powerful, and as the mines become deeper it seems probable that more effective measures for ventilation will have to be adopted. If the Guibal fan were placed at the shaft, and used for forcing instead of exhausting, it might be found a serviceable and not costly machine, though its design is perhaps not the best for a pressure blower.

The present dependence for ventilation is upon a mixed system of natural and artificial methods. Wherever the mines are connected there is a good draught, though not so strong as is to be expected from the heat of the ground and the consequent high temperature of the upcast. The whole amount of air passing out of the shafts of eleven mines on one day in July, 1877, was found to be only about 300,000 cubic feet, as the following table shows:

Mine.	Cubic feet per minute.	Temperature of upcast, top of shaft.
Utah	4, 000	....
Sierra Nevada	7, 700	76° F.
C. & C	21, 600	84° F.
Consolidated Virginia	48, 750	89° F.
Gould & Curry	12, 000	....
Savage	58, 500	100° F.
Chollar Potosi	18, 000	77° F.
Bullion	10, 080	89½° F.
Imperial Consolidated	28, 800	95° F.
Belcher	52, 200	89° F.
Overman	27, 000	93° F.
Total cubic feet per minute	288, 630	

This is probably to be considered as near a minimum quantity. A great difference is discernible in the ventilation of the mines on different days, due perhaps to the direction of the wind. This day (July 2, 1877) was not a bad one, and the outside temperature, taken in the shaft-houses (and therefore in the shade) of those mines which were downcast, averaged about 73° Fahrenheit from 10 a. m. to 4 p. m.

At the time these observations were taken the task of connecting the lower levels of the different mines had not been completed in the northern portion of the lode, and some shafts were then partially down and partially up cast, which may now be exclusively one or the other. The shafts which were then altogether downcast were Ophir, Hale & Norcross, Julia, Yellow Jacket, Crown Point, and Caledonia. Since then the Overman has changed to a downcast.

The operations of this survey were begun at a time when the mines of the Comstock region were suffering a depression which they had not been obliged to undergo for years. Many of the secondary mines of the district were shut down in consequence. The entire series of mines at the Devil's Gate part of the district, including the extensive and important Justice, are omitted from the above table. Observations of this kind can be more favorably carried out another season.

Where the mines are connected there are good air-currents passing through the connecting drifts, and at these points the subsidiary engines spoken of above are usually placed in the upcast mines. They are small upright engines of from two to eight horse-power, of the type commonly seen in machine-shops. They are driven by compressed air, and their motion is carried by belting to fans of four vanes, made in the workshop of each mine. The speed of the latter is about 600 revolutions a minute, and their yield of air from 700 to 1,200 cubic feet.

This air is conveyed to the face of each drift where men are at work by means of a galvanized sheet-iron pipe, usually 11 inches in diameter, hung from the roof of the drift.

Such in brief is the system of ventilation employed in a mining region which presents unusual natural obstacles to comfortable and economical working. A marked characteristic of the Comstock is the ample size and general regularity of the drifts and other openings. Without this the difficulties of the miners would probably be greatly increased.

The sketch here given is not intended to be thorough. A complete description is impossible without illustrations. This is true not merely of the machinery, but of the shaft-houses and other surface works, in the arrangement of which decided improvements have recently been made. These details are of great value to engineers, and it is important to publish them in order to relieve newer mining districts, which otherwise might wade through years of experiment to place themselves on a level with the Comstock.

The value of the experience in these mines does not consist in the originality of the numerous appliances. Very few or none of them are really novel, and most of them are to be found in other countries. But nearly every piece of machinery or system of work that is adopted from other regions undergoes important alterations that fit it to American conditions, and make the adopted and altered machine a better subject for introduction into other Western mines than the original.

Examples of this fact are to be found in every piece of machinery that has been mentioned, except the small compressed-air motors used as auxiliary means of ventilation. A very good instance is also to be seen in the "skeet," designed by Mr. I. L.

Requa, superintendent of the Chollar Potosi. The self-dumping "skip" is well known in American as well as foreign mines, being in common use in the copper mines of Lake Superior and elsewhere. The machine which Mr. Requa calls a "skeet" is, as its name implies, a large skip, adapted to vertical hoisting, capable of holding about four tons of rock, and perfectly self-discharging. It is to devices of this kind that the mines will probably be forced to look in the future for relief in deep working. Nor does it seem improbable that the "skeet" may solve the problem of working the vertical and inclined shafts together. That is frequently done with the smaller "skips," and the greatest obstacle to the practice on the Comstock is probably the extreme length of rope to be wound on the reel of the hoisting-engine. This, however, is a difficulty that does not appear to be insurmountable. A reel to hold 4,000 feet of rope is certain to be one of the requirements of the deep mining to which all are looking as the work of the future. This would work a vertical shaft of 2,500 feet together with an incline of 1,000 feet, vertical depth. By the present system of breaking the lift at the foot of the vertical shaft, the incline requires a separate engine and car, with shoots that are both costly to make and repair, and which require a tender to fill and unload them.

PRODUCT OF THE MINES IN 1877.

The amount of bullion extracted during 1877 was as follows:

Mine.	Silver.	Gold.
Consolidated Virginia	$7, 463, 500 39	$6, 270, 518 68
California	9, 538, 104 00	9, 386, 745 00
Ophir	126, 651 00	96, 825 00
Chollar Potosi	353, 655 16	157, 984 17
Crown Point	53, 060 54	23, 059 70
Belcher	221, 297 45	192, 844 16
Overman	4, 433 81	3, 018 85
Total	17, 760, 702 35	16, 130, 995 56
Total gold and silver		33, 891, 697 91

Besides this, the Justice Mine produced a large amount of bullion, officially reported at $2,028,700, but the proportion of gold to silver is unknown.

The total product up to December 31, 1877, of the great ore body which has supplied the principal part of the Comstock bullion since 1873, and which has become so celebrated as to be known distinctively as *the* Bonanza, is as follows:

Mine.	Silver.	Gold.
Consolidated Virginia	$29, 674, 531	$23, 061, 587
California	16, 590, 618	16, 025, 830
Total	46, 265, 149	39, 087, 417
Proportions	54.2 per cent.	45.8 per cent.
Total gold and silver		85, 352, 566

SUBTERRANEAN HEAT.

The most striking phenomenon connected with the mines on the Comstock lode is the extreme heat encountered in the lower levels. This heat is not due to the burning of candles, heat of the men, and decomposition of timbers, all intensified by bad ventilation, as was the case nearer the surface; it proceeds from the rock, which maintains constantly a temperature very much higher than the average of the temperature in Nevada.

The heat of these mines is a matter of more than usual interest, for they are the only hot ones now worked in the United States, and both in the present atmosphere encountered and in the increase which is to be expected as greater depths are reached they appear to surpass any foreign mines of which we have a record.

Hot mines are known also in other countries, as in the tin and copper lodes of Wales, where one of the veins worked by the United Mines is known as the Hot Lode. It has springs which discharge water at a temperature of 116° F., the depth being 220 fathoms, or 1,320 feet. The heat of the air in these workings is given (in "Useful Metals and their Alloys") at 100° to 113° F. The air is bad and the heat in the drifts seems to be traceable to defective ventilation rather than to the real necessities of the case. Air is supplied through a small pipe and is drawn from a place where the temperature is 95° F. Under such circumstances it is not surprising to read that in this hot mine the air is hotter than the rock, a state of things which I have never observed on the Comstock. Other mines have been reported to the British Coal Committee as having temperatures of 106° F. and thereabouts, but the only positive comparisons that are available at this writing are the following, all from Cornish mines:

Mine.	Depth in feet.	Temperature.	
		Air.	Rock.
		°	°
Tresavean	1,584	86	83 to 85.
Consolidated mines	1,500	87	86.
Do	1,722	94	93.
Do	1,764	94 to 96	92½ to 93½.

These high temperatures appear to be partly due to the usual sources of heat in mines and partly to chemical action in the rock, for the average depth in which the heat rises 1° F. from the surface downward, varies with the ground. It is given by Mr. W. S. Henwood as follows:

	Feet.
In granite	51
In slate	37.2
In cross-veins	40.8
In lodes	40.2
In tin lodes	40.8
In tin and copper lodes	39.6
In copper lodes	38.4

The copper-bearing lodes are, therefore, the hottest, and in Cornwall heated ground is thought to be a good indication of copper, just as hot ground is looked upon, in the Comstock mines, as a favorable sign of ore.

TEMPERATURE IN THE COMSTOCK MINES.

The rock in the lower levels of the Comstock mines appears to have a pretty uniform temperature of 130° F. This was the reading obtained for me on several occasions by Mr. Comstock, foreman of the Ophir Mine, and about the same temperature was found by Mr. Perrin, foreman of the Chollar Potosi, Mr Cosgrove, foreman of the Yellow Jacket (139½° F. and 136° F.), and by myself in the Crown Point and other mines.

These readings were obtained by placing a thermometer in a drill-hole, immediately after the hole was finished, and leaving it there for periods varying from ten minutes to half an hour. Very little or no difference was discovered between holes which were drilled wet or dry; or, if wet, between holes which were naturally wet and those which were made so artificially. No doubt there must be some differences due to these varying conditions, but they are so slight as to be completely masked by the steady flow of heat from the rock during the exposure of the thermometer.

The holes in which the thermometers were placed were not sunk especially for this work of testing, but were the ordinary drill-holes made for the purpose of blasting the rock. They varied, therefore, from about 10 inches to 3 feet in depth.

No variations in the height of the thermometer were found to be caused by this difference of depth, and this also is quite reasonable. Mining on the Comstock proceeds with extraordinary rapidity. The drifts are advanced steadily at the rate of three, five, and sometimes even eight and ten feet a day, and therefore the ground in which the miners are working is always fresh ground. The low conductivity of minerals to heat forbids the supposition that a rock of 130° F. temperature can lose heat sensibly to any depth, in the course of twenty-four hours. The shallow holes which were made use of always lay in new ground, and exhibited results which may be accepted with as much confidence as if they were twenty feet or more deep. Very often they were in ground which had been exposed only one or two hours, having been sunk immediately after a blast which threw off four or five feet of rock. The surface which was thus thrown down had not been exposed more than than twenty-four hours. The high temperature and small flow of air in the heading forbid the supposition that any sensible diminution of heat could have taken place at the bottom of the drill-hole, under such circumstances.

The surface of the rock exposed to the air of the drift was found to be about 123° F., the experiment being made near the "header" or end of the drift. The air itself was found to show considerable uniformity when its temperature was taken under circumstances that were at all similar. In freshly opened ground it varied from 108° F. to

116° F., and higher temperatures are reported at various points, reaching, in fact, as high as 123° F. in the 1900-foot level of the Gould & Curry.

The temperature of the air is subject to more fluctuations than that of the rock, for the simple reason that it is artificially supplied to the mine, and varies according to the distance to which it is carried, the quantity, velocity in the pipe, and its initial temperature. All of these elements of the problem vary within wide limits. The initial temperature of the air which supplies a particular drift will, for instance, depend upon the place it is drawn from, whether the surface, the bottom of a shaft, where it is often cooler than above ground, or some old air-way where it has had time and opportunity to take up heat.

Nevertheless, even under such variable circumstances as these, the temperature of the air in a new drift does not ordinarily vary much more than eight degrees, and in this variation the length of the drift appears to be the most important factor.

This uniformity of temperature under such changing conditions is due to the well-known fact that the amount of heat absorbed from the walls of a drift or shaft in a mine depends upon the difference in the temperature of the air and rock. The greater this difference the greater is the absorption, but as soon as the temperature of the air current approaches that of the rock the heat absorption proceeds much more slowly.

In the Comstock mines it is the custom, without exception, to blow the air through galvanized iron pipes, the diameter of which is usually from 8 to 20 inches. The size most used is 11 inches in diameter and the usual amount of air blown is about 700 cubic feet per minute, this being the supply for two to six or more men, working in one or two headers.

In most cases the air is not sent down from the surface but taken from some point in the incline or at the bottom of the shaft. Its temperature may be assumed at about 85° or 90° F. in summer, though it is sometimes higher than this. Its velocity in the air-pipe is not very far from 1,000 feet per minute. From these data it will be seen that we have about 15 or 20 degrees of heat added to the air, in from one-half minute to two minutes. The iron of the pipe is so thin and its conductivity so great that we practically have a slender current of air moving through a body of hotter air. Even this statement of the case does not exhibit all the opportunities for absorbing heat which are forced upon the air. The iron receives heat both by immersion in the hot air and by direct radiation from the still hotter walls. The current confined in it must be thrown against its sides by eddies and the air is thus made to absorb heat by contact as well as by the transmission of heat rays through it.

Drifts that do not exceed two or three hundred feet in length are usually not above 110° or 112° F. in temperature, and more often they are below this. But when the length increases to 1,200 and 1,500 feet the temperature may rise to 116° F. without any other change in the circumstances.

So far as my personal experience goes, the latter temperature has not been exceeded in any drift into which a good current of air is blown. By a "good current" I mean one of not less than 700 or 1,000 cubic feet a minute. Still there is no hesitation in assserting my confidence in the higher temperatures which others have sometimes obtained. The view which I take of the phenomenon and its cause admits of such exceptional heat at particular points as a rational consequence of the forces at work. But I regard them as exceptional, and believe the average temperature of those drifts which are considered to be distinctively "hot" is usually not above 108° to 112° F., though rising to 116° F. when they are very long.

These limits are, however, not in the least degree true of the water which enters the drifts from the country rock, and also from the lode-rocks. That approaches more nearly 150° F. The vast body of water which has filled the Savage and Hale & Norcross mines for more than a year, and from which it is safe to say a million tons of water have been pumped within twelve months, gave me a temperature of 154° F. Even after being pumped to the surface, through an iron pipe, éxposed, in the shaft of the Hale & Norcross, to a descending current of fresh air for more than a thousand feet, and then flowing for one or two hundred feet through a drain-tunnel which discharges into a measuring box, the water in this box was found to have a temperature of no less than 145° F.

But the water varies in temperature, like the rock and the air. In the east crosscut 2,000-foot level, of the Crown Point mine, which is noted for its extreme heat, the water, after flowing for nearly 150 feet over the bottom of the drift, was found to have a temperature of 157° F. On the contrary, in other places the water is much less hot, but I believe it is, as a rule, always hotter than the air, and in many cases it appears to be hotter than the rock is found to be, except in especially hot spots.

HOT AND COLD BELTS.

In giving this short description of this remarkable phenomenon, I have frequently referred to the fact that there are points in the mines which are much hotter than the average. The east cross-cut of the Crown Point 2,000-foot level, which was temporarily abandoned and boarded up on account of the heat, gave me an *air*-temperature of 150° F., the thermometer being thrust through a crack in the boarding. I felt convinced that at the head of this cross-cut the heat must be higher than this, and Mr. Balch, foreman of the mine, informed me that it had been proved so.

Another hot spot is in the Imperial Consolidated Mine. The incline there has always been very hot, and near the bottom, above the sump, but under the shoot—a position which allows of no ventilation except that which is induced by local air currents—the air must stand at 130° F., or higher, though I did not test it. In this mine the black dike splits, sending a shoot off to the northeast, and a drift has been run on the 2,000-foot level along the eastern side of this branch dyke.

This proved to be a very hot spot indeed. Rock, air, and water were all so much above the usual limits of temperature, even in these hot mines, that the work of cutting the drift must have been extremely severe. It might not have been accomplished if the expedient had not been adopted of boarding or "lagging," up the sides of the drift with a double thickness of plank, breaking joints. This confined the water, which poured down the walls, to a tight chamber, and left the main part of the drift for the men to work in with comparative comfort. The lagging remains and has been carried around into the main drift which is still in active use. Its joints are calked with tow, and one of these being stripped for me the steam from the water immediately poured out and proved to be scalding hot when tested by the finger. I did not, however, succeed in getting a fair reading of the thermometer, because the crack was too small to admit more than the end of the bulb. But even under these adverse circumstances the temperature of the steam was taken at 123°.

The Belcher south incline has a hot belt of rock, quite narrow, a short distance above the 1,900 station, and similar hot places are found in most of the mines.

I am inclined to the opinion that, as a general rule, these hot areas lie in belts and are not irregular or promiscuously placed in the mass of east country rock. Where this seems to be disproved by the distance run in the super-heated rock, it will probably be found that the drift, or incline, and the hot belt have the same direction.

It is noticeable that the neighborhood of a dike is apt to be hotter than any other portion of the rock. An example of this has already been given in the Imperial Consolidated mine, where a drift run immediately east of a branch dike is still wet and intensely hot, although opened for some years; the incline of this mine which is very hot, is also quite near the Black Dike.

But nearness to the Black Dike is also a characteristic of most inclined shafts on the lode. Some are west of it, some in it for long distances, others east of it. These inclines do not all exhibit greater heat than the average of the mines, and there must be some special reason for the heat of the Imperial Consolidated incline. Hot belts are also found at the contact of the diorite and propylite in the Virginia mines. The diorite is itself in active decomposition and mines which have carried drifts in or near it are very hot. The Julia has explored a great seam which appears to lie entirely in the diorite, and this has proved to be one of the hot belts.

This apparent concentration of the heat on the line of contact of two rocks is not supposed to be due to any thermal or electro-thermal action, but to depend merely upon the fact that in this neighborhood the ground is more broken up, and the surfaces of the rock increased. These conditions are obviously favorable to the action of the atmospheric waters and the passage of hot gases.

Belts of excessively hot ground are not the only noticeable phenomenon in these mines. More remarkable still are the belts of unusually *cold* rock. These are fewer in number than the hot belts, but they are very strongly marked. They are always wet, and the water that drips through the crevices of the shattered rock that composes them is noticeably cold to the touch and cools down the air of the drift. Such a wet, cold belt of rock exists on the 800-foot level of the Justice Mine, and there is a very decided change of temperature in passing from one to the other side of it. Lest the low temperature of this spot should be attributed to the water which drains through it from the surface, it is well to add that water drips from the rock in numerous places in these as in most mines, and that usually it is hot or at least warm.

Other cold belts are formed in the mines which are not so cool as that in the Justice, but are perceptibly cooler than the rock at a short distance from them. They complete a well-linked chain of heat phenomena, extending from rocks that are sensibly cold to the touch, and may not have a temperature above 50° or 60° F., through rocks that have the average atmospheric temperature, and those which are as hot as surface rocks ever become in Nevada, to those which have a temperature of 157° F. There is no reason to doubt that the gradation is quite regular, and the transition from the lower to the higher temperature is made through a much larger series of intermediate steps than the accidental thermometer readings of the survey show.

Finally in the chain of testimony relating to this phenomenon is to be noted the condition of the rock. Wet places have been spoken of, but the rock cannot be considered as generally wet. There are water-ways of limited breadth, like the belts of hot rock, and many of them appear to reach the surface. This water is usually hot, but sometimes cool or tepid.

Very often, usually in fact, the rock is perfectly dry, though very hot. That is the case in all the mines. Wet rock may be considered as the exception, and dry rock the rule. In the drifts cut through this hot dry rock the walls of the freshly-exposed surfaces are painful to the hand, and the air is often filled with dust. The rock is both hard and tough, but in spite of its strength it gives an impression of fine porosity to the touch, due probably to its trachytic character. It often has the odor of clay, but not always. It may be slightly adherent, or the impression of dryness upon the tongue may be due to its heat, or to the fine dust which covers every fragment.

SOURCE OF THE HEAT.

Wherever eruptive or plutonic rocks are found it is quite common to witness evidence, in the breaking out of hot springs, that heat agencies are still active within them, and this phenomenon is so frequently observed that hot springs are often referred to as the last phase of eruptive activity. The heat in the Comstock and other mines similarly situated is quite generally spoken of, for instance, as the feeble remnant of a temperature that once reached the point of rock fusion, but the facts encountered have compelled me to seek another explanation. It is impossible to assemble in an annual report all the data upon which this conclusion is based, but many of them will be given. They have led me to refer the high temperatures encountered in the mines not to the internal heat of the earth, nor to the residual heat of the rocks, which were once melted, but to chemical action now maintained in the erupted rocks.

This action is not a combustion, for the oxidizable minerals in the lode and its accompanying rocks, the metallic sulphides, are little altered. In fact, the total quantity of pyrite and other sulphides is not large for the neighborhood of a mineral lode, but, on the contrary, strikingly small, and not sufficient to maintain the heat of the rocks and water except under circumstances of unusually rapid oxidation. That no metallic oxidation of any moment goes on in these rocks is susceptible of proof. The metallic sulphurets in the rocks show little sign of decomposition, and this is true even in layers of the propylite that are fissured and seamy and drenched with water, whether hot or cold. In fact, the preservation of the sulphur compounds in presence of so much heat and moisture is a noticeable fact, which I have frequently remarked in all the mines.

An examination of such analyses of the mine waters as I am able to find confirms this statement. In a geological view of the Comstock lode, which Mr. King has prefixed to the third volume of the Report on the Fortieth Parallel, an analysis of water taken from the Savage 600 level is given. This is compared in the following table with other analyses recently published in the Virginia newspapers:

Analyses of water taken from the Comstock vein, taken at different levels.

	Savage, 600 feet.	Gould & Curry, 1,700 feet.	Gould & Curry, 1,800 feet.	Hale & Norcross.
	Grs. per gal.	*Grs. per gal.*	*Grs. per gal.*	*Grs. per gal.*
Silica	1.77	2.21	4,025	3,500
Sodic chloride	0.13	0.04	1,162	1,327
Calcic sulphate	29.40	14.35	16,683	22,532
Magnesic sulphate	1.77			
Sodic carbonate	0.91			18,518
Potassic carbonate	7.56	6.42	26,199	8,342
Magnesic carbonate	2.98			
Alumina and ferric oxide	0.05	Trace	Trace	Trace.

This table shows that the source of the heat cannot be the decomposition of a metallic sulphide like pyrite, for the resulting sulphate would be highly soluble, and the water would be much stronger in sulphuric acid. It is true that sulphuric acid enters more largely into the analysis than any other acid; but even if this is derived entirely from the decomposition of pyrite, the quantity is entirely insufficient to account for the effects. The Hale & Norcross water, for instance, contains only 54.219 grains of solid matter to the gallon of water, weighing 58.373 grains, or less than a tenth of 1 per cent. Of this solid matter, only $5\frac{1}{4}$ grains are sulphur, and this quantity corresponds to a little less than 11 grains of pyrite, containing, say, 5.3 grains sulphur and 5.2 grains of iron. If these substances were not in combination, the iron and sulphur in oxidizing would give out heat enough to raise 42,462 grains of water 1° F. in temperature, or the heat given out would be sufficient to raise 408 grains of water from 50° F. (the assumed temperature of surface water) to 154° F., the temperature of this great body of water. This calculation omits the loss of heat which would be suffered by the breaking up of the combination of iron and sulphur, as they exist in pyrite. It is only an approximation, but it shows clearly that the oxidation of the iron and sulphur account for less than $\frac{1}{143}$ of the heat present in this water.

It is true that the analyses given do not account for the portion of calcic sulphate which has been deposited as an insoluble precipitate in the crevices of the rock. Gypsum is present, in fact, everywhere in and out of the lode, but its quantity is quite limited in the lower levels, and, considered as the cumulative result of many centuries of activity, it affords additional proof that the oxidation of the pyrite has been very small in amount.

AMOUNT OF HEAT WITHDRAWN FROM THE ROCKS.

The quantity of water pumped from the mines the past year must have been as much as 350,000 or 400,000 tons a month. If its temperature is assumed to be only 135° F., and the average temperature of the air for the year 50° F., we have in the year, say $350,000 \times 12 = 4,200,000$ tons of water raised 85 degrees in temperature; or, as the usual expression is, $4,200,000 \times 85 = 357,000,000$ ton-heat-units have been absorbed by the water. If the heating power of anthracite coal is estimated at 7,500 heat-units to the ton, the heat in this water is as much as would be obtained from the combustion of 47,700 tons of coal. A cord of pine wood weighing 2,700 pounds will probably give about 4,300 heat-units in practice, so that 84,000 cords would be necessary to keep up the heat withdrawn from the rocks in the mine waters alone.

If 10 tons of air pass through the mines collectively each minute, or 14,400 tons daily, and the air when discharged from the mines has an average temperature of 92° F., the total quantity of air for the year will be 5,256,000 tons, and the average rise in temperature 42 degrees. The specific heat of air being 0.267, we have $5,256,000 \times 0.267 \times 42 = 58,940,784$ ton-heat-units for the amount of heat absorbed by the air. This corresponds to an expenditure of 7,859 tons of anthracite coal, or 13,707 cords of wood. The total quantity of heat carried out of the mines yearly by the water and air is therefore 416,000,000 ton-heat-units, to produce which in ordinary industrial operations would require 55,560 tons of anthracite, or 97,700 cords of wood. The number of men employed under ground in the mines of the Upper Comstock is less than 3,000, and the heat from their bodies, together with that produced by the burning of the large number of candles, could not account for any considerable proportion of this heat. Indeed, it may be assumed, in the absence of calculations, that all the heat from these and other ordinary sources of heat in mines is no more than sufficient to compensate for the large amount of refrigeration produced by the liberation of the compressed air which is employed in every mine to work numerous underground machines. This heat absorption has not been taken into account in the above calculations.

These calculations show that the source of the heat is one that acts on a magnificent scale, and also that it cannot reside in the pyrite. That source I consider to be the chemical alteration of the felspathic minerals of the propylite and other rocks. This change consists apparently in the process of transforming feldspar to clay, technically known as kaolinization, from the fact that China clay or *kaolin* is produced in this way. Numerous zones in which this process of alteration has gone so far as to produce complete disintegration of the rock are passed in drifts cut into the country-rock on both sides of the vein. No analyses of this decomposed material are at hand, those which have been published always being made upon the clays of the vein itself, where the introduction of silica in large quantities has necessarily exerted a dominating influence upon all alterative processes. In the absence of such analyses, it is difficult to say whether the decomposition that has taken place to such a marked extent at a distance from the vein, owes any of its force to the special solfataric action to which the filling of the lode may be ascribed, or whether more general agencies have been sufficient to produce the observed effects. Nor can it be declared, without such a critical analytic examination, that this great mass of heated rock, extending for miles in length and breadth and for thousands of feet in depth, has passed through ages of drainage from the surface without undergoing some general change in its chemical structure.

On the contrary, I assume that alterative action has gone on throughout portions of these rocks, and is still in progress. The usual explanation for the heat which is found to exist in eruptive rocks in so many districts, namely, that it is the last manifestation of the heat which formerly fused the rocks, is rejected because of the persistence with which the supply of heat is maintained under circumstances that make extraordinary draughts upon it. From data previously given it will have been noticed that the mines receive about ten tons of air per minute and raise its temperature from 50° F., which I suppose to be about the yearly average of the atmosphere at Virginia and Gold Hill, to about 92°. This represents a constant abstraction of heat from the rock amounting to no less than 161,482 ton-heat-units daily, corresponding to the combustion of 37 cords of wood. The real quantity is probably at least ten per cent. greater than this, the difference being represented by the vaporization of moisture in the downward course of the air.

Fortunately for the purpose of this survey, Capt. T. G. Taylor, superintendent of the Yellow Jacket Mine, has caused observations to be taken for several months on the temperature of the air-current in different parts of that mine. By noting the increase of heat and the amount of air flowing through the drifts, I have been able to obtain an approximate estimate of the amount of heat drawn from the rock surfaces. It is approximate only, because the records of surface temperatures for several months were accidentally destroyed, and I was compelled to replace them from the careful records taken by Mr. B. Gilman, of the Chollar Potosi Mine, which is in Virginia, and has a higher position and a different exposure from the Yellow Jacket. The present calculations are intended to be replaced by more accurate ones in a subsequent report, and are presented now, merely to show that these observations contain trustworthy evidence that the heat taken up by the air cannot be derived from deep sources by transmission through the rocks, nor from a magazine of heat lying dormant in the strata.

The Yellow Jacket is a down-cast mine and the air-current passes down the vertical shaft to the 1,119-foot level, thence down the incline to the 1,732-foot level, through a drift to the south winze, and thence down this winze to the 2,200-level, the bottom of the mine. On its way from the 1,732 it sends a current through the 1,935 and 2,040-levels, these currents being reunited in the north winze, which is the up-cast. The north winze does not reach to the surface, and no air rises to day in the mine, the entire current flowing into the Imperial and Bullion mines, both north of the Yellow Jacket, and both of them exclusively up-cast.

Captain Taylor has placed Fahrenheit thermometers of the common kind, with japanned tin cases, at the surface, foot of the vertical shaft (1,119 level) 1,732 south and north winzes, 1,935 north winze, and 2,040 south and north winzes. The observations obtained are extremely suggestive, the plan of the mine being such as to eliminate complications from the problem of heat absorption by moving currents of air from rock surfaces. The thermometers placed at the south winze on the different levels measure the increase of heat in the winze itself, while those which are hung at the north winze measure the increase of heat which each "split" of air gains in moving through 413 feet of drift, that being the distance between the winzes. This fortunate arrangement of the ventilative currents presents the most favorable opportunity I have ever observed for studying the problems involved. The thermometers should be replaced with standard instruments and the air-current measured twice a week for a year, in each drift. The result would be the best series of observations obtainable, for the comparative shortness of the paths followed by the air, when contrasted with the long drifts of some coal mines, is compensated for by the high temperature of the rocks and the marked increase of heat in the air.

Before giving the table of results obtained during the first half of 1877, it is necessary to say that they are merely tentative. The destruction of the surface readings and the absence of standard instruments forbid the acceptance of the results as perfectly accurate indications of the heat absorption. It is expected that more accurate figures will be given in the final report, when records more complete and covering a longer period, together with measurements of the distances traveled by the several air-currents, will be available. At present only two of the monthly records—those for May and June—were taken entirely in this mine, the surface readings having been preserved. The irregularity due to the introduction of surface temperatures does not, however, affect the underground readings, but merely make it impossible to gauge the absorption of heat in the vertical shaft. The gain of heat after the foot of the vertical shaft is passed is fully given for the whole six months, the records in the lower levels being continuous from that point.

The air-current entering the mine July 2, 1877, was measured and found to be 18,140 cubic feet. On the 1,732 level the "split" or secondary air current was found to contain 7,200 cubic feet, and for the purpose of illustrating the steady flow of heat from the rock, we may reasonably assume that 18,000 cubic feet of air enter the mine every minute, and that this current is divided into three splits of 6,000 cubic feet each, which pass from the south winze 413 feet to the north winze, on each of the three levels 1,732, 1,935, and 2,040. The second of these is out of consideration from the fact that there is only one thermometer on it, so that no comparison of the initial and final temperatures can be made. From the average temperatures given above, we find that the gain on the two other levels was:

1,732-foot level .... 10.56 degrees Fahrenheit.
2,040-foot level .... 7.87 degrees Fahrenheit.

Six thousand cubic feet of air weigh nearly 400 pounds avoirdupois, and the amount of heat absorbed in traveling 413 feet through the drift is—

In the 1,732-foot level .... 1,128 pound Fahrenheit heat-units.
In the 2,040-foot level........................... 840 pound Fahrenheit heat-units.

As one pound of anthracite has been assumed to produce 7,500 heat-units, and one pound of wood 3,185 heat-units, the heating power of these two drifts is, per minute—

For the 1,732-foot level, 0.150 pound coal, or 0.353 pound wood.
For the 2,040-foot level, 0.112 pound coal, or 0,264 pound wood.

The reason for the different absorption in the two levels is that the initial temperature of the air in the drifts increases from 78°.20 at the 1,732 level to 85°.96 on the 2,040, by its journey of about 520 feet in the winze connecting the two levels. The absorption of heat by a moving current of air is known to vary with the difference in temperature of the air and the rock surface. The nearer these approach each other in temperature the less is the heat absorption.

The most conclusive evidence that the incessant drain of heat cannot be maintained by a constant store accumulated in the rock is supplied by the 1,732 level. The exact date at which the drift connecting the two winzes on this level was finished is not in my possession, but as the station in the main incline was completed in July, 1874, it is fair to conclude that the drift was cut through by the end of 1875. This would give one year's exposure of the rock surfaces by January, 1877, the date when the thermometer readings were begun. The quantity of air flowing through is assumed to be 6,000 cubic feet, as in the previous calculations. The gain of heat under these circumstances was as follows in degrees Fahrenheit, and monthly averages:

Yellow Jacket Mine, 1,732-foot level, 1877.

	South winze.	North winze.	Gain.
	Deg.	*Deg.*	*Deg.*
January	75. 62	86. 50	10. 88
February	76. 85	83. 87	7. 02
March	76. 10	88. 89	12. 79
April	77. 48	88. 23	10. 75
May	81. 42	91. 11	9. 69
June	79. 39	91. 62	12. 23
Average for six months			10. 56

As before shown, the heat absorption amounts to 1,128 pound heat-units per minute, which corresponds to the heat from 0.15 pound of coal per minute, or 216 pounds in twenty-four hours.

In this drift, then, with an average age of a year and a quarter at least, the rock surface gives out as much heat as would be obtained from coal fires, placed at distances of 100 feet, the whole length of the drift, and each burning 52.3 pounds of coal daily. Only one candle burns constantly in the drift, and the travel does not amount to more than two hundred trips of one man in one direction in twenty-four hours The effect of this travel is limited to the change of shifts and the transport of rock and timber, both of which are concentrated in short spaces of time. A hoisting engine in the winze uses about 9,000 cubic feet of compressed air daily, at 50 pounds pressure, which is quite sufficient to neutralize all the heat that can be obtained from the transitory presence of men in the drift. To further show how completely this source of heat may be neglected, it is enough to say that only the morning observation, at 6 a. m., is made at or near the time of this travel.

In other respects I have not observed any circumstances which throw serious doubt upon the thermometer readings. The instruments are not standards, it is true, but they are properly hung on timbers, and usually with ten or twelve inches of wood or air between them and the rock-surface. Whenever compared with one of the survey thermometers hung in the center of the moving air-current, they have not shown a variation of more than one degree. The daily readings are quite uniform, the fluctuations of more than one degree not exceeding 23 in a series of about 360 observations. The highest fluctuation noticed is three degrees.

There can be no doubt that the discharge of heat is real, that this heat is constantly removed by the air, and that it comes from the rock. When we regard the two main hypotheses which have been trusted to explain the high temperature so often noticed in volcanic rocks, namely, internal heat of the earth, and residual heat stored up in the rock mass, it is difficult to understand how either one of these sources can maintain this enormous discharge of heat for years. The circumference of the drift is about 28 feet, outside of timbers, the dimensions being 6 feet 6 inches at bottom, 5 feet 6 inches at top, and 8 feet high, when the timbers are twelve inches thick. The area of the walls is therefore 413 multiplied by 28, or 11,464 square feet, and the heat radiation amounts to 142 pound-units per square foot in twenty-four hours.

Experiments have been made to ascertain the radiation of heat from a blast-furnace, smelting iron ores. Its walls were probably less than five feet thick, and within the furnace a furious fire, producing an average temperature in the upper part of the furnace of probably 1,500° F., was constantly maintained, and under these circumstances the radiation in twenty-four hours was ascertained to be about 3,450 Fahrenheit pound-units of heat. The heat as constantly given out by the walls of this drift is, therefore, 4 per cent. of that which the furnace walls radiated. Considering the long exposure of the rock, for one year, and the unremitted removal of heat, it seems incredible that a definite store of heat placed in the volcanic mass, once for all, could furnish the necessary supply. It is, in fact, possible to show that without constant accession of heat the rock would soon cool down to the temperature of the air which enters this drift.

The temperature of the rock being 130°, and that of the air 78° F., it may be safely assumed that a layer of cooled rock 5 feet thick would effectually prevent the rapid radiation noticed. For the area of 11,464 square feet, this would give 57,320 cubic feet, which, at 160 pounds to the foot would weigh 9,171,200 pounds. With a specific heat of 0.202 this mass of rock would lose 96,334,284 pound-heat-units in cooling to 78° F. Air has a specific heat of 0.267, and if its temperature is supposed to be constantly raised 10°.56, as we find it under existing circumstances, the necessary cooling would be accomplished by the passage of 34,161,095 pounds of air, or 512,416,425 cubic feet. At the rate of 6,000 cubic feet per minute, 59.3 days would witness the absolute equalization of the air and this 5-foot layer of rock in temperature, omitting all transmission through the layer from the mass beyond. By the dates above given 547 days had already elapsed when the last of the June observations were recorded, and no diminution of radiation was noticed. That would not be the case if the heat came either from an accumulated store, or by transmission from a deep-lying source. Considering the low conductivity of rocks, amounting to only 0.11, that of silver, it appears to me that the facts here given are conclusive against the two hypotheses spoken of. It is on these facts that I base the suggestion advanced in this report, that the supply of heat is constantly maintained by chemical action of some kind. There is only one kind of chemical action that is known to have gone on to any considerable extent in the Comstock rocks, and that is the alteration of feldspar to kaolin. The facts here given are held to indicate that this extensive alteration is still in progress.

Even if this conclusion is granted, it still remains to show how the heat produced by this alteration can be poured into the drifts in such quantities. There is good evidence that the chemical action is not confined to the surfaces of the mine openings, for in that case the rock would necessarily flake off and swell in consequence of its superficial alteration. This takes places to a considerable extent, but not enough to account for more than a small portion of the heat, and there are extensive areas where the drifts remain for years without any visible sign of decomposition in the rocks. The principal part of the chemical action must take place in the body of the rock mass, and it is evidently necessary to find some means for the constant conveyance of the heat produced to the artificial openings. It has already been pointed out that the low conductivity of minerals to heat forbids the assumption that this can be done by ordinary transmission.

The vehicle for the conveyance of this heat I conceive to be gaseous currents, heated by the chemical action spoken of, penetrating the rocks in every direction and tending to discharge themselves into any free channel, like a drift, opened in the ground. The source of this gas is primarily the atmosphere. Water is capable of absorbing 0.025 of its own volume of nitrogen, 0.046 of oxygen, and its own volume of carbonic anhydride, at the ordinary atmospheric pressure. At a higher pressure the absorption is greater, and as the water in the rocks, two thousand feet below the surface, is under a considerable hydrostatic head, it probably contains a maximum quantity of gas.

The fixation of this water in the solid form by combination with the silicate of alumina necessarily liberates the gas it has dissolved, and this gas must then seek to discharge itself at the only point that is free under natural conditions—the surface. On its way upward it continually meets fresh supplies of water, and is reabsorbed until the water becomes saturated. As the water would always carry down carbonic anhydride and air derived from meteoric sources, there would be additions at every rainfall to the store of gas in the strata, and the cumulative results of years of this action must be the saturation of the rocks with gas, so that whatever is liberated by the solidification of the water will find no place to rest without pushing out some of the gas already held so abundantly in the strata. From the point where this chemical alteration of the feldspar takes place, there must be a discharge of gas at least equal in quantity to the rainfall which reaches that depth, and this stream of hot gas will take its way to the surface and maintain the heat lost by radiation from the rocks through which it passes.

This explanation satisfies the conditions observed. The dryness of the propylite in the greater portion of the area explored has already been mentioned as proof that the heat is not brought in by water from greater depths. Its porous condition gives ocular evidence that gases may pass readily through it, and its tendency to absorb water from moist air would make it as effective a drier as a chloride-of-calcium tube.

It is therefore conceivable that the rapid flow of heat into the drifts is caused by streams of hot gas liberated by the combination of the water in which it was dissolved with feldspar, and filtering readily through the porous rock under the pressure to which it must be subjected as a consequence of its deep subterranean position. These gaseous currents do not make themselves evident to the senses over the ordinary surfaces of drifts, but they do sometimes pour out of drill-holes with strength sufficient to flare a candle flame. This is not a constant, though a frequent phenomenon. "Blowers" of gas are met with, but not with more than the usual frequency in mining operations. Accumulations of choke-damp in old drifts are common, though perhaps not more so than in all mines. The mine waters evidently contain gas, which bubbles through them, and sometimes in quantity sufficient to produce a moderate boiling.

None of the analyses quoted above give the amount of carbonic anhydride present in the mine waters, but there are evidences that it must be dissolved in considerable quantities. All water-channels in the mines fill up with a reddish powder, caking but slightly, and sometimes nearly filling conduits that are placed at a considerable distance from the source of the water. In the absence of analysis this may be assumed to be composed mainly of alumina, lime, iron, and silica, precipitated by the evaporation of the gaseous carbonic anhydride, which is recognized as a powerful agent for the solution of these elements in water. Similar depositions occur in other mines from this cause, and they indicate decomposition of the neighboring rocks.

The presence of such gas-currents affords another explanation of the hot spots observed in the mines. In discussing this phenomenon it was assumed that these places lay in belts of rock that are peculiarly susceptible to decomposition, but if the rocks are permeated by currents of hot gas, it is evident that those portions which are most fissured will give the most ready means of exit to the gas, and therefore be kept at the highest temperature. Such may be the true cause of the high heat observed in the Imperial incline lying along the Black Dike, which is not everywhere exceptionally hot; and also in the northeast drift on the 2,001-foot level of the same mine, which is run along a branch dike. The Black Dike appears to be on the whole less susceptible to decomposition than the rocks which inclose it, but it is frequently accompanied by highly-fissured rocks some feet in thickness, a phenomenon common to eruptive dikes. A thin and unimportant seam of quartz is also found at many points in its course, which indicates the presence of a previous crevice, or broken ground. These conditions evidently are favorable to the free passage of currents either of gas or water.

Such currents of gas do not account for the cold belts of rock, and it is probable that both the causes here advanced—local decomposition of different intensities and gaseous currents—are in action.

It has been pointed out above that the susceptibility of the Comstock rocks to feldspathic decomposition cannot be considered a peculiarity, since volcanic areas in other places exhibit similar heat phenomena. All the rocks, propylite, diorite, and andesite, show this tendency to break up under the action of water. On the surface there are areas where the alteration has been deep, and others, of just as ancient exposure, where hardly anything more than discoloration has taken place, the material remaining firm. A similar state of things is found below the surface and at all depths reached by the works. Soft seams, hard rocks which remain hard through years of exposure, and hard rocks which flake down and soften under the action of the air, are all met with, and apparently are not distinguished by mineralogical differences.

Upon examining these varying layers the conclusion seems irresistible that the very soft rocks have been the channels of the meteoric waters and perhaps also of the rising mineral waters which have formed the vein, while the solid and unaltered ones have not been the seat of water movements to any great extent. This observation makes the heat of the hard rocks all the more noticeable. They are hot, and sometimes rock which is perfectly solid, both before and after exposure to the air, is as hot as any of the layers met with, though, as a rule, the more decomposed seams are either colder or hotter than the unchanged layers.

This high temperature of the dry and unaltered portions of the ground is sufficiently accounted for by the presence of currents of hot gas. It is known that when a porous rock once becomes filled with water it is impervious to gas currents, and on this fact the modern theory of volcanic action is partly based. In the Comstock ground we have decomposed seams, or strata, that are the channels of aqueous penetration, the seat of chemical decomposition, of gaseous emanation, and of heat evolution. These strata lie in a great mass of rock which is elsewhere dry, and therefore pervious to gases, and the gas discharged in the wet belts makes its way through the dry portion of the rock, imparting its heat and maintaining the apparently abnormal conditions of a rock that is hot from chemical reactions, and yet is not the seat of those reactions.

In the decomposed layers which I have supposed to be the channels of the rising solfataric waters, the clay exists in a state of incomplete hydration. It absorbs water with great avidity, and under such circumstances develops unusual heat. When drifts are opened in such material the clay absorbs moisture from the air-currents, swells and throws off flakes of rock which would come down indefinitely if they were not kept back by timbers. Sometimes the breaking of a pump allows water to rise upon such a stratum, and then the swelling is so great and forcible that timbers 12 and 14 inches thick are broken and split into small pieces.

These decomposed layers may be looked upon as the furnaces of the district. They are found on both sides of the vein and in all the rocks of the region. Sometimes widely separated, they also frequently lie within one or two hundred feet of each other, and the slow diffusion of the heat produced in them may be supposed to have aided materially the effects of the more moderate chemical action in the intervening rocks. Considering the low specific heat and conductivity of rocks it is not surprising that a temperature of 130° F. should have been reached and maintained at depths of 1,500 feet and more, where radiation is necessarily low.

Whatever the exact mode is, it is certain that the result is the same as if the Comstock mines were excavated in a mass of burning material. At present the source of the decomposition is probably atmospheric action. For a certain distance from the surface, which may be approximately put at 1,000 feet, the process was complete, or nearly so, before the advent of man. The fire had burned out, and the rock had cooled down.

When this zone of burnt-out rock had been passed in the mines a lower zone was entered, and here the fire was found to be still in progress. It is not unfrequently said that the heat of the mines has not increased as they have deepened, and in proof of the assertion it is reported that the first bodies of hot water struck were nearly as hot as those that have been tapped at lower levels.

I am inclined to doubt the strict accuracy of this statement, though it is quite possible that isolated bodies of water, tapped on the upper levels, may have had high temperatures, and been derived from portions of the country-rock that were in a more vigorous state of chemical action on that level than the general mass. But the average heat of the water has increased in going lower. Mr King gives, as before quoted, 70° to 75° F. as the average from the surface down to the 700-foot level, and 108° F. as the maximum in the lowest workings of the Empire, Crown Point, Hale & Norcross, which, at that time (1869), were about 1,000 feet below the surface. This conclusion was formed after a careful comparison of numerous observations. It is probable that after passing through a certain thickness of rock in which alteration had nearly ceased, the temperature has increased with some uniformity to its present standpoint.

FUTURE INCREASE OF THE HEAT.

This brings me to the important question, will the heat continue to increase? If it does increase, will it rise to the point of boiling water? The elements of the problem are too vague for a definite opinion on the subject. We do not know how rapid the alteration of the feldspar is, how much heat it produces, nor how much surface-water reaches the hot ground yearly.

The temperature of the water in some of the springs at Steamboat, 12 miles distant from the vein, is sufficient local proof that the rocks of the region are capable of producing heat enough to raise a considerable quantity of water to the boiling point, and at a certain depth this may be the temperature of the rock at the mines. It seems probable, however, that this depth is one that will not be reached by mining in this century, if ever.

In discussing this question it is necessary to keep clearly in mind the fact that there are two distinct classes of hot rocks encountered. The one is the ordinary rock which forms much the greater part of the ground worked in. The other contains a number of individual belts, or bands, of hot or cold rock which are found inclosed in the former. The nature of these peculiar bands will be considered hereafter. It is upon the condition of the first class, or the rocks which compose most of the mining-ground, that a discussion of the general temperature must be based. If we assume the rate of increase in these rocks to be uniform from 108° F. at the 1,000-foot level to 130° at the 2,000 level, it represents 2°.2 for 100 feet of depth or 1° to 45.45 feet. The lower of these temperatures is that assigned by Mr. King to the "lowest workings of the Empire, Crown Point and Hale & Norcross," and this depth at the time he wrote was between 1,000 and 1,100 feet. Mr. King gives this as the maximum temperature, and from the table of observations published by him it is probable that the average may have been in the neighborhood of 100° F. On the other hand, the temperatures on the 2,000-foot levels and below that, were sometimes 136° and 139° F. Assuming it at 140°, in order to obtain a maximum, we have a difference of 140° — 100°, an increase of 40° in 1,000 feet of depth; an average of 4° to 100 feet, or 1° to 25 feet.

The great difference between this minimum and maximum calculation shows how untrustworthy such estimations are when based upon a limited number of observations. The uncertainty is greatly increased by the differences in temperature which exist within small distances. When such calculations are presented in this report, they are to be accepted rather as illustrations than as positive estimations. It is also worth noticing that these rates of increasing temperature, taken in the hottest mines in the world, and where the heat is almost entirely due to natural causes, and not to the artificial conditions of bad ventilation, of crowded mines and combustible material, do not exceed those which have been reported in numerous other localities where no remarkable circumstances were noted. The higher rate, 25 feet to 1°, is perhaps excessive, but many determinations in ordinary rocks have given as much as 45.5 feet.

The greatest depth to which engineers of the present day are looking forward as the maximum to which they may be called upon to sink is from 4,000 to 6,000 feet. The former depth will no doubt be reached by the present generation, but I believe preparations for sinking to the latter distance have not yet been made in any country.

If the heat of the general mass of rock increases at the rate of 1° for 45.5 feet, and the temperature at 2,000 feet is 130° F, the increase for 2,000 feet more would be 44°, and the temperature at the 4,000-foot level would then be 174° F. At the 6,000-foot level it would be 218°.

By the maximum rate of increase calculated above, or 1° to 25 feet, the temperature at the depth of 4,000 feet would be 210° and at 6,000 feet depth 290°.

It is, however, a matter for grave doubt whether under the existing circumstances of the Comstock region the rock will be found at any depth to have the temperature of 212° F. The access of atmospheric air and water must decrease proportionately to the depth, after a certain point is reached, and at that point the decomposition of the rock and the heat produced will be at a maximum.

The opinion that the heat will increase from its present standpoint is a necessary deduction from the explanation which I give of the whole series of phenomena. I cannot agree with the conclusion of Mr. King, that the heat of the rocks is brought in by water that rises from great depths and in a heated condition. I consider that the reverse action is the one which is really going on. The rock heats the water.

The temperature of the rock was determined by a number of trials to be 130° F., as stated above, while water in large quantities comes into the workings, exhibiting a temperature of 154° F. According to the hypothesis here advanced there must be rock of this temperature somewhere in or near the vein. If the water is assumed to rise from great depths and the rate of increase of the heat is uniformly 1° for 45.5 feet, the Savage and Hale & Norcross water of 154° temperature must come from the depth of about 3,100 feet, if the temperatures taken in the Crown Point 2,000 level are assumed as a basis for calculation. Unfortunately it was not possible to obtain data from the flooded mines, as their lower levels were covered by several hundred feet of water during the whole of the field season. The depth of 3,100 feet is 900 below the level on which the water was struck.

I have before stated that I cannot share this theory that the hot water is necessarily drawn from great depths, and it is necessary to explain how it is that the water coming into the mines is almost uniformly hotter than the rocks, except when it is palpably surface water, filtering down through a shattered seam.

It seems to be pretty well settled that the waters of the lode occupy strata of rock which are generally parallel with the vein, these strata being separated by clays, dikes, or solid strata which are impervious to water, and accordingly retain the liquid between them. The numerous long drifts run to the eastward from the vein, cut these parallel strata in great numbers, and tap the water they contain, sometimes in formidable quantities; but in spite of the number of these drifts it is probable that some bodies of water have never been drained, but remain in the country-rock at levels much above the lowest workings of the mines.

I consider these water-bearing bands of rock lying parallel with the lode, to be identical with some of the hot bands previously described, and a little consideration will show that the seamy and shattered condition which fits a rock for storing up water in large quantities, also increases its susceptibility to decomposition by increasing the surfaces acted on. The vast quantities of water which have, again and again, suddenly flooded one mine after another, are evidence that the reservoirs which contain them are also made up of shattered seams, for the undecomposed rock of this region is finely porous and not coarsely porous. It could hardly contain as much water as an ordinary sandstone, and certainly it could not give up its fluid contents with any great rapidity when in its natural condition. These facts have been recognized for a long time on the Comstock, where there is now a settled conviction among intelligent observers that the great inflows of water come from shattered and decomposed seams parallel with the lode and sometimes of great thickness. The old idea that the country-rock contains cavernous openings holding large bodies of water, has been abandoned in consequence of the proof, afforded by more than a hundred miles of exploratory workings, that the inclosing rocks are singularly free from vugs and open crevices. Very few have been found in proportion to the ground penetrated.

These facts force upon us the conclusion that the high temperature of the floods of water is not necessarily due to the depth of their origin. It is more probable that the hot waters come from seams which, on account of their shattered condition, are both more susceptible to chemical action and also more capable of storing up the fluid. Not only is the deep origin of the hot waters not proved by the facts, but the contrary hypothesis is strongly borne out. When they are encountered, it is quite a common experience to strike them *below* the highest point of their source, and the mine is often flooded by such an occurrence to the depth of several hundred feet. The case of the Savage and Hale & Norcross mines is quite in point. The vast accumulation of water which has disabled them for nearly two years was first struck in the 2,200-foot level of the Savage, and filled the two mines to the 1,700-foot level, a height of 500 feet, besides filling the 2,400-foot level of the Savage. This pressure cannot be attributed to the tension of any gas, for it has been shown in a former part of this report that the emanations of gas in the mines have never been very forcible.

The head of 500 feet under which this water entered the mine, and which was steadily maintained for several months, during which new pumps were put in, may be referred with the most probability to a simple hydrostatic head. Its origin was not deeper than the 2,200-foot level, but, on the contrary, at least 500 feet above it; and this fact, taken with its temperature of 154° F., forms the most significant evidence in regard to the origin of all these bodies of heated water.

The fact that the great bodies of water come from the upper portions of the country rock, taken with the other fact that their high temperature may reasonably be ascribed to their occupying the bands of hot rocks, as reservoirs, throws strong light upon the important question of the future continuance and increase of the heat in the mines. The conclusion is that the heat will continue and may increase somewhat, but probably will not reach the boiling point.

The uniform disposition of the rocks in the Comstock region, entirely unbroken as they are by faults, gives good assurance that these collections of water extend to great depths. I suppose that there is a certain amount of convection in this water, currents from the upper portions of the strata setting downward and pressing up currents of hot water from lower depths. This action maintains the water in the upper parts of the strata at a higher temperature than it would otherwise have. The hot water drawn from the lower depths presupposes the existence there of rock of equal temperature. In fact, as there is a constant loss of heat near the surface, we must look upon the highest temperature yet observed in a large body of water, 154° F. as a mean obtained by mixing colder water from the upper rocks with hotter water from those below. The limited rain-fall of Nevada would, however, make the yearly accession of water very small when compared with the quantities which we may suppose the rocks to hold as a permanent store, and this yearly addition would be heated probably above 130° F. by the heat of the upper rocks and the fresh chemical action set up by its presence.

Until water temperatures above 154° F. are observed, we may content ourselves with the belief that nothing in the present condition of things indicates the certainty that the heat will ever rise to the boiling point of water, 212° F. As above stated, it is rational to suppose that the access of atmospheric air and water must diminish in proportion to the depth after a certain point is reached. At that point the temperature will be at a maximum. Below it there will be a state of equilibrium, probably, for a very considerable depth. Below that, the heat may diminish even to a point below that of the highest of the three zones. There must be some point where the absence of drainage allows the water to lie like a blanket over the rocks, protecting them from the action of air or gases from the surface. The known depth required for the production of a temperature amounting to 130° F. is so great that we may fairly doubt whether air or water penetrate to lower depths in quantity sufficient to maintain mineral decomposition with the activity necessary to obtain the boiling temperature. The boiling heat of the water at Steamboat Springs is evidence that the chemical action is going on there near the surface. The common impression that these springs are the last indications of the volcanic forces which poured out the torrents of melted rock that now cover this whole region, may be accepted in a modified form. The rocks of that neighborhood may be the last of a series that certainly occupied an enormous time for their ejection, and in that sense they are the last to undergo decomposition. Chemical action is nearer the surface in them because it is newer. Its maximum line is higher than in the older rocks of the series, which are those that now inclose the lode.

To recapitulate briefly the facts here given, this explanation of the heat phenomena connected with these remarkable mines therefore supposes the existence of a cold, and what may be called a burnt-out, layer of rocks extending for a thousand feet below the surface, a zone of hot rock still in active decomposition, which has been proved to exist for a depth of about fifteen hundred feet more, and no doubt extends thousands of feet further, and finally a mass of cold rock at a great depth which has not yet begun to decompose. This hypothesis will be found to satisfy all of the observed facts.

The peculiar bands of hot and cold rocks which have been described are simply layers of rock in which decomposition has been delayed or hastened. When the texture of a rock is such that it resists decomposition longer than other layers in its neighborhood, it will be at its maximum temperature long after its fellows have passed theirs and cooled down, and this I conceive to be the situation of the hot bands. They are individual layers of rock undergoing delayed decomposition.

On the other hand, when a rock is peculiarly susceptible to the action of the air and water, its alteration will proceed more actively than that of the surrounding rock. It will therefore pass its maximum temperature sooner, and be cooled down by the time that its neighbors begin to be at their hottest. This is the state of the cold bands. These bands, in fact, offer us at several places in the mines examples in miniature of the action that is going on upon a grand scale throughout the whole system of rocks.

All the known facts strengthen the supposition which is advanced in this report, that the heat in the mines is subject to a steady and moderate increase as their depth is increased, this comparatively regular progression being broken by the passage through belts of rock heated above the average of the "country."

In regard to the single mode of heat production suggested here, it is of course possible that other forms of mineral alteration than the transformation of feldspar to clay may have taken place, but they have not been observed. The minerals of the country rock and vein appear to be the same in depth as near the surface, in the cold zones. The rocks are remarkably free from zeolites and other evidences of mineral interchange through the medium of water. Whatever has been done of this kind is almost confined to the deposition of quartz in the upper mines, and of quartz and calcite in the lower mines of Virginia and Gold Hill, and to the formation of clay. Calcite is found in the Black Dike and in rocks of apparently similar composition east and west of the vein, and gypsum also occurs on the surfaces of fissured seams. But the quantity of both is so small, excepting in the Devil's Gate part of the district, that they might well be referred to the ordinary action of atmospheric waters in any series of strata.

RELATION OF TEMPERATURE TO DEPTH.

The temperature of the rock has no relation to fixed levels. There do not appear to be horizontal zones in the earth, with a temperature peculiar to each one; but the relation of temperature to depth from the surface is apparent through all the variations due to differences in the rocks and other causes. The depths given are reckoned from the top of the present shaft, or some old one in each mine, and there is no common datum assumed. The altitudes of the shafts vary to the extent of several hundred feet, but there has been a certain correspondence, though not a close one, in the depth at which hot water was tapped in the different mines; that is to say, the depth from the varying outline of the surface is the only one that can be called constant.

This is illustrated by the case of the Justice Mine. The mouth of its shaft is nearly 1,000 feet below the Gould & Curry croppings, and its lowest workings were about 1,000 feet below the surface. These workings are therefore within a few feet of the same absolute level as the Gould & Curry 1,900-foot station and drift, where the remarkably hot ground above referred to is reported to be. In the latter mine an air temperature of 123° F. is reported in the drift, but in the Justice the rock is still quite cool, and though the temperature of the mine is somewhat higher than on the surface, this increase is mostly due to the burning of candles, heat of the workmen, and other causes that raise the temperature of most mines.

What the future of the Justice in regard to temperature may be cannot be positively foretold, because the filling of its lode is entirely different in character from that of the upper crevice. It is carbonate of lime, while the whole series of mines, from the Utah to the Caledonia, have quartz for their gangue. One is basic, the other acid. Still, as the heat is derived from the decomposition of the country rock, and depends upon the vein only so far as to be increased by the numerous surfaces exposed to atmospheric influences near the crevice, it is to be expected that the Justice and other mines in that neighborhood will, in sinking a few hundred feet more, take their places among the hot mines of America. The basic character of the gangue probably cannot of itself affect the result, and is to be regarded only as an indication of conditions in the formation of the lode which may have lessened the liability of the country rock to decomposition.

The depths referred to in this report are all vertical, and for that reason they do not represent the path which the atmospheric agencies have actually taken. That is to be measured along the dip of the rocks, which varies from 40 to 60 degrees. No other course is opened to surface waters, which have been clearly proved to be limited in their spread by the numerous clay seams which abound both in the country rock and in the vein, and which generally dip with the other rocks. My own observations have convinced me that these waters may also be confined by sheets of massive and comparatively impermeable rock, of which there are countless exposures in the east crosscuts of the mines.

We must, then, consider that the path of these decomposing agencies has been followed, not only for a depth of 2,400 feet in the Savage Mine, but for a depth on the dip of the rocks that is approximately one-half greater than this, or nearly 4,000 feet. For more than one-third of this distance the action has passed by; the rock is burnt out. At the bottom of the lower portion, or 4,000 feet from the surface, the decomposing action may perhaps be considered to be approaching its maximum.

These distances do not exceed, nor in fact equal, those which have been indicated by theory as the possible depths of atmospheric penetration. Observations upon volcanic action and deep artesian wells have familiarized us with the idea that chemical action due to the presence of atmospheric air and water is going on at the depth of thousands of feet. But no instance of this action at depths greater than those exhibited by the Comstock mines has been pointed out.

The Comstock mines, however, offer a greater promise of discovery in this matter of rock temperature than any others that I am acquainted with. The extraordinary rapidity with which their operations are prosecuted, the extent of the works, and the fact that they open to inspection a great eruptive mineral lode thoroughly for two miles in length and partially for many thousand feet more, give them unusual value as a field for investigation. They not only follow an eruptive dike throughout its course, but they also explore a parallel system of eruptive rocks by cross-cuts which are often from 300 to 500 feet long, and sometimes stretch out to 1,000 feet and more. They are also certain to be opened to much greater depth than now, and with a rapidity that will no doubt make them foremost in deep mining within a few years. These conditions, combined with the peculiar susceptibility of the country rock to decomposition, give good reason for expecting that the future of these mines will afford opportunities for valuable observations of many kinds, and it is to be hoped that means for carrying them out without intermission will be provided.

THE SUTRO TUNNEL.

This important enterprise has been pushed with great vigor for several years, its progress having lately been 9 or 10 feet a day when not in very bad ground. It had reached a distance of 19,542 feet on May 1, 1878, and then had 648 feet of cutting to be made. It is the deepest mining adit in the world, being expected to enter the Savage Mine between 1,600 and 1,700 feet below the mouth of the shaft. Its importance to mines which are always subject to flooding is therefore evident, as most of this lift will be saved in pumping. The tunnel mouth is in the town of Sutro, in the valley of the Carson River, about 7 miles distant by road from the Comstock lode. In its way to the mines it will cut three of the representative rocks of the district, the trachyte, the propylite, and the andesite. These eruptive rocks will be exposed through their whole section, unless the trachytic Mount Rau, on the eastern bank of the Carson, is ascertained to belong to a period later than the Mounts Emma, Rose, and Kate, on the west bank of the river.

From every point of view, the Sutro tunnel is an undertaking of the first importance. I much regret my inability to spend the first field season of the Comstock survey entirely in its examination, as it evidently furnishes the key to th e rock system of the whole region. It offers a rare opportunity to obtain an intimate knowledge of a great area of eruptive rocks, and with its aid it is probable that the story of the Comstock can be finally read. This work is necessarily left for another season, my entire efforts this year being concentrated upon the task of mapping the formations, as before said.

The tunnel, fortunately, remains open for inspection almost uninterruptedly throughout its whole length. Mr. Sutro, the organizer and superintendent of the work, has with unusual forethought reserved a series of rock samples taken daily from the header for several years; and as an example of the amount of work which the extensive mining operations of this region everywhere require, it may be mentioned that the mere selection and preparation of specimens from these samples will probably require the work of one man for a month or more. It is proposed to take a Canfield's mineral dresser into the field another season, for the preparation of these and other illustrative specimens.

The superintendent has also preserved a careful record of the work done, and the labor and material required to do it, for several years. It is to be regretted that this does not cover the whole period of tunnel-work; but it does cover the entire period of work with machine drills, and when the undertaking is completed it will offer the only example of a mining tunnel of the first class cut under the peculiar conditions which are found in America.

The history of this tunnel indicates that the country east of the great lode presents essentially the same characteristics as the vein and its neighborhood. Quartz veins in considerable number have been passed through. Water belts have been cut that poured out more that 2,000,000 gallons a day for a long time, the supply then dying away to nothing. Dikes that resemble the Black Dike of the Comstock have been passed. The tunnel, in fact, offers us an epitome of the geological history which the surface presents in broader features, more dimly outlined.

The completion of this work is to be expected within a few months, when the greatest silver-mines of this continent will be provided with a new base of operations. The value of the tunnel will increase as the mines get deeper, for no other engineering difficulty of the future presents such obstacles as the problem of pumping great quantities of water from extreme depths. This obstacle the tunnel, as an adit for drainage, will postpone for ten years at least, and lessen for all time.

APPENDIX I.

GEOLOGICAL REPORT ON PORTIONS OF WESTERN NEVADA AND EASTERN CALIFORNIA, INCLUDING PART OF THE SIERRA NEVADA RANGE, BY A. R. CONKLING, FIELD SEASON OF 1877.

NEW YORK CITY, *March* 15, 1878.

SIR: I have the honor to submit a geographical report on the regions of Nevada and California explored in the season of 1877. The area examined in 1876 lies adjacent to that surveyed in 1877, so that the report presented herewith connects directly with the work of the previous year in the Sierra Nevada Range. In order to complete the triangulation begun in the central part of the range in 1876 it was deemed necessary to revisit a small part of the area surveyed in that year. Wherever this was done I have avoided repeating a description of the geology, and the reader is referred to the annual report for 1876 for detailed information about the region in question.

Very respectfully, your obedient servant,

ALFRED R. CONKLING.

Lieut. G. M. WHEELER,
Corps of Engineers, in charge.

INTRODUCTION.

The region surveyed in 1877 lies in Eastern California and the extreme western part of Nevada, between latitude 38° and 39° 30′, and longitude 119° 15′ and 120° 54′ approximately. The area exhibits little aside from metamorphic and igneous rocks; and the paucity of sedimentary rocks is remarkable. Throughout the mountain area I did not observe a single outcrop of this latter class; but limestone occurs in the western foot-hills of the Sierra near the edge of the area. The area examined lies in Douglas County, Nevada, and in Alpine, Mono, Tuolumne, Calaveras, Amador, El Dorado, Placer, and Nevada Counties, in California. It extends from San Andreas and Placerville on the west to Bridgeport and the Como Mountains on the east, and from Meadow Lake and Mount Jackson, in Nevada County, on the north, to the Sonora and Mono turnpike road on the south. In general the geographical formation is very simple. A strange feature in the scenery of the Sierra Nevada is the occurrence of igneous rocks on the ridges of granite, which project from the ridge-lines as tors, domes, pyramids, and in other forms.

There is abundance of evidence of former glaciers in the Sierra Nevada, for vast surfaces of granite have been polished and in some cases grooved by glacial ice, so that it is probable that during the glacial period the greater part of these mountains was covered with a vast icy mantle. The glaciers, as a rule, extended to the west, and after moving over the foot-hills escaped to the Sacramento Valley. Some of these moving masses were very large. I had not the opportunity to trace the exact limit or extent of any of them. About 100 miles farther south in this range Messrs. King and Gardner, of the California Geological Survey, surveyed the course of an ancient glacier and found it 40 miles long, which is double the size of the Aletsch Glacier, the largest in Switzerland. There is very little doubt that the portions of the Sierra Nevada explored in 1877 were formerly covered with moving masses of ice as great as any in the southern part of this lofty chain of mountains.

It might be well, though difficult, to trace out a series of glaciers rising in the crest of the Sierra and filling the deep cañons of such rivers as the Stanislaus, the Mokelumne, the various forks of the American, Alpine Creek, and several minor cañons bearing no name. Bowlders of gray granite from the western summit are scattered along the divides in the western foot-hills. The evidences of glaciation on the eastern side of the Sierra Nevada are not as well marked as on the western. Yet it is probable that part of the vast sheet of ice escaped to the east and northeast, and melted in the plain of Nevada.

Much mineral wealth exists in the Sierra Nevada, especially in the western foot-hills, but very few ore deposits have been observed on the summit of the range. On the eastern slope the ores are usually found in diorite and diorite porphyry, but on the western side they occur in chlorite schist, talcose schist, and serpentine of blue, green, and gray colors. Placer diggings are found on both sides of the range, but chiefly in the western foot-hills, which contain the great mineral belt of California that runs north and south from one end of the State to the other.

The mineral wealth of the area surveyed in 1877 lies mainly in El Dorado, Nevada, Alpine, Calaveras, and Mono Counties. In El Dorado County my examinations were in the vicinity of Georgetown and Placerville. In Nevada County Meadow Lake was visited. The important mineral deposits at Grass Valley were not in our area. Alpine

County was thoroughly explored, but of Calaveras County the eastern and central portions, and of Mono County the northern part only, were examined. A few ore deposits were observed in the northern edge of Tuolumne County.

Twelve mining districts were visited and reported upon, and notes were made respecting several undeveloped outcrops of mineral in the Sierra.

Throughout the entire area there is no peak which rises 12,000 feet above the sea-level, but several are as high as 11,000 feet, and two or three are still higher—*e. g.*, Silver Mountain (Highland Peak) and Stanislaus Peak. In this region there has been much erosion, many cañon-cutting rivers having left their mark on the slopes of the range. Some cañons, such as the middle fork of the American River, near Michigan Bluffs, reach the great depth of about 3,000 feet. These cañons are generally V-shaped; but a few have the shape of a U, as that of the main Carson River, near Dumont's Meadow, and that of the west branch of the Carson between Woodford's and Hope Valley. The cañon-walls are usually perpendicular, or nearly so, for about 1,000 feet, whence they slope toward the top of the ridges which include them. A singular feature of these cañons is that the highest walls or deepest portions are frequently near the head or upper part. In many of these the walls are so steep and rocky that there is not a trace of soil or vegetation on them. All the deep cañons of the Sierra Nevada are in granite, and hence unlike many other equally deep cañons of the West; for in Colorado and Utah these are oftentimes in limestone and sandstone, particularly the Grand Cañon of the Colorado River. There is one moderately deep cañon in igneous rock; *i. e.*, the Scandinavian, in Alpine County, which is formed in diorite.

The fauna and flora are monotonous throughout the area explored in 1877. The former consists principally of small mammals and small birds, such as gray and red squirrels, quail, partridge, grouse, sage-hen, rabbits, a few bears and deer, as well as several species of reptiles and insects. Fresh-water shells were also collected. The flora is mainly composed of conifers, quaking aspens, and underbrush of manzanita, whitethorn, wild honeysuckle, and poison-oak. There are a few alpine flowers, and ferns, moss, and lichen are abundant. A curious feature of the Sierra Nevada is the occurrence of a fine patch of grass wedged in between barren granite ridges where trees can scarcely grow.

The following passes were crossed, beginning at the north: The summit road by Donner Lake, the Placerville road, the Amador road, the Big Tree road, the Mono and Sonora road. The finest scenery along any of these routes is found on the last.

The Sierra Nevada is very thinly populated. Many stockmen, of course, take advantage of the good grazing-land in parts of the Sierra and keep their cattle and sheep in the mountains during the summer months. All available land is occupied by sheep, so that as early as the 1st of September almost every blade of grass is eaten off. There are fine cattle-ranches in the mountain portions of El Dorado, Alpine, and Nevada Counties, but the sheep go everywhere.

THE CARSON VALLEY AND ADJACENT MOUNTAINS.

Beginning with the environs of Carson City, we have first to consider the valley o the Carson River from this point southward to its head. But before entering upon this description, a reference may be made to the sandstone-quarries one mile east of the capital of Nevada. A brief account of these deposits was given in the annual report for 1876, and the fact was mentioned that fossil *Unios* were abundant, some of the specimens being very perfect. Since then I have found many living *Unios* on the banks of the Carson River, about two miles distant. Their shells strongly resemble those of the fossil species. Prof. D. S. Martin, of New York, informs me that two species are represented in the specimens I have collected, and that they are closely allied to the types of the Atlantic States and Mississippi Valley. Within the past year a block of gray granite, about 30 inches long and 16 inches wide, was found embedded in the yellowish sandstone about 25 feet from the surface. It has the same texture with that of the Eastern Summit, and was evidently transported from this range, which is about 4 miles distant.

Impressions of fossil birds are found in the sandstone. They are three-toed, the toes being equal and about 4 inches long. Several teeth of the elephant and horse were collected, but these are rare. The sandstone is of Tertiary age; but as the fossils have not yet been accurately determined, I cannot state to what epoch they belong. Lake basins replete with vertebrate remains are seldom met with in Nevada, although common in portions of Nebraska and Wyoming. And considering the facts that there are no other fossiliferous deposits within a hundred miles, and that igneous rocks occur on all sides of the State Prison quarries, so that the deposit of sandstone is like an island in a desert sea, the occurrence of vertebrate fossils is particularly interesting.

That part of the Carson Valley lying in Ormsby and Douglas Counties is a broad alluvial plain, which includes some of the best agricultural land in the State of Nevada. The level is interrupted in a few places by low ridges and buttes of granite and igneous rocks. In the southern part of Ormsby County, about 3 miles east of the Carson River, a bed of earthy graphite occurs, associated with calcite in bluish limestone. The limestone runs northwest and southeast, and is about 6 feet thick; but it has been traced only a few feet. The ledge is in a ravine, about half a mile from the wagon-road leading to McTanahan's Bridge. Other croppings of graphite are found in the neighboring hills on the south. Several miles south of the bridge just mentioned is a low basaltic ridge containing the Humboldt Mine, which is being worked at present, but was not visited.

A large deposit of graphite is found in a ravine of the eastern summit behind Genoa. There are hot springs two miles south of the town, at which a hotel and water-cure have been erected. The temperature of the water is 135° F., and the hot air or vapor within the bath-house has a temperature of 115° F. The attendant informed me that the water is hottest in the night.

Tors of gray granite outcrop on the spurs of the eastern summit. In the Carson Valley there is no rock *in situ* between the ridge that contains the Humboldt Mine and a point one mile from Woodford's. There seems to be an uninterrupted mass of granite from the eastern summit, at the south end of Lake Tahoe, to the West Carson Cañon; and the west branch of the Carson River runs through a deep cañon of gray granite, in which the jointed structure is well shown. About 4 miles west from Woodford's is a small lateral cañon, at the top of which on the plateau, and about 1,500 feet above the level of the river, occurs volcanic breccia of a brownish color, which is traversed by joints. The northern wall of the cañon is a little higher than the southern. At the entrance to Hope Valley the granite becomes quite feldspathic, and hornblende enters into its composition. Granite and syenitic granite continue up to the head of Hope Valley, which contains excellent pasturage, and has many bowlders of gray granite scattered over it. A low, broad ridge of gray granite occurs about the middle part of the valley, and an outcrop of coarse gray trachyte, about 40 feet thick, was seen just behind the house of Mr. T. M. Stevens. A stream of water has cut through it and formed a small chasm.

Hope Valley is bounded on the west by Stevens's Peak, a mass of red trachyte, containing hornblende, orthoclase, and plagioclase. The main mountain of Stevens's Peak runs east and west and presents a rugged outline, and a vast amount of detritus covers the summit. The south side of the peak is much steeper than the north, and there is no timber within 600 feet of the top, but underbrush extends nearly all the way up the mountain. On the east side is a perpendicular face of rock for about 400 feet, but on the west the peak curves around toward the north, and the red trachyte extends to about one-third of a mile west, and then blue diorite with black crystals of hornblende appears. About three-quarters of a mile on the ridge northwest of the peak the diorite assumes a slaty structure, has light-blue color, and contains olivine. Brown volcanic breccia occurs at the foot of the western slope of Stevens's Peak, and north of the peak, just across the ravine, and on the same mountain mass, the breccia outcrops again. The rock has been denuded so as to form pinnacles and turrets. The grooves are perpendicular, and probably they have been formed by rain and melted snow. Brown volcanic breccia occurs also on the narrow ridge that extends eastwardly from the peak. The lower half of this peak on the east side is gray granite, containing black mica, limpid quartz, and white orthoclase. Directly south is Red Mountain, which has essentially the same petrographical formation. At the head of Hope Valley low ridges of granite occur.

Southward from Stevens's ranch the land rises rapidly to the head of the valley, and the dome-shaped hills and bosses of gray granite have been rounded by glaciers. West of Stevens's Peak is an alluvial flat, about one-half mile wide, which holds two ponds. There the Little Truckee River rises, and flows thence through the narrow granite cañon in a northeast direction to Lake Valley. The cañon shows three lakelets, whose western sides are densely wooded. The east side of Hope Valley is a large ridge consisting of granite in the lower part and trachyte in the upper. Cary's Peak, just east of this valley, is a knob of bluish-gray trachyte about 150 feet high. The rock contains black hornblende and white plagioclase, and is similar to the trachyte on the eastern side of Stevens's Peak. It is slightly laminated, and on the south side is in prismatic columns. The slopes of the mountain are much covered with *débris;* there is no timber on top, but a few conifers are on the ridge. About three-quarters of a mile to the northwest on the ridge there are two knobs of igneous rock which I did not visit. The western one is the higher. Looking southward the observer sees the low granite ridges in Hope, Faith, and Charity Valleys. South of Hope Valley the eastern and western summits run together, and are henceforth one broad range as far as my observations extended. Blue basalt, having a somewhat slaty structure, occurs about 2 miles west of Cary's Peak, in a cañon. Gray granite now appears, and on the eastern border of the west fork of the Carson River are two low ridges of gray granite perpendicular on the side toward the river. There is a similar perpendicular wall of gray granite on the opposite side of the grassy flood-plain of the river. Both are about 50 feet high. The Hope Valley gold and silver mine lies near the head of the valley. Mineral croppings have long been known in Alpine County, and this deposit was discovered as far back as 1854 by Mexicans. Since then the mine has been worked at intervals. The wall-rock is partly white quartzite, and partly granite. The ledge is traced for a width of 50 feet, and runs nearly north and south. The ore is chiefly auriferous quartz, but chalcopyrite also occurs. Blue basalt outcrops near this mine, and also near the head of Hope Valley, 2 miles south of Stevens's ranch. The red trachyte stops at the Amador road. Going southward into Faith and Charity Valleys the rock is all gray granite, except a few bowlders of basalt are scattered over the country. The pasturage on the broad alluvial bottoms of these valleys is fine. The ridge on the west side of Charity Valley is basaltic, and on the east side light-brown trachyte containing a few particles of black mica. The west branch of the Carson River rises in Faith Valley. Following up Charity Valley we cross a low ridge of red volcanic breccia, which is much decomposed and takes the form of tors, knobs, pinnacles, &c. The next large valley on the south is Indian Valley, which contains an abundance of fine grazing-land. There is a lofty serrated ridge of volcanic breccia on its eastern side, which has been called the "Devil's Ridge." The crest-line is jagged, and erosion has produced very fantastic outlines. The ridge is one of the most picturesque in California, and has several outliers and devil's walls. At one locality a tor of rock, known as the "Devil's Toe," and about 100 feet in height, projects above the ridge-line.

There is a large lake on the eastern side of Indian Valley. *Roches moutonnées* of gray granite occur on the north and northwest; the peak at the head of the valley is grayish-blue basalt, and gray granite extends several miles to the westward, as far as Blue Lakes. A lateral valley runs west from the head of Indian, and at a distance of 3 miles blue syenitic granite outcrops. Southward from this valley one finds the hills composed of volcanic breccia for about a mile and a half, beyond which curved and straight basaltic pillars about a hundred feet in height occur near the road.

The north side of the ridge north of Hermit Valley is strewn with bowlders of several kinds of igneous rocks. The rock now passes into gray granite. Farther southward is the cañon of the Mokelumne River, which is formed in the same kind of rock. The walls are rather high and steep, but not in so marked a degree as a few miles farther down. The first ridge south of the river is composed of light-gray to dark-brown volcanic breccia, and between it and the river there are several ledges and knolls of gray granite. The breccia contains both vesicular and scoriaceous basalt, and is more varied in its composition than that of the Amador road. This ridge has two outliers composed of the same rock and running at right angles to it northward, or toward the Mokelumne River. This cañon exhibits unmistakable evidence of glaciers; and doubtless a glacier once had its rise on the western slope of Silver Mountain, moved westward and scooped out the Mokelumne Cañon. The *roches moutonnées* are occasionally covered with a little soil and clusters of coniferous trees.

Gray granite forms both walls of Pacific Valley. There are several outcrops of igneous rocks at the head as well as on the eastern side. Lookout Mountain is about 2 miles east of the valley, and near it is a butte of columnar basalt. The pillars have usually five sides, and the rock is dark blue and contains many specks of olivine. Next to the basaltic pillars occurs a kind of gray porphyritic diorite encrusted with white calcite. A few other buttes of blue basalt occur on the same mountain mass, the northernmost of which is the highest. Gray granite occurs on the northeast side of this mountain, about half way down to the valley; and at half a mile west of the mountain gray hornblende porphyry and volcanic breccia outcrop. Trachyte having a slaty structure and light-gray color was seen in a gulch about one mile west of the mountain.

Traveling east toward Silver Mountain, we have gray granite all the way, with occasional tors and knobs of basalt and volcanic breccia. From Hermit Valley gray granite continues along the wagon-road till the summit of the pass is reached and forms the densely-timbered ridge south of the Mokelumne River. There are two lakelets just north of the summit of the pass, and several dome-shaped buttes of basalt occur in this vicinity. Gray granite is found on both sides of the Big Tree road as far as Silver Mountain City. There are a few ledges of auriferous quartz near the head of Silver Creek; and a small outcrop of blue diorite was seen in the south side of the same stream. I visited the Noble Canon Mine, first opened in 1863, in company with Mr. Ford, one of the owners. The ore occurs in ledges of white quartzite in gray granite.

Silver Mountain consists of four peaks—two on the northern and two on the southern end, which are connected by a low, narrow ridge. The highest peak is 10,956 feet above the sea-level. In making the ascent of the mountain by the north side one sees at first blue basalt *in situ;* a little farther up, and slightly to the west, occurs blue diorite containing many crystals of green hornblende; and on reaching the broad plateau basalt again appears. At the south end of this plateau, which is about a quarter of a mile long, the land rises rapidly, and the rock is now yellowish-white granite much decomposed. The granite is *in situ*, and the northern slope is here covered with disintegrated fragments. Farther up the mountain and toward the south is compact yellow granite containing chiefly glossy quartz and black mica. To the south the two low buttes that outcrop just east of the northern peak are formed of granular bluish-gray diorite, containing a little mica. The peak itself, or Silver Mountain proper, consists of gray diorite porphyry with a bluish-gray matrix, in which many crystals of white plagioclase are imbedded. Just beneath the peak and on the northwestern spur considerable masses of yellowish-white trachyte are found. A narrow spur runs east of Silver Mountain, which is composed of blue diorite porphyry for about a quarter of a mile, then diorite, stained red on account of oxidation of the iron, and finally volcanic breccia forms the end of the spur. On the eastern side of the mountain, about midway between the two peaks, occur first volcanic breccia of a brownish color; then gray hornblende porphyry, which constitutes the mass of two large crags lying directly north of the south peak. The main south peak of Silver Mountain, or Highland Peak as it may be called, is made up of grayish trachyte with much disseminated hornblende. Just north of the peak there are several sharp buttes of porphyritic diorite, having large rectangular crystals of feldspar; then comes a large mass of trachyte decomposed in some places as far as the lowest part of the connecting ridge. The lower part of Highland Peak is composed of ferruginous volcanic breccia, often stained dark red. A large spur of volcanic breccia extends to the eastward from the southern peak.

A brief reference to the topography of the mountain may be made here. The ridge is perhaps three miles long, and has a serpentine course. The southernmost spur is north and south. The main mountain mass now trends northeast and southwest; there are several small ridges that run east and west. From this place the main ridge stretches northeast and southwest again, and finally extends north, with projecting crags here and there, till the steep wall of Silver Creek Cañon is reached. The western side of the mountain is steeper than the eastern, and the general trend is north and south. The nucleus is gray granite, as I ascertained by entering the tunnel of the Mountain Gold and Silver Mining Company, at the bottom of the peak on the north side. This side of Silver Peak is a break in the broad plateau before mentioned. Whitish trachyte porphyry, having a slaty structure, occurs in a ravine on the northern slope of the mountain, but the rock is chiefly basalt on this side.

Ledges of auriferous quartzite outcrop on the extreme northern edge of the mountain, and one of these has been worked to some extent by the Mountain Gold and Silver Mining Company. Work on the claim was begun in 1863, and continued till 1869, since which time only enough labor has been expended annually to enable the owners to hold the property. There is another tunnel, about 300 feet long and 1,000 feet above the valley. The highest croppings are about 1,200 feet above the lower tunnel. It would have been better to have sunk a shaft on the ledge instead of driving a tunnel at the bottom of the cañon wall in hopes of tapping the vein. A great deal of money has been spent throughout Alpine County in boring tunnels, and there is reason to believe that if this amount had been expended in sinking shafts the mines of the country would now be in a more prosperous condition. Hard blue basalt occurs for about 500 feet from the entrance of the mine tunnel, the rock then passing into gray granite, which extends as far as the heading.

The principal lateral cañons extending from Silver Creek are Pennsylvania and Scandinavian Cañons. In the former there are a few partially-developed mines which I did not visit. In the latter the rock is blue diorite and diorite porphyry, passing occasionally into fine-grained feldspar porphyry. These rocks extend to the head of the cañon. Here are the well-known I X L and Exchequer Mines. The north side of the cañon of Silver Creek is chiefly diorite, although a mass of white trachyte occurs just below Silver Mountain City, and volcanic breccia is seen near the Exchequer Mill. Farther down Silver Creek a great variety of rocks were observed. Where the creek crosses the road on the south side of the cañon there are many pillars of basalt, both horizontal and curved. Then occurs volcanic breccia of a dark color on both sides of the cañon for about 2 miles, and farther on a whitish-yellow trachyte. Beyond the Carson River diorite and diorite porphyry, generally blue in color, outcrop again. Leaving Bullion and following the toll-road we have blue basalt as far as the bridge; thence there is no rock *in situ* for about a mile.

Just beyond Markleeville volcanic breccia occurs and extends for about 5 miles on both sides of the road. About 2 miles west of the town gray granite outcrops and stretches back to the line of the Sierra Nevada. Gray and bluish-gray diorite then appear and continue as far as the alluvial plain of Diamond Valley. There are a few low buttes of basaltic rocks on the north side of this valley which separate it from the alluvial plain of Carson Valley. From Thompson's ranch the rock is diorite and diorite porphyry for a mile and a half to the eastward, then quartzite ledges outcrop and extend as far as the main Carson River, and even to a short distance on the east side of it. Diorite now appears having a porphyritic texture, varies in color from light blue to gray, and stretches southeast to within a mile of Double Springs. Near these springs there is a flat grassy patch marking the bottom of an ancient lake, and surrounded on all sides by mountains composed of igneous rocks. The line of our route now runs into Nevada for a few miles.

An alluvial plain covered with sage-brush and with rolling hills of basalt on either side extends from Double Springs, past the Mountain House on the Aurora road, to the edge of Antelope Valley. Going southward there is an outcrop of blue mica slate at the State line. Crags of this rock occur west of the road on the hill-side, but it soon graduates into bluish feldspar porphyry. Mica slate, from dark blue to brown in color, then appears. Leaving the ravine and having reached the flat the observer sees no rock *in situ* for several miles, but on the west there are diorite and light-gray granite toward Slingert's Valley. The ridge bounding this valley on the east has a serrated outline, and is partly granite and partially basaltic. The southern end as well as the greater portion of the crest-line is gray granite. The ridge is flanked on the northwest side by ferruginous basalt, and its northern part is chiefly volcanic breccia. Slingert's Valley, about a mile wide and perhaps 6 miles long, is covered in great part by sage-brush, but the eastern side contains good grass in the upper portion. Bold crags of blue mica slate crop out on the western side of the head of the valley, and the rock contains so much white quartz as to give it the appearance of a compact quartzite at first sight. Diorite also occurs on this ridge.

On the eastern side of the road leading out of Slingert's Valley there is a blue diorite with much disseminated olivine. On the summit of the divide blue mica slate again appears, and is, in fact, the continuation of the ledges just mentioned. The same rock also forms the greater part of the next ridge on the southeast. There is an upheaval of brownish quartz porphyry south of the wagon-road that leads to Antelope Valley, and still farther south is a small butte of light-blue basalt, while on the south and southeast there are outcrops of blue mica slate, and in one place the rock graduates into whitish quartz schist. Toward the village of Silver King, blue mica slate occurs for 1 mile from the summit of the road, where gray granite appears, and extends as far as the junction of the forks of the Carson River. At Silver King a compact white quartzite occurs, and a mass of gray diorite on the eastern side of the east branch of the Carson River. The ridge above it is formed of volcanic breccia on the greater part of its summit and western slope. The mountain south of the junction of the east fork with the main Carson River is composed of gray phonolite containing a little transparent feldspar. Grayish diorite, porous or compact, occurs on the eastern and northern spurs, and volcanic breccia was seen on the eastern spurs. On top, the mountain is quite flat; is very steep on the southern side, while it slopes gradually on the northern. Between this mountain mass and Silver Peak there is a narrow ridge, which consists of gray granite, and a low hill of basalt, varying in color from light blue to dark blue with disseminated olivine, about one-half mile south of the junction of the east branch of the Carson River. It shows many long and narrow pillars, and the butte is one-eighth of a mile long, 200 yards across, and 50 feet high. South from the "junction" is a deep cañon of gray granite, in which the main Carson runs southward for 1 mile, then trends to the west. Tors and knobs of igneous rock were seen on the summit of the granitic ridge on the west, and a fine pyramid of gray granite projects from the cañon wall near the bend of the river. The next prominent point on the west is Wolf Creek Peak, described in the latter part of this report. The ridge lying between the main Carson Cañon and Fish Lake Valley is formed of gray and yellowish granite with occasional outcrops of igneous rocks on the summit. North from the junction there is good grazing land all the way to the head of Bagley Valley. Gray granite occurs on the western, and light-blue diorite on the eastern side of this valley. The quartzite ledges that outcrop near the Carson River probably extend westward to Monitor. There are auriferous deposits at this place as well as at Mogul on the north.

Blue basalt occurs at the eastern end of Monitor Cañon, and blue feldspathic diorite extends through the rest of the cañon to the town. The gold-bearing quartzites that outcrop at Monitor continue northeastward to the abandoned hamlet of Mogul. The rock varies in color from light brown to white, and is sometimes stained red. The Morning Star Mine, the most important in Mogul Cañon, was discovered in 1863, worked till 1869, and then abandoned. The ore occurs in white quartzite.

Traveling toward Slingert's Valley from this point, the observer sees first light-blue diorite porphyry on the southeast; then diorite for 1 mile, and then a few buttes of gray trachyte. This latter rock contains flakes of black mica and black hornblende, and is similar to that of the southern part of Silver Mountain. At an abandoned mine in Leviathan Cañon, 6 miles northeast of Monitor, native sulphur, chalcopyrite and malachite were seen.

Mineral croppings are found on the ridge bordering Antelope Valley on the west in the vicinity of Coleville and the Napoleon Mine. Antelope Valley is bounded by the Sweetwater Mountains on the east and southeast, is about 15 miles long, has a varying width, the broadest part being at the northern end, and contains many farms and dairy ranches. A low ridge of igneous rocks forms the northern boundary, and the West Walker River has cut a cañon through it in escaping to the plains of Nevada. The rocks are mainly volcanic breccia and diorite; but there are several low knolls of basalt on the northwest edge. The western boundary of the valley is formed of gray granite, as is the conspicuous wall of rock about 1 mile south of Coleville, like that throughout the Sierra Nevada.

On the southeast side of the road, near Watkin's ranch, soft decomposed light brownish granite occurs, containing blackish mica, white feldspar, and limpid quartz.

In the country lying immediately west of Antelope Valley, gray granite extends westward as far as the east branch of the Carson River. About a half mile south of Silver King there is an outcrop of gneiss containing much blackish mica, that in places almost passes into mica slate. Up the east branch of the Carson, in Fish Lake Valley, gray granite continues with tors and knots of igneous rocks projecting from the ridges. Near the head of this valley I counted nine outcrops of igneous rocks within a square mile. The ridge lying west of the head of the valley presents an interesting example of alternating granite and igneous rocks. The walls of the cañon are very steep here, and the ridge-lines of gray granite are irregular in outline and present fine pyramid-shaped peaks. Occasionally the observer sees perpendicular walls of gray granite on the sides of mountains capped with basalt and diorite, and the lower part of the wall is frequently covered with the *débris* of the igneous rock. The mountain mass at the head of Fish Lake Valley is principally diorite and basalt. In general, it may be stated that in this section of country, as well as in other parts of the Sierra Nevada, the ridges are formed of gray granite on the lower part, while igneous rocks occur along the crest and oftentimes on the spurs.

The summit of the peak just east of the main cañon of Fish Lake Valley is diorite, varying from blue to dark brown in color. Below the peak the rock becomes vesicular, and bright red vesicular lava occurs along the ridge. There are many pools and springs of warm mineral water near the head of this valley, with a temperature of 73° F., and the ground in the vicinity of the springs is covered with efflorescences of carbonate of soda. The rock at the source of the east branch of the Carson River is mainly gray granite; gray diorite containing black crystals of hornblende occurs about 1 mile from the head of the stream; and blue basalt is found near the divide.

The divide between this river and Silver Creek is composed chiefly of grayish-blue diorite, which also forms part of the ridge lying on the east, and having a southeasterly direction. The opposite wall of the cañon consists of grayish-blue diorite, containing small particles of olivine, and graduating into the vesicular texture. Red vesicular lava occurs in the southeast side of the cañon lower down. Granite predominates for about 4 miles from the source of Silver Creek; then dark-red volcanic breccia appears. Some mineral croppings have been found near the creek; and half a mile from it is the Arctic Mine, discovered in 1864 by Mr. Carr. Gray granite is the wall-rock, and there is a pocket of ore from 4 to 6 feet wide, traced for a distance of 500 feet. Galenite, native silver pyrite, blende, and quartz occur. The ore shows no trace of gold.

THE SWEETWATER MOUNTAINS.

These mountains lie directly south and southeast of Antelope Valley, and extend from it to the Big Meadows. A broad valley bounds the range on all sides. The main ridges run north and south. Considering the altitude of these mountains they are very flat, the ridge lines being nearly level, and there are no high, sharp peaks. The ridges are so gently undulating that a mule can be ridden to the top of the highest peak. These mountains lie in Mono County, and the Sonora road runs along their southern boundary. The range is chiefly granite, and contains nearly all the members of the granitic family. Little igneous rock occurs on the summit, but there is some in the foot-hills. In general, one may say that the low ridges are igneous while the higher ones are granitic. Throughout the range the cañons are generally **V**-shaped, and high plateaux of considerable extent and dome-shaped peaks are common. The southeastern spurs consist partly of dark quartz porphyry. The part of the mountains that bounds the Sonora road on the north is described in the next chapter.

Leaving this road and following up the first large cañon on the north, Swanger's Creek, we find light-gray porous trachyte, consisting of transparent plagioclase, and hexagonal crystals of brown mica disseminated through it. The cañon runs north for half a mile, then trends to the east for a quarter of a mile, and finally resumes its northerly course Farther up the cañon and on both sides there are outcrops of white and grayish-white trachyte, with flakes of black mica and grayish-white plagioclase. Just before the cañon turns to the northeast dark-purple basalt with white particles of orthoclase occurs. This outcrop is on the spur of a ridge composed of dark-colored quartz porphyry. Beyond the bend, a fan-shaped mass of white trachyte. The low ridge northwest of Swanger's Creek is gray granite to within 400 feet of the top, above which there are a few crags of reddish volcanic breccia, and the summit is blackish-brown quartz porphyry. This is a very peculiar rock, and contains nodules of black flint and particles of transparent sanidine. Grayish and whitish trachyte occurs on the northern, eastern, and western sides of the grassy flat at the forks of Swanger's Creek. Up the cañon of the western fork we have gray syenitic granite on the north side for a mile and a half. The peak west of the main ridge of the Sweetwater is grayish-white syenitic granite containing transparent plagioclase, white quartz, black hornblende, and very little black mica. Often hornblende is wanting, and in places the feldspar is present in such small quantities that the rock almost passes into a quartzite. Streaks of olivine are scattered through the granite.

The highest ridge in this range is nearly level, and without vegetation. The eastern part contains more igneous rock than the western, which is chiefly granite and rocks of the granitic group. Diorite porphyry, much like that of the I X L Mine, near Silver Mountain City, is found on the main-ridge line in small tors. The principal part of the higher ridges in the Sweetwater Mountains consists of grayish-white and white granite, which successively passes into granulite, feldspar porphyry, and quartzite. The rock directly east of Sweetwater Peak is white quartzite, that graduates into a dark, decomposed quartzite, which is ferruginous. There is an outcrop of bluish diorite, sometimes porphyritic, about a half mile long on the highest ridge. Hexagonal prisms of clear quartz are found near the highest peak. A few clusters of these crystals were observed in the quartzite, and in one of them the prisms are 2¼ inches in length. Drusy quartz is found on Monument Peak, which is about 2 miles southeast of Sweetwater and a few feet lower. The rock of this peak is yellowish-brown quartzite, which contains a few minute particles of plagioclase. Near Monument Peak there is a knoll of slightly porphyritic gray diorite, which soon passes into dark and light red feldspar porphyry. A short distance to the west two flat domes of red trachyte occur. A large, elevated plateau lies west of the main ridge, on which may be seen a solid tor of white quartzite, a small ledge of grayish-yellow feldspar porphyry, and a knoll of bluish granite, similar in appearance to the famous Quincy granite so much used as a building-stone in the Eastern States. The rock at the head of Peavine Creek is gray granite. Going eastward, the first knoll is white feldspar porphyry, which in places passes into a quartzite. Near by occurs a butte of dark brownish-red feldspar porphyry with white particles of plagioclase. Northward, along the main ridge, and toward the highest northern peak, we have, successively, white quartzite, white feldspar porphyry, and white granulite often tinged with yellow. The northern and highest peak is white compact granulite. On the summit of this main ridge, for a quarter of a mile to the southward, there are several outcrops of diorite porphyry. A little further south there is a rock composed of light blue quartz and black specks of hornblende; then reddish trachyte, containing hexagonal crystals of black mica, occurs. The rock is somewhat porous. To the west of this outcrop there are two more knolls of reddish trachyte, in one of which the rock is streaked, and graduates into red feldspar porphyry. Light-blue granite occurs near by. The rock on the east side of the cañon of Peavine Creek is chiefly granulite, and consists of limpid quartz and white feldspar.

The northwestern part of the Sweetwater Range is all gray syenitic granite, being composed of black hornblende, limpid quartz, black mica, and white feldspar. Tors of this rock project on all sides of the cañons, often much disintegrated, and in places the walls of the cañon are covered with fragments of it. These mountains slope very gradually toward Antelope Valley reckoning from the cañon of Desert Creek. The first ridge north is quite flat on top.

One mile east of the grassy patch on the bank of Peavine Creek there is a pyramidal mountain, composed mainly of a very peculiar porphyritic granite, consisting of white feldspar, reddish quartz, and particles of black mica. Occasionally the rock has a banded structure, layers of white feldspar and dark-reddish quartz occurring side by side. Toward the base of the mountain on the west side dikes of blue basalt occur. This is the first large mountain mass west of Sweetwater Peak. A spur of basalt projects into the cañon that lies partially between these peaks; there are several other outcrops of basalt, generally of a blue color, in the immediate neighborhood. Down Peavine Creek whitish granite occurs on the east side, and beyond that volcanic breccia, which forms a mesa. Then, near the artificial pond, there is a butte of dark-brown syenitic porphyry, consisting of black mica, white feldspar, and black hornblende.

Just east of the head of Desert Creek light blue granite outcrops, composed of bluish-gray, which is the predominating constituent, black crags of mica, and transparent plagioclase. This rock resembles the grayish diorite found in many parts of the Sierra Nevada. At the mouth of a tributary of Desert Creek, perhaps 3 miles from its source, whitish feldspar porphyry, with many crystals of transparent plagioclase, occurs. On the hill lying on the opposite side of the creek there is an outcrop of whitish granite consisting of white quartz, transparent plagioclase, and a few particles of black mica. Following up this branch creek for half a mile, the stream trends to the south, and a large mass of blue feldspathic basalt, containing particles of olivine, occurs on the west side of the cañon. One mile farther the creek again flows along an east and west line, and a mass of white siliceous conglomerate outcrops. The pebbles are small, and there are many grains of white quartz in the matrix. About one-third of a mile away, on the opposite side of the valley, there is a low ridge of bluish granular diorite, and at 300 yards to the north another butte of compact blue diorite. Running parallel with it, and about 200 yards to the eastward, is still another low ridge of blue feldspathic basalt. The creek that rises on the northern slope of Sweetwater Peak breaks through both of these ridges and forms a cañon. Going north from this point, the first mountain mass is made up of pinkish granite, containing light red quartz, yellowish-white decomposed feldspar, and a few flakes of mica. The rock is at times streaked, as in the peak on the east side of Peavine Creek, and occasionally it almost graduates into a feldspar porphyry. On the northeast side of this long undulating ridge, the rock is grayish-white granite, with black flakes of mica, white quartz, and transparent plagioclase. Feldspar porphyry of a light color occurs on the eastern slope of this same ridge. A valley about a quarter of a mile broad, and containing a few ponds and marshy ground, together with several acres of pasturage, lies east of the ridge just described. Various kinds of rocks are found on the mountain lying northeast of this valley—bluish volcanic breccia, finer grained than that of the Sierra Nevada usually is; a few yards east gray feldspar porphyry, with rather large patches of white feldspar; on the southern slope of the peak, near the summit, light-brown feldspar porphyry. The top of the highest northern peak of the Sweetwater consists of whitish granite, which has a slaty structure, and consists chiefly of white quartz and glassy feldspar with some black mica. There is a high and rather flat plateau on the north side of this mountain toward Desert Creek. The southern slopes of the peak are mainly grayish-white granite. On a low and sharp ridge just west of this peak pinkish feldspar porphyry outcrops; then a grayish-white granite appears, which has so little mica in it that it may almost be called a quartz porphyry. There are small cavities in the rock lined with minute crystals of quartz. Banded and jaspery quartz occur just west of the peak.

Returning to Desert Creek, grayish-white granulite occurs on the western side of the cañon. Down the cañon there is no rock *in situ* for 2 or 3 miles; then gray syenitic granite occurs on the western side of the creek. Farther on syenite of a grayish color outcrops on both sides. In fact, Desert Creek has cut its way through two large ledges of syenite. Following down the creek, at the distance of a half mile, we have whitish granulite and grayish-white granite, containing transparent plagioclase and white quartz. The outcrop of granite is a quarter of a mile long, succeeded by red volcanic breccia and bluish diorite a half-mile farther. The cañon is now V-shaped, and pine-nut trees are abundant on the sides. The creek runs northwest for several miles, then trends west for half a mile, and finally flows northward, cutting through a ledge bearing east and west. Beyond this point light blue diorite occurs on the west side of the cañon. Volcanic breccia is seen along the eastern wall for at least one mile. This rock is at first light colored, inclining to pinkish gray in places, then it changes to a dark color and assumes a very coarse texture, the bowlders being sometimes 3 by 4 feet. The ridge south of Desert Creek, which embraces the highest peak in the extreme northeastern part of the Sweetwater Mountains, is undulating and consists of several species of rock. The peak itself slants quite rapidly on the northern and northwestern sides, and is composed of pinkish trachyte having a porphyritic texture. A few feet below the summit there is a considerable outcrop of blackish volcanic breccia; a wall of reddish brecciated volcanic scoria occurs about 200 feet lower, and dark blue basalt containing olivine lies below this. The slopes of this peak are covered with much *débris* of red basalt and volcanic breccia. The ridge lying east of the lower portion of Desert Creek is essentially igneous and trends north and south. The eastern part, west of Desert Creek, is diorite and volcanic breccia. This flat and scantily timbered ridge lies between Antelope Valley and the cañon of Desert Creek. The extreme northwestern ridge of the Sweetwater Mountains is a long and nearly flat plateau, which on the northern side descends abruptly to the plain.

Returning to the creek and traveling northward one finds volcanic breccia on both sides of the cañon; but a short distance farther down blackish basalt outcrops on the western wall, and directly opposite there is a large mass of grayish-green diorite. The cañon now gradually widens and the plain is soon reached. Here the creek continues in a northerly course and empties into the East Walker River. A few undeveloped mineral croppings are found on the extreme northern spurs of the Sweetwater Mountains, about 2 miles from Matthew's ranch. A little work has been done, and the ore found is gold quartz. A large sage-brush plain lies on the northeast side of these mountains. This was the eastern boundary of our area. Gray volcanic breccia occurs on the northern side of the small cañon of West Walker River, between Wellington's and the head of Antelope Valley, and grayish diorite is found on the south side of this river.

On the western part of the Sweetwater Mountains the northern part of the West Walker River Cañon is dark gray granite, but the rock soon changes to light gray, and 2 miles farther south becomes nearly white. Four miles from the mouth of the cañon large masses of compact blue diorite occur on the western side. Farther on many tors and ledges of gray granite appear on both sides; and continuing southward bold and extensive outcrops of igneous rocks are seen on the eastern wall of the cañon which reach nearly to the summit of the ridges lying to the eastward.

THE REGION NEAR BRIDGEPORT.

Hot springs occur in a small plateau one mile east of this town, which is in the southeast corner of the area examined. There are about thirty wells, with an average diameter of two feet. The Big Meadows contain many thousand acres of arable land, and crops of hay and vegetables are raised in abundance.

The Bodie Mines, although outside of the area of exploration for 1877, were visited briefly on account of their importance. The ore is a compact auriferous white quartzite, which occurs in bluish diorite porphyry. This deposit may be said to belong to the same mineral belt as the Comstock Lode, Belleville, Benton, &c. There are valuable placer diggings in the Mono mining district, about 12 miles south of Bridgeport, and Mr. Patterson, of that town, informed me that a million dollars in gold had been taken out of them.

THE SONORA ROAD FROM BRIDGEPORT TO SAN ANDREAS.

Leaving Bridgeport and crossing the Big Meadows, Buckeye Cañon is reached. At its mouth there are small tors of gray syenite; farther up, dark gray granite outcrops on the north side, and is probably a continuation of the ledges seen on the south side of Tamarack Cañon; and higher still are dark blue compact granite, gray syenite, blackish-blue syenite, and finally, syeniteic granite. The syenite comes down almost to a level with the creek in terraces. Near the head of the cañon there are large knolls of gray granite on the north side. The ridge between Buckeye Cañon and the Sonora road is composed principally of light gray trachyte and basalt.

Obsidian porphyry occurs on the Sonora road, near Rickey's ranch. This rock becomes coarse grained, and the obsidian occurs in streaks soon after entering the cañon. At the entrance to the grassy valley of Swanger's Creek the obsidian is absent, and the rock becomes dark quartz porphyry, containing plagioclase and quartz. Compact iron-gray syenitic granite outcrops on the western side of the cañon, about a mile from Rickey's ranch, consisting mainly of black hornblende and white feldspar. The cañon now trends nearly east and west, and on the northern side shows large ledges of whitish-yellow granite, which extend from the upper slope of the cañon toward the summit of the Sweetwater Range. Farther on dark-gray compact granite occurs, different from the ordinary gray granite of the Sierra Nevada. The ridge south of the Sonora road contains chiefly yellowish granite, with some igneous rock scattered along the summit. Many disintegrated fragments of this granite are found on the south side of Tamarack Cañon, at the western end of which granite appears, varying in color from light gray to yellowish white, and consisting of limpid quartz, white plagioclase, and blackish mica, the latter in small quantities. The south side of the gap at the west end of the cañon, is a little higher than the north. On the wagon-road the wall of granite rock rises nearly perpendicular for about 400 feet, and is essentially the same on both sides of the cañon.

Hot springs occur on the road, about 13 miles from Bridgeport, with a temperature of about 130° F. The strata, of yellowish-white calcareous deposits, are about 25 feet thick. Prismatic columns of bluish diorite, having a porphyritic appearance, occur at the springs in a small ledge. Just before the Sonora road enters the cañon there is an outcrop of gray syenitic granite, about 400 feet high. Then light-gray granite occurs on the road east of the bridge across the west branch of the West Walker River. The prominent rocky knoll, about 500 feet high, and lying west of the bridge, consists of gray granite, and is continued on the north side of the river. There is a conspicuous gap here, through which the Sonora road passes. The north side of the West Walker Cañon here consists of trachyte porphyry, dark purple hornblende porphyry, and volcanic breccia. A long ridge of brownish diorite, containing many prismatic columns, occurs near the mouth of the west fork of the Walker, many of the pillars being five and some six sided. At this point the Sonora road begins to ascend, and for 20 yards on the north side light-blue decomposed diorite porphyry occurs. Then for about 50 yards comes feldspar porphyry having a purplish color, succeeded by reddish volcanic breccia in pinnacles and tors. On the north side of the cañon, and further on, are large bench-like masses of blue basalt encrusted with much olivine. At the point where the road rises rapidly and leaves West Walker River there is a grassy flat about 2 miles long and half a mile wide. Gray granite forms the basis of the ridge and bluish basalt stretches nearly to the summit. Gray granite now covers the country for about 2 miles, containing prominent white crystals and patches of plagioclase. Then small ledges of light and dark gray diorite and diorite porphyry containing olivine outcrop, the latter holding crystals of hornblende. The main mass of the ridge on the north side of the road-summit is gray granite, with many outcrops of igneous rocks. The first prominent peak is Pyramid Peak, which consists of volcanic scoria and volcanic breccia, varying in color from gray to light brown. A gently undulating ridge runs northwardly to Little Pyramid, an adjoining knoll of basalt. Then comes Stanislaus Peak on the north, described elsewhere. The ridge lying west of Pyramid Peak on the north side of the Sonora road is quite flat, and consists of gray granite with knolls of diorite porphyry and gray feldspar porphyry. The altitude of Sonora Pass is 9,660 feet above the sea-level. The granite contains arg e masses of whitish orthoclase, which project in relief from the matrix, giving the rock a porphyritic appearance. Leaving the summit one sees much gray granite on the north side, and on the south dark-gray compact diorite occurs, which soon changes to light gray. A large mass of this rock was seen on the south side of the Stanislaus River, and there is a small outcrop of bluish feldspar porphyry where the road turns. One mile farther, on the south side of the turnpike, blue diorite, containing olivine, occurs, and exhibits many fissures. Large knolls and domes of gray granite, polished by glaciers, now appear on both sides of the road. There is a thick growth of manzanita and whitethorn, with some conifers, on the sides of the now deep cañon of the Stanislaus. Gray granite continues for several miles, and 2 miles south of Hay's Station a large cañon branches off from the Stanislaus. One mile beyond Hay's there is a low ridge of blue feldspathic columnar basalt. Gray syenite and gray granite now extend along both sides of the Sonora road for many miles. Soon after the road leaves the Stanislaus Cañon and trends southwest a few buttes of whitish trachyte with many fissures occur. Leaving Strawberry Flat, the road follows a level ridge and volcanic breccia outcrops for about 3 miles. A peculiar variety of this rock is found at Bald Mountain. The matrix is compact and of a yellowish color, containing fragments of all kinds of igneous rocks. The southern slope of the ridge near Bald Mountain is thickly covered with volcanic breccia. Looking back on the ridge south of the Sonora road from this mountain, the observer obtains an excellent view of the serrated ridges and pinnacles of volcanic breccia projecting above the ridge lines. A very conspicuous and peculiar group of rocks, called the "Devil's Toothpicks," or Castle Rocks, consists of three turret-shaped masses of dark-colored volcanic breccia. This peak is one of the primary-triangulation stations. Westward along the route slightly granular yellowish trachyte occurs, and gray granite outcrops occasionally all the way to within a few miles of Sonora. The Confidence Mine is a mile and a half, and the Soulsby Mine about 5 miles from Northrup's. There is very little rock *in situ* in this portion of the foot-hills. The vicinity of Columbia deserves notice, and has been fully described by Professors Whitney and Blake.* Much blue limestone occurs in the neighborhood of Columbia, Springfield, and Shaw's Flat. It is continued farther to the southwest, and extends beyond the limits of the area of 1877. At Springfield many pockets in the limestone contain gold, and these crevices have acted like large riffles in retaining the precious metal when the land was swept over by currents.

Prof. W. P. Blake says: "Nearly all the gold is taken from the deep crevices and fissures in the limestone at from 4 to 25 feet from the surface. * * * A very irregular surface of limestone has been exposed by mining. The rocks inclose many hollow spaces, and loose bowlders are formed in them by decomposition around Springfield and Columbia. Gold is found in a stiff blue clay at the bottom and sides of the spaces. * * * The spaces between the vertical crags of limestone are filled with earth, clay, gravel, and large fragments of slate. Great erosion and denudation has caused this very singular conformation of the limestone."

Sir Roderick Murchison mentions and figures a similar case of denudation in his report on the geology of Russia in Europe and the Ural Mountains.

Vertebrate remains, arrow-heads, Indian skulls, &c., have been found at Springfield, and a large collection of them was made by the late Dr. Snell, of Sonora. The famous Table Mountain lies just west of Shaw's Flat.

Traveling over the road toward Robinson's Ferry several mining-camps are seen. Bluish metamorphic crystalline schists now cover the western foot-hills of the Sierra Nevada for many miles. The region under consideration is in the great gold-belt of California, which has been fully described by Prof. J. D. Whitney. Upon approaching Tuttletown mica slate occurs; talcose slate crops out at the Patterson Mine, and chlorite schist is found beyond Tuttletown. There are many abandoned mines between Robinson's Ferry and Angel's, and many gulches in this section of country have been washed for placer-gold. The Morgan claim at Carson Hill may be mentioned as a valuable mine. The wall-rock is talcose slate, and the ore has assayed as high as $80 to the ton. There are several mines and mills at Angel's, but between Angel's and San Andreas there is a rolling country with occasional outcrops of mica slate, mica schist, and chlorite schist. The rock at San Andreas is yellowish granite, poor in mica, with white feldspar and yellow quartz.

THE WESTERN FOOT-HILLS.

Northeast from San Andreas blue mica slate, and farther on small outcrops of serpentine, appear on the road, and then the slate occurs again. Much compact blue limestone, in which I found no fossils, was seen at Cave City, 13 miles from San Andreas. An inn at the cave is much visited by tourists. Eastward from Sheep Ranch bluish mica slate appears, and blue basalt occurs just beyond Washburn's saw-mill, and white and bluish-white quartzite outcrops along the old road on the ridge leading toward the Big Tree Grove. Grayish volcanic breccia is also found on the same ridge, but rock *in situ* is seldom exposed there. North from Big Tree road there is a large space toward Placerville that was not surveyed, nor were the mines in the vicinity of Jackson, Sutter Creek, West Point, and Fiddletown visited.

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* Geology of California, Vol. I, and Pacific Railroad Reports, Vol. V.

PLACERVILLE AND GEORGETOWN, IN EL DORADO COUNTY.

At Hazel Valley, in this county, blue quartzose mica slate occurs on the road to Pleasant Valley. Gray sandstone outcrops near Sley Park, and is the westernmost occurrence of sedimentary rock observed in the foot-hills. Two miles east of Pleasant Valley blue mica slate is seen; but the rocks just mentioned are not very common in the western foot-hills, which consist largely of granite with many outcrops of volcanic breccia. There are several abandoned placer diggings in the vicinity of Pleasant Valley, and others were seen along the road leading to Placerville. Bluffs of grayish-white sandstone, resembling that at Sley Park, outcrop one mile west of Pleasant Valley. A mesa about 300 feet high runs northeast and southwest, and its slopes are thickly covered with chaparral and whitethorn. Mica slate and chlorite schist occur in several places on the road from Pleasant Valley to Placerville. The foot-hills are now gently undulating and densely wooded, not only with conifers as on the lofty Sierra, but also with deciduous trees.

Placerville, formerly called Hangtown, is well known as the cradle of placer-mining in California. But the mines that were extensively worked twenty-five years ago are now generally abandoned. Still there is considerable mineral wealth in the neighboring hills.

At the extensive placers in Coon Hollow, half a mile south of the town, seventy Chinese laborers were at work in the summer of 1877. The sluices are half a mile long, and there are two giants with 8-inch nozzles. The property is owned by the El Dorado Water Company. There are two other claims just south, one of which has four giants and the other two.

Of the many quartz mines in the vicinity of Placerville the Saint Lawrence Mine, 5 miles northwest of the town, is perhaps the most important, and has been worked since 1868. The wall rock is talcose slate and the gangue is quartz. The rock between Placerville and the mine is chiefly talcose schist. Some Chinamen are mining at present at Chile Bar, in the bed of the south fork of the American River.

The country through which the Placerville road passes is underlaid by metamorphic schists and slates for several miles east of the town. At Shaw's Flat blue talcose schist occurs; then for 8 or 10 miles there is no rock *in situ*. Just east of the tavern called Sportsman's Retreat, gray granite containing much black mica occurs. Eastward the granite becomes dark gray and then bluish gray. The road along the southern wall of the deep cañon of the South Fork of the American is cut in granite in which gray veins occur, and a little farther east bluish gneissoid granite outcrops; then blue and gray granite alternate. Passing Pacific Station gray granite continues to MacConnaha's. The remainder of this route is described farther on.

The geological formation of the foot-hills east of Georgetown is similar to that east of Placerville. Gray granite occurs at Big Silver Creek; between this creek and Forni's, gray mica slate extends for several miles, and volcanic breccia is found not far from the Pilot Creek reservoir. West from Forni's, for 3 miles, we have yellow and red sandstone, with much silvery mica, then beds of laminated shale tilted vertically, and finally ledges of sandstone traversed by veins of white quartz.

Upon approaching Georgetown hard blue chlorite slate occurs. The town lies in a region entirely underlaid by metamorphic rocks, and, unlike most mining camps in California, is situated on a divide instead of in a cañon. There are many mines in the vicinity, but the principal ore deposit is at the Mameluke Hill. Prof. W. P. Blake has described this region in detail, and I cannot do better than to make an extract from his report: *

"The alluvial deposit is 200 feet or more in thickness. * * * The talcose and argillaceous slates crop out along a ravine. The alluvial deposits rest on a basin-like depression in the bed-rock, and the gold-bearing layer is at the bottom. In order to reach this tunnels are cut in from the side of the hill at such a distance below the summit that the lowest part of the basin will be intersected. * * * The claim of the Mameluke Tunnel Company is opened by cutting off at least 300 feet in length through the slates before the gold-bearing earth is reached. This forms a layer not over 2 feet in thickness, and rests immediately upon the upturned edges of the slates. It is overlaid by a firm deposit of clay having a dull ash-color, and containing a large amount of volcanic ashes. * * * There is another mine on the Mameluke Hill owned by the Washington Tunnel Company. * * * The slate of this vicinity appears to contain many auriferous veins. * * * Talcose and clay slates are the prevailing rocks and present a low degree of metamorphism."

Another important placer deposit is found at Crane's Gulch, and is known as Whiteside's Diggings. The rock is talcose slate, and has been washed out in the form of an amphitheater 100 feet high and 150 yards across. Tunnels from 40 to 50 feet in length were bored in the hillside, and the rock was blasted out. The riffles in the bottom of the gulch are 12 feet long. Many thousands of dollars have been taken out of this claim. Ledges of auriferous quartz occur in the talcose slate along the roads in the

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* Pacific Railroad Reports, Vol. v. p. 272.

neighborhood of Georgetown. Most of the gulches within 10 miles have been extensively "washed." A quartz mine, known as the Woodside, on the main street of Georgetown, was opened in 1863, and worked at intervals until 1877, when it was abandoned. The country rock is talcose schist, and the gangue quartz, generally white but sometimes bluish. The minerals are native gold and pyrite, the gold being nearly pure. Silver is found in traces.

There is a vein of white fibrous asbestos, from 2 to 6 inches thick, 4 miles southeast of Georgetown. The long-fibered variety is worth $50 a ton, and the ordinary is valued at $35. Limonite is found a mile and a half southeast of Georgetown.

I had time to visit only two important placer-mining towns in the vicinity of Georgetown, viz, Greenwood and Spanish Dry Diggings. The former is about 5 miles west of Georgetown. The principal claim is the French or Nagler, which is owned by the California Water Company. The country rock is serpentine and talcose slate, which is much decomposed and contains numerous quartz veins. The most important mine at Spanish Dry Diggings is that at French Hill, which has been worked at intervals since 1850. The rock is talcose schist and slate, and light green serpentine containing auriferous pyrite. Green asbestos occurs in seams in the serpentine.

Other claims at the Spanish Dry Diggings are the Old Grit, the Rice and Taylor, and the Sligo. Respecting these placers, it may be remarked that the metamorphic crystalline schists on the western slopes of the Sierra Nevada contain much native gold and auriferous pyrite. Our rapid marches through this section of California did not afford me the opportunity to examine in detail any of these deposits. There are hundreds of ledges, not only in our area but also throughout the western foot-hills, some very rich and productive. The water necessary to work all these claims is owned by rich companies with large capital. They have ditches and branches everywhere, and generally sell their water at the rate of $100 per week.

At Volcanoville, 8 miles north of Georgetown, there is a large quartz vein, which I did not visit, in one place said to be 8 feet thick. Considerable masses of magnetite occur, with bowlders of quartz, but not *in situ*.

THE COUNTRY NORTH AND NORTHEAST OF GEORGETOWN.

Leaving Georgetown, and following the road leading toward the Sierra Nevada, one sees no rock *in situ* for several miles; then blue compact granite outcrops on a ridge near Forni's. After crossing a flat thickly covered with manzanita, and traveling over the trail toward the Little South Fork House, gray basalt, somewhat laminated and containing olivine, is found within two miles of the house. The ridge along which the trail runs, the southern wall of the south branch of the middle fork of the American, consists chiefly of blue granite. At the Little South Fork House gray granite occurs, and extends eastward to the Sierra. Robb's Mountain, about 2 miles south of this place, is a mass of dark blue compact granite. Its top is dome-shaped, and exhibits but little rock *in situ*. A ridge of white quartzite about a quarter of a mile long occurs on the western side. Robb's Mountain is the only prominent point in the foot-hills between Georgetown and the Sierra Nevada. It is covered with a very thick growth of manzanita and white thorn. There is but little timber except on the northeastern side, where we ascended the mountain. The divide forming the northern wall of the middle fork of the American River is covered with many bowlders of blue basalt which have been transported from the main range. The ridge lying southwest of French Meadows consists partly of grayish-white trachyte containing particles of transparent plagioclase. On the western part of the ridge talcose schist occurs. Several of the foot-hill ridges in the vicinity of the forks of the American River unite and form one main ridge at various places in the western part of these foot-hills. The bottoms of the deep cañons are thickly covered with bowlders of gray granite from the Sierra. The middle fork of the American flows through a cañon cut in light brown talcose schist. At the suspension bridge, commonly called the "Sheepherder's bridge," the cañon is 2,800 feet deep, according to the aneroid. As a general rule, very little rock occurs *in situ* on the plateau in which these deep cañons are formed. In surveying the foot-hills the work was more rapid, and hence less complete, than in the Sierra Nevada itself.

THE MAIN RANGE OF THE SIERRA NEVADA, FROM THE BIG TREE ROAD NORTHWARD TO MOUNT JACKSON, IN NEVADA COUNTY, CALIFORNIA.

Beginning with the Big Tree road at the Calaveras grove, there is no rock *in situ* in the immediate vicinity, nor along the road for 3 miles west. Gray diorite occurs 1 mile east of the Big Trees, then dark-gray gneissoid granite, and a little farther on dark-gray granite, containing black mica, white feldspar, and limpid quartz. Bowlders of volcanic breccia are found along the road 2 miles east of the Calaveras Grove. Toward Blood's Station the granite contains but little mica, and dark and light gray granite occur alternately. The deep cañon of the North Fork of the Stanislaus River, formed in gray granite, lies just south of the ridge on which the Big Tree road runs. Sometimes the granite changes to syenite, and both these rocks extend to Blood's. Going south from this point toward Highland Creek many ledges of granite, polished by glaciers, were observed. There is a granite basin in this vicinity bounded by the ridge north of the Big Tree road, by the Dardanelles, and by a ridge running at right angles to them. *Roches moutonnées* are numerous in this basin, and I noticed one butte of igneous rock not far from the reservoir, and a few small outcrops of bluish granite. The glacial scratches on these rocks run nearly east and west.

The cañon of Highland Creek is quite narrow, and the walls are high and very uneven. There is occasionally a little soil in the bottom, and one cattle-ranch (Gabbert's) is situated in the cañon. The land south of the creek rises in a series of terraces. About 1 mile from the creek is a high and steep wall of gray granite, and half a mile south of this, another still higher, known as the Dardanelles, because there is a pass through a notch in it. Light-pinkish trachyte, which is traversed by many joints, occurs on the western end of the Dardanelles. This ridge consists partly of basalt and partly of volcanic breccia. About three-quarters of a mile south there is a third irregular line of bluffs. The pyramidal peak at the eastern end was christened Dardanelles Peak. This last ridge runs east and west, except at the eastern end, where it trends to the northeast. The lower part of the peak, as well as the greater part of the ridge just spoken of, is volcanic breccia. Blue basalt occurs half way up the mountain, and the peak is grayish basalt, has gray porphyritic diorite on the south, and a little farther south light-gray volcanic scoria occurs. In fact, it is almost a pumice-stone. Dark-red basalt also outcrops on this part of the ridge. Granular blue dolerite is seen on the western slope of the peak. The north side of this ridge is very steep and rocky, while the south side slopes gradually, and is covered with soil and occasional clusters of conifers, until the wall of the grand Stanislaus Cañon is reached. The Dardanelles and the ridge containing the peak have been upheaved through gray granite, and this rock outcrops in the valley lying between the two ridges.

We have next to consider the portion of Alpine County between Stanislaus Peak and Highland Lakes. For the most part the rock at the head of the Mokelumne is granite, though much interrupted by volcanic breccia and bluish basalt. Both light and dark gray gneissoid granite occur near Highland Lakes. Gray diorite sometimes tinged with blue is found on the east side of the upper part of Mokelumne Cañon, and a ledge of blue basalt running north and south also occurs here. The first ridge lying east of the Sheep Flat, and bearing north and south, consists of gray trachyte having a porphyritic texture on account of particles of black hornblende. The rock on the northern part of the summit of this ridge is light gray volcanic breccia. The ridge just south of Noble Cañon is gray diorite on the top and on the southern slope. Gray granite occurs in the valley. This rock is ferruginous, and is in places colored light-red and yellow. The same ridge also contains tors of trachyte as well as fine-grained light-gray volcanic breccia.

Going southeast a thin layer of blue basalt, containing particles of olivine occurs on the summit of the first divide. This ridge now trends to the east, and three tors of volcanic breccia about 20 feet high outcrop. Gray granite appears again in the valley on the south.

The valley lying east of Highland Peak is igneous on this same side, and also as far as the eastern side of the Carson Cañon, where precipices of gray granite occur. The ridge immediately south of the peak consists of gray granite with volcanic breccia on top, and several of the neighboring ridges are formed of light and dark colored volcanic breccia, with occasional outcrops of granular diorite and feldspathic basalt. Light-blue and grayish diorite occur in the cañon of Wolf Creek, the diorite on the east side having a slaty structure; and near by is dark-colored diorite porphyry, containing many long crystals of hornblende. The ridge on the south consists of blue as well as vesicular basalt, and higher up gray volcanic breccia occurs. On the east side of the summit the basalt has been weathered to a brown color. This mass extends down for about 60 feet, when gray granite outcrops and continues to the bottom of the cañon. The main fork of the Upper Carson runs through a magnificent cañon of gray granite. Leaving this stream and following up Golden Creek the same rock continues almost to the head. Gray volcanic breccia occurs on the northwestern bank of the upper part of the creek, beyond which is an outcrop of pinkish-gray diorite. Blue vesicular dolerite is seen at the head of the creek. The rock passes into blue basalt and gray diorite containing olivine, which forms the summit of the divide. This ridge is very narrow and trends nearly east and west.

The northern and southern slopes are very steep, and the rock on the western edge of the ridge is laminated. The ridge lying south consists of gray granite. A curious butte of blue basalt in the form of a very perfect dome is seen on this mountain mass. The rock is much disintegrated and the base is covered with talus. The ridge of which Stanislaus Peak is the culminating point consists chiefly of gray granite, but the peak itself has two igneous buttes; the northern one, gray trachyte containing hornblende; the southern, bluish gray diorite, and in one place red basaltic lava. The yoke connecting them is brown hornblende porphyry. The short ridge lying north of the northern peak consists of dark-gray vesicular basalt and bluish vesicular volcanic breccia. The height of Stanislaus Peak is upward of 10,000 feet. Crystals of feldspar 3 inches long and veins of white quartz occur in the granite forming the western side of Carson Cañon. There is a fine patch of grass in this cañon, about one mile below Golden Cañon, called Dumont's Meadow. Wolf Creek Peak lies west of it. This mountain, the first east of Silver Mountain, consists of gray granite capped with a mass of light and dark colored volcanic breccia about a mile in length, a striking peculiarity of which is that it contains bowlders of gray granite about 6 inches in diameter. Just above the level of the granite in this peak is a small knoll of blue diorite porphyry full of crystals of black hornblende. The summit of the peak is a tor of bluish-gray diorite, about 20 feet high, of columnar structure, and extending along the ridge for half a mile. The upper part of the Carson Cañon is very rocky. The walls are very steep, and the granite is traversed by numerous fissures. The eastern wall is almost perpendicular for nearly 2,000 feet, and the top is very irregular, the rock often projecting in the form of pinnacles. The western wall consists of many bench-like and dome-shaped masses of gray granite, with an occasional patch of soil which bears a dense growth of conifers. Near the head of the cañon there is a large dome of gray granite about 500 feet broad, and the summit is perhaps 1,000 feet above the river. There are many immense bowlders of granite between Bixby's Camp and the source of the river, and a few small outcrops of blue basalt in the bottom of the cañon, notably one about a mile south of Golden Cañon. On the northwestern side of Stanislaus Peak, and within a few rods of the source of the main Carson River, red basaltic lava occurs. Traces of glaciers are abundant in the cañon just mentioned.

Amador and El Dorado Counties, the eastern part of Placer and the southeastern corner of Nevada Counties remain to be described. The survey of Amador County was confined to the eastern or non-metalliferous portion, which is quite narrow. The ore deposits in the vicinity of Jackson and Sutter Creek were not visited, and the country lying on the east and southeast has already been described.

SILVER ERA PEAK.

The first ridge south of this mountain is long and narrow, having a trend from east to west. The base is gray granite, which passes into syenite in one place. The summit of the ridge is gently undulating, and consists of various igneous rocks. The rock of the highest portion varies in color from light gray to dark maroon, resembles clinkstone, and passes into feldspar porphyry on the west. Diorite and basalt also occur on this ridge, which is for the major part destitute of timber. The rock is much disintegrated on the south side, about half way down to the valley. The North Fork of the Mokelumne River rises on the south side of Elephant Peak, in a magnificent cañon of gray granite with nearly perpendicular walls that trends east and west at first, but soon turns to the southwest. The Blue Lakes, just southeast of Silver Era Peak, are in an alluvial basin surrounded by granite ridges, and are used as reservoirs in dry seasons by the Amador Ditch Company. The peak itself is a serrated mass of igneous rocks thrust through gray granite. This igneous part of the mountain is about a mile long, and rises from a plateau on the north side for about 500 feet perpendicularly. The top of the peak consists of blue feldspathic diorite; and hornblende porphyry, with a grayish matrix, constitutes part of the rocky wall. The southern side of the peak is much steeper than the northern, being almost perpendicular for upward of 800 feet. Just below the peak, on the north side, there are two ponds, of emerald-green water, about 300 yards long and a quarter of a mile apart. North of these is a flat plateau of gray granite covered with a little soil and supporting a few dwarf conifers. Somewhat farther north a butte of volcanic breccia, 150 feet high and 200 yards across, occurs. The northern and northwestern spurs of Silver Era Peak are for the most part gray granite, though bluish granite sometimes occurs. Glacial scratches were seen on the faces of granite on the northwestern spurs, running on an east and west line, or toward the western foot-hills. Gray granite extends northward from the peak for 2 miles to the Amador road, where volcanic breccia and red trachyte outcrop, forming the outliers of Red Mountain, already described. The country east of Silver Era Peak is igneous, blue basalt and volcanic breccia being the principal rocks.

The alluvial plain of Twin Lakes contains some excellent grazing land. The lake themselves are only three or four fathoms in depth. The mesa north of them consist of reddish volcanic breccia. Light gray trachyte with acicular crystals of greenish-black hornblende and dark gray diorite occur on the Amador road. Many *roches moutonnées* are seen west of Twin Lakes, near the road. About one mile north of this route an irregular line of bluffs, formed of volcanic breccia, and underlaid by yellow trachyte having a slaty structure, extends for a distance of two miles. The rock is much furrowed and sculptured by running water and rain. The wall of breccia is about 250 feet in height, and is prolonged to the eastward, forming a sort of amphitheater. The summit of Round Top, which lies about three miles north of Caple's ranch, is blue diorite, containing white plagioclase, like the rock of Silver Era Peak. Many knolls and low ridges of gray granite are seen on the north side of the Amador road. Formerly a glacier had its rise on Elephant Mountain, and moved northwesterly, filling the valley of the Amador road and escaping into the Sacramento Valley.

The surfaces of granite are traversed by numerous joints and fissures and finely polished, but it is very difficult to observe glacial scratches.

From Twin Lakes westward gray and bluish diorite alternate. The blue granite has many large specks of black mica. The southern wall of the cañon, along which the Amador road runs, is volcanic breccia for five or six miles. About four miles west of Caple's ranch the cañon widens and grows much deeper. There are many *roches moutonnées* in the bottom and on the northern side. Patches of soil occur here and there, with clusters of pines and spruces. The breccia mentioned is much eroded, and isolated pinnacles and turrets project from the main mass. This cañon, containing Alpine Creek, is half a mile wide and at least 1,000 feet deep. The ridge bounding this cañon on the north rises almost perpendicularly, and forms the southern boundary of the south fork of the American River. At the point where the Amador road leaves the cañon the walls become lower, and slope gradually to the west till they pass into the foot-hills. Gray granite now extends all the way to Silver Lake, interrupted only by occasional knots and tors of volcanic breccia and basaltic rocks along the ridges south of the Amador road.

Silver Lake lies in a granitic basin about two miles long and half a mile broad. The volcanic breccia on the summit of the ridge east of the lake is eroded into fantastic shapes, so that it bears the name of Thimble Rocks. The southern wall of the lake consists of a series of rising benches and bosses of granite. A low ridge of the same rock cuts off part of Silver Lake, almost dividing it. The road beyond this lake runs along the southern side of a ridge of gray granite which rises gradually toward the west. Tragedy Springs are in a grassy flat, about a quarter of a mile wide, noted as a camping place for cattle-men. Grayish-black syenitic granite occurs just north of the road, and resembles that of Mokelumne Peak. There are two ponds about a mile south of the springs. A large, smooth face of rock, polished by glacial action, was seen on the northern side of this basin. There are several ridges of volcanic breccia running east and west between the Amador road and Mokelumne Peak Granite bowlders are found in some of these hills, and they have evidently been left there by glaciers.

Mokelumne Peak, situated on the north side of Mokelumne River, about nine miles south of Tragedy Springs, is a large mass of gray granite, containing dark-colored gneissoid granite on the northern side of the summit. Leaving the many ledges of volcanic breccia, the benches of granite rise gradually in going toward the mountain. This peak is 9,467 feet above the sea-level. On the south side the peak is an almost vertical wall 2,000 feet high and destitute of vegetation. The country southward has been described elsewhere. Just north of Tragedy Springs there is a cañon trending northwest; at its head is volcanic breccia, and farther on are many *roches moutonnées* of grayish granite. The glacial striæ run nearly north and south. The observer soon loses sight of the course of this cañon as it passes into the densely wooded foot-hills.

Westward from Tragedy Springs one finds blocks of basalt and volcanic breccia scattered along the road to Corral Flats, five miles distant. On the old emigrant road, toward Placerville, very little rock occurs *in situ;* the country is covered with a dense forest of conifers; a ledge of volcanic breccia occurs here and there, while the underlying rock is gray granite until Hazel Valley is reached. There is no running water along this emigrant route. The region between this locality and Placerville has been described in this report.

Passing northward over a gap not surveyed, till the Placerville road is reached, gray granite is found at MacConahea's Station. Sugar Loaf Mountain, a conical mass of the same rock, about 400 feet in height, lies half a mile east of the station, on the north side of the south fork of the American River. There are many large bowlders, some from 30 to 40 feet square, in the cañon of this river. The granite occasionally passes into syenite, and is traversed in places by veins of white quartz. Gray granite extends all the way to Georgetown Junction, and thence to Sawyer's ranch at the base of Pyramid Peak, one of the highest mountains in the Western Summit. The greater part of this range was described in the annual report for 1876, and in this place it is necessary to mention only a few localities in the western part. At the north is Bald Mountain, a prominent dome of gray granite, bare of vegetation, with an almost vertical surface on the western side. There is another rocky knoll near by. Both these surfaces of rock have been rounded by glacial action. Gray and bluish granite occur near Tell's ranch. A few small buttes of gray granite and an anticlinal knoll of blue basalt occur at this ranch, which is situated in a grassy flat about four miles west of the lofty Sierra.

In making the ascent of the nearest prominent peak, I found that the granite contained spots of bluish compact granite scattered through it as in other parts of the Western Summit. This ridge is undulating, and there are many ledges with slopes almost perpendicular on the west side. The eastern declivity is very steep, and forms the western boundary of a vast granitic basin, about four miles long by one mile broad, in which is a series of lakelets. There are many *roches moutonnées* and occasionally a little timber in this basin. No basalt was observed. North from Tell's ranch, toward Loon Lake, gray granite extends over the country, although two large outcrops of basalt occur at Pleasant Lake and at Grizzly Peak. The Rubicon flows through a deep and picturesque cañon, and might be called the middle branch of the middle fork of the American River. A few places in the Western Summit may be mentioned that were not described in the report of last year. Near the head of Squaw Valley, and about 2,000 feet above it, Fort Sumter, a knob of gray diorite and volcanic breccia, rises about 75 feet. There are several other tors of igneous rock along the crest of the Western Summit. One, known as Bunker's Knob, has a pyramidal form and lies a mile or two northwest of Fort Sumter. Another outcrop in this vicinity is the "Needle," which consists of gray trachyte and is 150 feet above the ridge-line. Prof. J. D. Whitney says: "The volcanic formations are less extensively developed in El Dorado County than in Amador County, although there are still the remains of at least one large flow of lava to be traced through the central part of this county." Pinkish-white trachyte occurs near Berkeley Springs, where there are several wells of carbonic-acid water. On the west, the Forest Hill divide consists principally of volcanic breccia. It is densely wooded and has a ridge-line which is nearly horizontal, like most of the ridges on the western side of the Sierra Nevada. Southwest for 12 miles the rock is all blue basalt to French Meadows, where gray granite occurs again. Near this place, on a branch of the middle fork of the American River, some auriferous quartz is found, where a tunnel has been driven in gray granite a distance of 350 feet.

On the Sierra Nevada there are several lakes in the immediate vicinity of the summit of the pass through which the Central Pacific Railroad runs, and there is an alluvial flat with a swamp and small pond just south of the railway station. This pond was formerly used for obtaining ice. Two lakelets in granite basins were seen about half a mile north of Summit Station. Gray granite extends as far as Castle Peak, six miles north of the railroad. This peak, called likewise Mount Stanford, consists of volcanic breccia. The mountain mass runs nearly east and west. On the ridge-line there are three tors about 100 feet high, of which the easternmost is the largest. The north and south sides are very steep. There is a line of rocky bluffs about 75 feet high, and the slopes of the mountain are covered with *débris* from them.

Westward to Cisco and beyond, out of the area surveyed in 1877, gray granite continues. Blue compact granite with a laminated structure occurs near the old town of Cisco and ledges of white quartz are seen in the granite along the wagon-road.

There are many pot-holes and basins in the rock along the south fork of the Yuba River. There is a dome-shaped mountain half a mile southwest of Cisco, composed of dark gray syenite containing crystals of hornblende. Ledges of grayish-white quartzite occur on the north and east sides. The northwest side of the mountain is very steep, while it slopes gradually on the east. The summit of this peak consists of five rounded knobs, that on the northeast being the highest. There is a large knoll of gray syenite about half a mile south of this mountain, and bowlders of the characteristic gray granite of the Western Summit are frequent, evidently having been transported by glaciers. There are ten small lakes in the vicinity. Blue basalt occurs near Cisco Station, and northward gray granite is the predominating rock as far as Meadow Lake, in Nevada County, but bluish volcanic breccia outcrops in a few places. The middle fork of the Yuba River flows through a narrow and very rough cañon of granite.

The plain of the lake is bounded on the east by a granite ridge, beyond which volcanic breccia occurs. At Weber Lake the rock is basalt, which extends several miles to the northwest toward Mount Jackson, of which whitish and grayish granite make up the lower part. The main mass runs nearly north and south, and the peak consists of blue basalt with incrustations of olivine and black hornblende. The rock is much decomposed on the summit, and detached crags of basalt rise one above another. Basalt probably extends as far as Downieville Butte, which is a serrated mass of whitish trachyte. Mount Jackson is the extreme northern point in our area. This mountain is a mass of basalt upheaved through gray granite. Directly south of the peak is a lake lying in a granitic basin about a mile in diameter, the walls of which are quite steep and present fine examples of *roches moutonnées;* and there are several other small lakes near the mountain. Going southward toward Meadow Lake ferruginous quartzose granite occurs on the west. At Red Mountain it is almost a quartzite. The ore deposits at Meadow Lake are generally found in a mass of basalt inclosed in the country-rock, gray granite.

APPENDIX I 1.

REPORT ON THE LITHOLOGY AND MINERALOGY OF PORTIONS OF NEVADA AND CALIFORNIA, BY A. R. CONKLING, FIELD SEASON OF 1877.

NEW YORK CITY, *March* 21, 1878.

SIR: I have the honor to submit herewith a special report on the lithology and mineralogy of the area explored in 1877. The materials of this brief chapter can be more readily embodied under a separate heading than in the text of the geological report.

Next to granite the most common rocks are diorite and basalt. Their color is generally bluish and grayish. The basalts appear to be feldspar basalts. No leucite nor nepheline is visible to the naked eye in these rocks. It is interesting to notice how one igneous rock graduates into another on the summit of a ridge surrounded by granite. Sometimes the observer may find no less than six kinds of igneous rocks within a quarter of a square mile.

The peculiar kind of igneous rock which I have called volcanic breccia next demands attention.

As far as I know, this rock has never been minutely described in print. It is generally dark red or slate-colored. In a few localities it is grayish. A great variety of rocks form the constituents of the volcanic breccia. They are usually igneous, although at one place in Alpine County granite bowlders occur in it. This rock has been called "trachytic breccia" by Bowman in his Report on the Georgetown Divide.

The paucity of crystalline schists in the Sierra Nevada is remarkable. Mokelumne Peak is the single locality I know of where this kind of rock occurs. But talcose schist, mica slate, chlorite schist, &c., are abundant in the western foot-hills, especially between Sonora and Georgetown. What I have called granite in the geological report is often syenite and syenitic granite. One of these rocks is continually passing into the other, and it is impossible in a reconnaissance to trace the changes of texture.

The Sweetwater Range offers a good opportunity for the study of rocks belonging to the granite group. Quartzite occurs in this range, although fine-grained granite is the predominating rock in it. The granite weathers readily, and the peaks and ridges have been worn smooth and roundish without any evidence of glacial action. The gray granite on the western side of the Sweetwater Range contains olivine. The locality is near the head of Swanger's Creek. It has already been stated in my geological report that sedimentary rocks do not outcrop in the Sierra, but there are a few places in the foot-hills in the extreme eastern and western portions of the area of 1877 where they may be found.

The following is a list of minerals occurring in the parts of California and Nevada surveyed in 1877:

Native gold.—Abundant in the gulches and gravel-beds around Columbia, Placerville, and Georgetown; also in the quartz mines of Mono, Calaveras, and Alpine Counties. Localities specially deserving of mention are Silver Mountain, Bodie, and Sheep Ranch.

Native silver.—Sparingly at the Dunderberg and Napoleon Mines, in Mono County.

Native sulphur.—At Leviathan Cañon, six miles northeast of Monitor, in Alpine County.

Graphite.—Abundant at a point about three miles east of MacTanahan's Bridge, in Ormsby County, Nevada. A vein of it occurs in a ravine behind the town of Genoa, in Douglas County, Nevada; also at Meadow Lake and in Hope Valley, California.

Quartz.—At the mines of Alpine and Calaveras Counties; at the Napoleon and Dunderberg Mines, in Mono County, and at Meadow Lake.

Cuprite.—Found sparingly on the northwestern spurs of the Sweetwater Mountains.

Magnetite.—A large vein occurs at Volcanoville, in El Dorado County. It is said that a bed of this mineral is found near the head of Antelope Valley.

Melaconite.—At Monitor, Alpine County.

Limonite.—Found at a point a mile and a half southeast of Georgetown.

Argentite.—At Monitor, Scandinavian Cañon, and near Markleeville, in Alpine County.

Galena.—At Silver Mountain City, Hope Valley, Placerville, Sheep Ranch, in Calaveras County; Confidence and Soulsby Mines, in Tuolumne County, and at Meadow Lake.

Ruby silver.—In the Scandinavian Cañon and near Markleeville; also at the Dunderberg Mine, in Mono County.

Pyrrhotite.—In small quantities at Meadow Lake.

Pyrite.—At Georgetown, Spanish Dry Diggings, and Greenwood, in El Dorado County; at Meadow Lake; at the Soulsby Mine; at the Napoleon and Dunderberg Mines, and throughout Alpine and Calaveras Counties.

Chalcopyrite.—At Meadow Lake, Placerville, Sheep Ranch Mines, in Calaveras County; Soulsby Mine, and Leviathan Cañon, in Alpine County.

Blende.—At Silver Mountain City, Hope Valley, Meadow Lake, and the Soulsby Mine.

Hornblende.—At Meadow Lake.

Asbestos.—A bed occurs four miles southeast of Georgetown.

Calcite.—In the limestone of Calaveras County, at a point three miles east of the Carson River, in Ormsby County, Nevada; incrusting igneous rocks at the head of Pacific Valley, in Alpine County; at the Warm Springs, on the Sonora Road, in the form of calc tufa.

Azurite.—On the northwestern spurs of the Sweetwater Mountains.

Malachite.—In the Sweetwater Mountains; Meadow Lake; Monitor and Leviathan Cañon, in Alpine County.

Fossil wood.—At Mameluke Hill, Georgetown.

Of the above-mentioned minerals many occur abundantly. A few are very sparingly distributed, and the majority are not fine specimens.

Very respectfully, your obedient servant,

ALFRED R. CONKLING.

Lieut. G. M. WHEELER,
Corps of Engineers, in charge.

APPENDIX J.

PRELIMINARY REPORT ON THE ORNITHOLOGY OF PORTIONS OF CALIFORNIA AND NEVADA, BY H. W. HENSHAW, FIELD SEASON OF 1877.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 1, 1878.

SIR: A report upon the field-work has annually been required of me, which has been made to contain a more or less extended notice upon the zoology of the region visited, and in this have been included in a general way the results of each field season in the department of ornithology.

In view of the fact that the section selected for my work for the approaching season will, in a great measure, be a continuation of the past summer's area, it has been thought best to reserve the material for a report upon the birds gathered in 1877, and to combine it with the results of 1878 into a single paper, instead of presenting it as two distinct reports.

The area entered during the past season by the party with which I was connected has hitherto received very little attention at the hands of naturalists, and hence all facts pertaining to its animal life are of importance, even if they amount to no more than the actual fixing of points regarding distribution, &c., which were to be assumed from our knowledge of the faunæ of other and contiguous areas. No new species of either birds or mammals were discovered, as indeed was hardly to have been expected, but a number of items of value were ascertained regarding the range of species of either class.

In this connection mention may be made of the occurrence along the eastern slope of the Varied Thrush (*Turdus nævius*). This is a West-coast species, the summer habitat of which extends from the mouth of the Columbia River northward.

From information obtained in 1876, I conjectured that the species would prove to be at least an occasional visitor to the eastern slope of the Sierras, and this, I am now able to state, is an ascertained fact. It even passes the winter at the base of the mountains, and, as I recently learn, Mr. Parker found it very abundant near Carson, Nev., from January to April. The species thus includes in its area of winter distribution much of the eastern slope as far to the south as Carson, and probably much below that point, but retires with spring to the north.

The White-crowned Sparrow (*Zonotrichia leucophrys*) was found breeding in several localities in the mountains of Eastern California, and its nest and eggs secured. This gives us a fact of much interest, as the summer habitat of this species was supposed to be limited by a point far to the eastward. It seems probable that the mistaken idea of its restricted range has arisen by confounding with it the nearly allied but distinct species, the *Z. gambeli intermedia*. The latter appears not to breed in this region, but to retire to the northward.

As of further interest, the well-known Barn Owl (*Strix flammea*), which, though a common species in much of California, has never been ascertained to extend its habitat into the sections east of the Sierras, was found at two localities in Eastern California, specimens being shot at Camp Bidwell, where it is not uncommon.

The Northern Phalarope (*Phalaropus hyperboreus*) is a boreal species, whose presence in winter and fall is quite frequent on either coast, but which is rarely met with in the interior. At Carson, Nev., it was found to be migrating north in great numbers during the last of May, and a fine series of some 25 specimens was secured, representing the full nuptial dress of the species, a condition of plumage quite rare in cabinets.

Respecting mammals the fact of the occurrence east of the mountains of the large Gray Squirrel (*Sciurus fossor*) is worthy of mention, this being supposed to be a strictly West-coast animal. Trowbridge's Hare (*Lepus trowbridgei*), the most diminutive of our species, was found to be extremely numerous near Goose Lake, Northeastern California. Its discovery here has a peculiar interest from the fact that it has hitherto been reported only from the region west of the Sierra Range, where it has an extensive distribution, chiefly coastwise, from Fort Crook to Cape Saint Lucas. The *Spermophilus beecheyi*, the Ground Squirrel or "Gopher" of California, so much dreaded from the great damage it does to the crops, was found to be present all along the eastern slope from Carson, Nev., northward. It appears here in its typical condition of pelage, and shows no signs of intergradation with the Central Region form, *S. grammurus*, of which it is a geographical variety. For some reason or other, probably from climatic causes, it does not prevail in this region in anything like the multitudes that infest the coast districts of California, and hence the injury done by them passes comparatively unnoticed. In certain districts, as about Eagle Lake, the Townsend's Ground Squirrel (*Spermophilus richardsoni townsendi*) appears in a measure to replace this species, and as the colonies of this small rodent are often very large they occasionally inflict much damage to the vegetable and grain crop. From a point so far south this species is now for the first time reported.

Some valuable facts pertaining to the distribution of the Batrachians, Serpents, and Fishes have resulted from a study of the collections, and these will be found mentioned in detail in the respective reports.

The early date at which I was enabled to enter the field (May 12) afforded opportunity of studying the habits of the birds during the breeding season, by far the most interesting period, and the one concerning which our knowledge of Western species is the most limited; hence a very considerable amount of information concerning the nesting habits was gathered, and, when further increased by the experience of an additional season in the country immediately to the north, will, it is believed, contribute very materially to our knowledge pertaining thereto.

The collection of birds, some 200 in number, was a comparatively small one, but was made with special reference to illustrating such of the species as are more or less peculiar to the region; it also included many of the rarer forms, as well as new plumages of other and comparatively well-known species; hence it proves to be of considerable value.

The early part of the time, from May 12 to June 6, was spent around Carson; and here and in the neighborhood of Washoe Lake, including the results of a short trip to Pyramid Lake on the north, a large collection of nests and eggs was made, comprising between 600 and 700 specimens. The remainder of the season, or until the first of October, was occupied in connection with Lieutenant Symon's party in making the usual zoological collections in the region between Carson, Nevada, and Camp Warner, Southern Oregon, a summarized list of which appears in your own report.

It may be stated that the general facies of the avifauna of the region occupied strongly resembles that to the southward; and that the conclusions, stated in a previous report, that the faunal relations of the eastern slope of the Sierras are with the Pacific Region proper, and that it is to be included as a part of it, were still further borne out, the dividing line between the Pacific and Middle Regions here, as farther south, falling at the base of the main chain of the Sierras. Several of the mammals collected which have always been considered as strictly belonging to the Pacific coast, further attest the close relation that exists between the eastern flank of the mountains and the Pacific Region.

The usual disposition of the specimens gathered has been made, such as have not been retained in the office for working up having been forwarded to the respective specialists for examination and report.

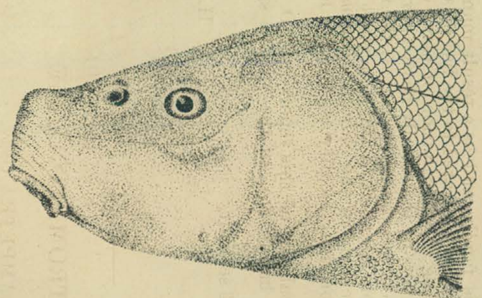
A report upon the Batrachians and Reptiles collected by the expedition during the successive seasons of 1875, 1876, and 1877, by Dr. H. C. Yarrow and myself, a report upon the Fresh-water Fishes, covering results for the same period, by Prof. D. S. Jordan, with notes by myself, and a report upon the Marine Fishes by Dr. Yarrow and myself, are appended.

Very respectfully, your obedient servant,

H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

Plate I.



CATOSTOMUS TAHOENSIS - GILL & JORDAN.
LAKE TAHOE, NEVADA.

APPENDIX K.

REPORT UPON THE FISHES COLLECTED DURING THE YEARS 1875, 1876, AND 1877, IN CALIFORNIA AND NEVADA, BY PROF. DAVID S. JORDAN AND H. W. HENSHAW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 30, 1878.

SIR: The report upon the fishes in vol. v, Zoology, of this Survey, contained an account of the collections made during the years up to and including 1874. Since that time more or less extensive collections in this department have been made in the several sections visited by the Survey. These, including the results of 1875, 1876, and 1877, form the basis of the present report. The combined collections, though not embracing a large number of species, have proved to be of unusual interest, coming as they do from regions, of the ichthyology of which, our knowledge has been extremely limited. Besides adding many facts respecting the geographical distribution of species already recognized, two new species are contained in it, one a fine trout (*Salmo henshawi*) from Lake Tahoe, and the other a sucker (*Catostomus arœopus*) of apparently extensive distribution in the waters of California and Nevada.

A study of the large series of Western trout in the Smithsonian Institution, many of them obtained by this expedition, has resulted in the discovery of a very great range of purely individual variation in this family, and as a result many nominal species hitherto admitted into our lists have been relegated to the list of synonyms. In the light of the facts ascertained concerning the distribution of many of the species, the theory assumed that most of the members of this family have a very restricted range and are peculiar to very limited areas is seen to be erroneous, the rule being exactly the reverse. *Apropos* of this, attention is called to the somewhat surprising fact of the discovery in the collection of specimens of the *Salmo pleuriticus*, the Rio Grande trout, at a point as remote from its original locality as the Kern River in the Sierra Nevada.

It may be stated that for the technical part of this report Prof. D. S. Jordan is alone responsible, the notes respecting the habits, &c., of the various species being contributed by myself.

Very respectfully, your obedient servant,

H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

Family PETROMYZONTIDÆ.

Genus LAMPETRA Gray.

LAMPETRA, sp. incert.

A larva of a small lamprey, about four inches long, not recognizable.

Four distinct types are recognizable among the American lampreys, for which the names *Petromyzon* L. (*marinus*), *Scolecosoma* Girard (*argenteus* Kirt.), *Ammocœtes* Duméril (*branchialis; niger*), and *Lampetra* Gray (*fluviatilis*) (*Entosphenus* Gill and *Ichthyomyzon* Girard) may be retained.

They may be briefly defined as follows:

*Maxillary teeth two or three pointed cusps, placed close together.
a. Dorsal fins two, wide apart .... PETROMYZON.
aa. Dorsal fin continuous .... SCOLECOSOMA.
**Maxillary tooth forming a transverse, crescent-shaped ridge, with a cusp at each end, and often a smaller one in the middle.
b. Dorsal fin continuous .... AMMOCŒTES.
bb. Dorsal fins two, separate .... LAMPETRA.

No.	Locality.	Collector.	Date.
41	Goose Lake, Modoc County, Cal	H. W. Henshaw	Sept.—, 1877

Family CATOSTOMIDÆ.

Genus CATOSTOMUS Le Sueur.

CATOSTOMUS TAHOENSIS Gill & Jordan.

(Plates 1 and 2.)

Lake Tahoe Sucker.

1868—Catostomus generosus *Cooper*, Cronise, Natural Wealth of California, p. 495 (not of Girard).
1870—Catostomus tahoensis *Gill*, MSS.
1878—Catostomus tahoensis *Jordan*, Bulletin U. S. Nat. Mus. xii, p. 173.

This fine sucker was first collected by Dr. J. G. Cooper in Lake Tahoe, and identified by him with *Catostomus generosus* of Girard. A comparison of specimens with Girard's description showed Professor Gill some discrepancies. He therefore suggested the provisional name in manuscript of *Catostomus tahoensis*. Later, Professor Cope identified Girard's *generosus* with *Catostomus fecundus* Cope & Yarrow, and afterward abandoned the identification. I have since examined Girard's original types, and have found that his *Catostomus generosus* is the fish since called *Pantosteus jarrovii* by Professor Cope.

Catostomus tahoensis may be thus characterized: Form subterete, elongate; the greatest depth of body in front of dorsal, contained nearly 5 times in the total length (without caudal, as in all cases in this paper). Head very long and pointed, conic, acuminate, its length contained $3\frac{3}{4}$ to 4 times in that of the head and body; muzzle very long, forming nearly half the length of the head, overhanging the mouth; mouth rather large; jaws without cartilaginous sheath; lips moderate, the upper pendent, with about three rows of smallish papillæ; lower lip moderately full, two-lobed, similarly papillose; interorbital space flattish, $2\frac{2}{3}$ in head; eye quite small, nearly median, rather high, $8\frac{1}{2}$ in head; fontanelle large, broadly open.

Fins small, dorsal beginning just behind the middle of the body, rather higher than long, its rays 11; ventral rays 10; pectorals long; caudal lunate, not much forked.

Scales small, crowded and reduced forward, closely imbricated, more deeply imbedded than usual; their number 12—83 to 86—15.

Coloration very dark; scales everywhere dusted with fine dark specks; even the belly is dusky; fins all dark. This species is most nearly related to *C. longirostris*, but it may be known at once by the large head and the much larger scales. Its coloration and squamation distinguish it at sight from all our other species.

The types of the present description were obtained by Mr. Henshaw in Lake Tahoe. The larger is 14 inches long, and the smaller 12.

This sucker is abundant in certain portions of Lake Tahoe, especially at the mouth of the Truckee River as it enters the lake. The specimens collected by no means represent the extreme of size attained by this fish, they sometimes being found two feet and upward in length. The suckers frequent the little bays and inlets, and in summer run up the streams to spawn.

No.	Locality.	Collector.	Date.
..	Lake Tahoe, California	H. W. Henshaw	—— —, 1876
44	Eagle Lake, California (probably)	do	—— —, 1877

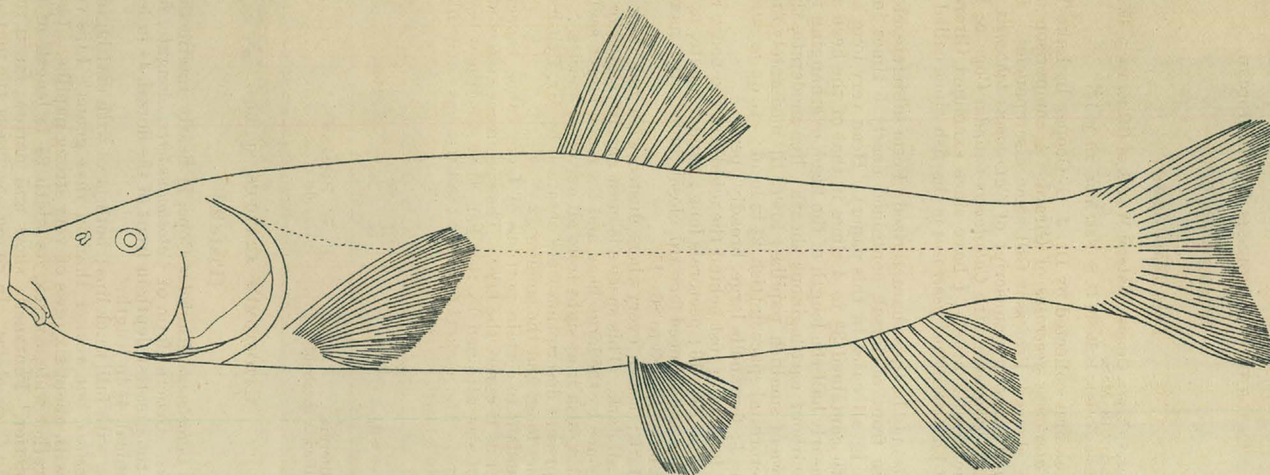
CATOSTOMUS ARÆOPUS, sp. nov.

(Plate 2.)

This species, like *Catostomus discobolus* Cope, is nearly intermediate between *Catostomus* and *Pantosteus*. General form of *Catostomus teres*, elongate, fusiform, subterete, compressed behind, the greatest depth in front of the dorsal, $4\frac{1}{2}$ in length. Head comparatively small, conical, $4\frac{2}{3}$ in length.

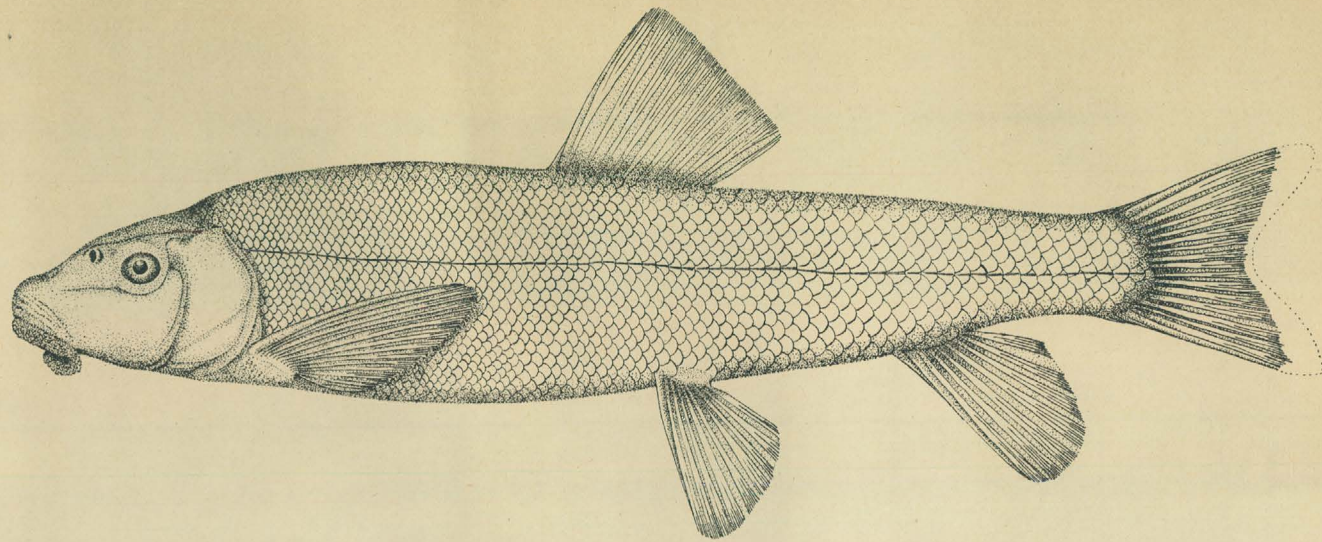
Mouth quite large, with full, thick lips; both jaws with cartilaginous sheaths, as in the species of *Pantosteus*, but weaker than in that genus. Lips very full, the upper wide and pendent, with about six rows of very strong papillæ. Lower lip two-lobed. Interorbital space rather wide, convex, its width $2\frac{1}{2}$ in length of head. Eye rather small, elevated, posterior. Fontanelle short and narrow, much restricted, although rather larger than in *C. discobolus*. In young specimens, the fontanelle is more open.

Fins moderate; dorsal fin beginning midway of body; dorsal rays usually 10, the fin higher than long; anal barely reaching caudal; pectorals well developed, but falling far short of ventrals; ventrals 10-rayed, not reaching nearly to vent. Scales



CATOSTOMUS TAHOENSIS - GILL & JORDAN.
LAKE TAHOE, NEVADA.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)



CATOSTOMUS ARÆOPUS–JORDAN.
(S. FORK KERN RIVER, CALA.)

small, crowded forward, as usual in *Catostomus*, larger on caudal peduncle; their number 10 or 9—70—8.

Coloration dark; belly pale; the scales all with fine, dark punctulations; head dark. This species bears much the same relation to *C. teres* that *C. discobolus* does to *C. longirostris*.

The type-specimens of *C. arœopus* were collected by Mr. Henshaw in the South Fork of Kern River in California. They are respectively 13 and 9 inches in length. Other young specimens were taken in Carson River, Nevada.

No.	Locality.	Collector.	Date.
17107	South Fork of the Kern River, California	H. W. Henshaw	— —, 1875
17103	Carson River, Nevada	do	— —, 1876

The relations of *C. tahoensis* and *C. arœopus* to the other species of this most difficult genus may be shown by the following analysis of the species known to me. The genus is divisible into three subgenera.

* Scales moderate, not crowded anteriorly, nearly equal over the body, 48 to 55 in the lateral line, 12 to 15 in a transverse series from the dorsal to the ventrals; head flattened above, transversely concave between the orbits, the frontal bone thick, broad, and short, the physiognomy therefore peculiar; ventral rays normally 9; upper lip very thick, strongly papillose, with a broad, free margin, which has 8 to 10 series of papillæ upon it; lower lip greatly developed, strongly papillose, incised behind, but less so than in the other subgenera; fontanelle comparatively short and small, although not narrowed; pectoral fins unusually large. (Subgenus *Hypentelium* Rafinesque.)

a. Depth 4½ to 5 in length; head 4 to 4½; eye rather small, 4½ to 5 in head: color olivaceous; sides with brassy luster; belly white; back brown, with several dark cross-blotches irregularly arranged, these becoming obsolete in old individuals; lower fins dull red, with some dusky shading: size large .... NIGRICANS.

y. Dorsal with 11 developed rays; scales 7—50—5; head rather large, 4 to 4½ in length; pectoral fins rather longer: colors relatively dull; no distinct whitish stripes along the rows of scales.—Habitat, New York to the Plains .... var. *nigricans*.*

yy. Dorsal with 10 developed rays; scales 6—48—5; head rather shorter, 4½ in length; pectoral fins rather shorter: colors brighter, blackish above; belly abruptly white; a pale spot on the base of each scale, these forming conspicuous whitish streaks along the rows of scales.—Habitat, Alabama Basin .... var. *etowanus*.†

** Scales small, reduced, and more or less crowded anteriorly, 58 to 72 in the lateral line, and about 20 to 25 in a transverse series from the ventrals to the dorsal; snout moderate or rather short .... (Subgenus *Decadactylus* Rafinesque.)

† Upper lip comparatively thin, with but few (2 or 3) rows of papillæ.

a. Dorsal fin with but 10 or 11 developed rays; scales but little reduced in size forward.

b. Body moderately stout; depth 4⅗ in length; head very small and short, about 5 in length; eye moderate; fins all notably small; scales small, subequal, 9—70—9, larger on the middle of the body than on the caudal peduncle; body with scattered dusky, nebulous spots.—Rio Gila .... CLARKI.‡

bb. Body rather elongate, subterete, heavy at the shoulders and tapering backward, the depth about 5 in length: head moderate, about 4½ in length; mouth comparatively small; lips moderate, the upper narrow, with about two rows of large tubercles; scales little crowded forward, 58 to 63 in the lateral line, 19 in a cross-series; a series of dusky spots along each row of scales, as in *Minytrema melanops*, the spots sometimes obscure.—Rio Gila .... INSIGNIS.§

aa. Dorsal with 12 or 13 developed rays; scales much reduced and crowded anteriorly.

c. Body moderately stout, varying with age, subterete, heavy at the shoulders, the depth 4 to 4⅗ in length: head rather large and stout, conical, flattish above, its 4 to 4½ in body; snout moderately prominent, scarcely overpassing the mouth; mouth rather large, the lips strongly papillose, the upper moderate, with two or three rows of papillæ: scales crowded anteriorly, much larger on the sides than below; scales 10—64 to 70—9: coloration olivaceous; males in spring with a faint, rosy, lateral band; young brownish, more or less mottled, often with about 3 large confluent lateral blotches, which sometimes form an obscure lateral band.—All waters east of the Rocky Mountains .... TERES.‖

†† Upper lip thick and full, with several (5 to 8) rows of papillæ; scales crowded forward.

‡ Fontanelle well developed; lips without evident cartilaginous sheath.

d. Dorsal fin comparatively long, of 12 to 14 rays.

e. Mouth quite large, with very large lips, the upper full and pendent, with 6 to 8 rows of strong papillæ; head large, 4¼ in length, rather narrow, quadrangular, the snout projecting; eye large; dorsal fin much longer than high, its rays about 14; scales 12—72—10: coloration rather dark; a dusky lateral stripe.—Oregon .... MACROCHILUS.¶

* *Catostomus nigricans* Le Sueur, 1817, = *Catostomus maculosus* Le Sueur, 1817, = *Exoglossum macropterum* Raf., 1818, = *Catostomus xanthopus* Raf., 1820, = *Catostomus planiceps* Val., 1844, = *Hylomyzon nigricans* Agassiz, 1855, = *Hypentelium nigricans* Jordan, 1876.

† *Catostomus nigricans* var. *etowanus* Jordan, 1876.

‡ *Catostomus clarki* Baird & Girard, 1854, = *Minomus clarki* Girard, 1856.

§ *Catostomus insignis* Baird & Girard, 1854.

‖ *Cyprinus teres* Mitchill, 1814, = *Catostomus communis* Le Sueur, 1817, = *Catostomus bostoniensis* Le Sueur, 1817, = *Catostomus flexuosus* Raf., 1820, = *Catostomus reticulatus* Richardson, 1836, = *Catostomus gracilis* Kirtland, 1838, = *Catostomus pallidus* DeKay, 1842, = *Catostomus aureolus* Valenciennes, 1844 (*non* Le S.), = *Catostomus forsterianus* Agassiz, 1850 (*non* Rich.), = *Catostomus suckleyi* Girard, 1856, = *Catostomus texanus* Abbott, 1860, = *Catostomus chloropteron* Abbott, 1860, = *Catostomus alticolus* Cope. 1876, = *Moxostoma trisignatum* Cope, 1876.

¶ *Catostomus macrocheilus* Girard, 1856.

ee. Mouth comparatively small, smaller than in *C. teres*, the upper lip thick, with 5 or 6 rows of papillæ, which are moderately large; head rounded above, 4½ in length, the profile steeper than in *C. teres*, the mouth more pointed, the two sides of the head more convergent forward; eye small; dorsal fin longer than high, its rays 12 to 14; scales 13—72—10.—Rivers west of the Rocky Mountains. OCCIDENTALIS.*

dd. Dorsal fin short, higher than long, of about 11 developed rays; head 4⅓ in length, rather bluntish; mouth moderate, the labial papillæ largely developed, the upper lip full, with about 5 rows of large, but rather sparse papillæ; scales 12—74—10: color dark above; sides clouded with black and yellow.—California .... LABIATUS.†

‡‡ Fontanelle very small and narrow; both jaws with a weak cartilaginous sheath; body elongate-fusiform, subterete, the greatest depth 4¼ to 4½ in length; head small, conical, 4⅔ in length; mouth quite large, with full, thick lips, the upper very wide and pendent, with about 6 rows of very strong papillæ; lower lip two-lobed, similarly papillose; interorbital space wide, convex; eye elevated, posterior, quite small; fins moderate; dorsal higher than long, with 10, rarely 11, rays; ventral rays, 10; scales small, crowded forward, 10 or 9—70—8; color dark; scales with dark punctulations.—Nevada, California........ ARÆOPUS.‡

*** Scales very small, much reduced and crowded anteriorly, 83 to 115 in the lateral line, and 25 to 40 in a transverse series from the ventrals to the dorsal; body and head more or less elongate; sides with a broad rosy or orange lateral band in spring males. (Subgenus *Catostomus.*)

‡ Fontanelle well developed; jaws without evident cartilaginous sheath.

f. Upper lip comparatively thin and narrow, with but few (3 or 4) rows of papillæ.

g. Body elongate, subterete, the depth 4¼ to 4¾ in length: head quite long and slender, 4¼ to 4¾ in length, depressed and flattened above, broad at base, but tapering into a long snout, which considerably overhangs the large mouth; lips thick, coarsely tuberculate; eye rather small, behind the middle of the head: scales very small, much crowded forward, 95 to 114 in the course of the lateral line, and about 29 (26 to 31) in a cross-row from dorsal to ventrals: dorsal rays 10 or 11: males in spring with the head and anal fin profusely tuberculate, the tubercles on head small; the sides at that season with a broad rosy band: size large, the largest species in the genus.—Maine to Wyoming and Alaska.. LONGIROSTRIS.§

gg. Body shorter than in the next, but still elongated, its greatest depth 4½ to 5 in length; head very large and long-acuminate, the muzzle nearly half its length, overhanging the rather large mouth; lips moderate, the upper pendent, with about 3 rows of small papillæ, the lower rather full, similarly papillose; eye nearly median, rather small, 8½ in head; scales small and crowded forward, closely imbricated, 83 to 87 in the course of the lateral line and about 28 in a cross-series from dorsal to ventrals: coloration very dark; fins dusky; scales everywhere finely punctate: size large.—Lake Tahoe and neighboring waters .... TAHOENSIS.‖

ff. Upper lip very broad, with several (5 or 6) rows of large papillæ.

i. Body slender and elongate, the caudal peduncle especially long, the depth 5½ in the length; head moderate, 4⅔ in length, rather slender, with prominent snout and rather contracted, inferior mouth; outline of the mouth triangular, the apex forward; the lips very thick, greatly developed; lower lip incised to the base, its posterior margin extending backward to opposite the eye; jaws with a slight cartilaginous pellicle; eye small, high up: scales long and low, posteriorly rounded, their horizontal diameter greater than the vertical, 17—98 to 105—17: fins excessively developed, much more elevated in the males than in the females, the free border of the dorsal in the males at least deeply incised; in the males the height of each of the 3 vertical fins greater than the length of the head; caudal fin especially strong, the rudimentary rays at its base unusually developed: coloration rather silvery, the males probably rosy and tuberculate in spring.—Wyoming to Arizona............ LATIPINNIS.¶

‡‡ Fontanelle almost obliterated, reduced to a narrow slit; each jaw with a well-developed cartilaginous sheath (as in *Pantosteus*).

j. Body subterete, compressed behind, the depth 5 in length; interorbital space 2 in head: head quite short, broad and rounded above, 4¾ in length: eye small, far back and high, 6 in head; mouth very large, inferior, beneath the projecting snout; upper lip very full, moderately incised, with about 10 rows: a notch separating the upper lip from the lower, each jaw with a slightly curved cartilaginous sheath on its edge, the two parallel with each other and fitting closely together: fins small; dorsal rays 11; caudal little forked: scales 15—90—11; very much reduced forward, and subjected to many irregularities: color dusky; size small.—Idaho to Arizona........ DISCOBOLUS.**

Of other species recently referred to this genus, *Catostomus rostratus* Tilesius, from Siberia, is probably a true *Catostomus*, but our knowledge of it is very imperfect. *Catostomus fecundus* Cope & Yarrow is probably a distinct species, related to *C. occidentalis*. *Catostomus plebeius* Baird & Girard and *Catostomus generosus* Girard belong to *Pantosteus*. *Catostomus retropinnis* Jordan (Bull. U. S. Nat. Mus. xii, 178), discovered since the above was written, is not included.

* *Catostomus occidentalis* Ayres, 1854, = *Catostomus occidentalis* Agassiz, 1855, = ? *Catostomus bernardini* Girard, 1856.

† *Catostomus labiatus* Ayres, 1855.

‡ *Catostomus aræopus* Jordan, sp. nov.

§ *Cyprinus catostomus* Forster, 1773, = *Catostomus longirostrum* Le Sueur, 1817, = *Catostomus hudsonius* Le Sueur, 1817, = *Catostomus forsterianus* Richardson, 1823, = *Catostomus aurora* Agassiz, 1850, = *Acomus griseus* Girard, 1856, = *Acomus lactarius*, Girard, 1856.

‖ *Catostomus tahoensis* Gill & Jordan, 1878.

¶ *Catostomus latipinnis* Baird & Girard, 1853, = *Acomus guzmaniensis* Girard, 1856.

** *Catostomus discobolus* Cope, 1872.

Family CYPRINIDÆ.

Genus APOCOPE Cope.

The species of this genus represent in the West the *Rhinichthys* of the Eastern streams. They are all of small size, and are covered with very small scales. They are very closely related; and as they are distinguished chiefly by the size of the scales, a matter not always easy to determine, they are extremely hard to recognize. In the present collection are very great numbers of small specimens, many in bad condition. Some of these are hardly determinable. Among those large enough and well enough preserved to be fit for study I recognize three species, apparently those called by Professor Cope *Apocope carringtoni*, *vulnerata*, and *ventricosa*.

APOCOPE CARRINGTONI Cope.

1872—Apocope carringtonii *Cope*, Rept. U. S. Geol. Surv. Montana, 1871, p. 472.
1876—Apocope carringtonii *Cope*, v. 5, Zoology, U. S. Geog. Surv. W. 100th Meridian, 1875, p. 645.
1876—Apocope carringtonii *Jordan & Copeland*, Bull. Buffalo Soc. Nat. Hist. v. 2, p. 149. (Name only.)
1878—Apocope carringtonii *Jordan*, Catalogue Fishes N. A., Hayden's Bull. Geol. Surv. Terr. iv, 2, p. 426.

Many specimens, answering fully to Professor Cope's descriptions. The largest one, from Camp Bidwell, California, is nearly 4 inches long, and has the head quite blunt and heavy. The lateral line, which is wanting on the posterior half of the body in the smaller specimens, is in this specimen nearly complete; but the tubes are lacking on many scales. It is probable that in this genus, as in many others, the lateral line becomes more perfect with age. In the larger specimens of *A. carringtoni*, the loral region, the base of the pectorals, ventrals, and anal, and part of the caudal fin are scarlet.

Professor Cope's types were collected at Warm Springs, Utah.

This little species was found to be extremely abundant in nearly all the pools and streams in the region of Camp Bidwell, California, in some instances the water being literally black with them. This is chiefly the case at the season of low-water. They form the chief dependence of the heron family.

No.	Locality.	Collector.	Date.
39	Camp Bidwell, Modoc County, California	H. W. Henshaw	Sept. 28, 1877
40	......do	......do	Sept. 28, 1877
10	Spring near Smoke Creek, Lassen County, California	......do	July 16, 1877

APOCOPE VULNERATA Cope.

1872—Apocope vulnerata *Cope*, U. S. Geol. Surv. Montana, 1871, p. 473.
1872—Tigoma rhinichthyoides *Cope*, U. S. Geol. Surv. Montana, 1871, p. 473.
1874—Alburnellus rhinichthyoides *Cope*, Proc. Am. Philos. Soc. p. 133.
1876—Apocope vulnerata *Cope*, v. 5, Zool., U. S. Geog. Surv. W. 100th Mer. 1875, p. 646, pl. xxvi, f. 4, 4 *a*.
1876—Apocope vulnerata *Jordan & Copeland*, Bull. Buffalo Soc. Nat. Hist. p. 149. (Name only.)
1878—Apocope vulnerata *Jordan*, Cat. Fishes N. A. p. 426.
1874—Rhinichthys henshavii. var. iii, *Cope*, Proc. Am. Philos. Soc. p. 133.
1876—Apocope couesii *Yarrow*, Field and Forest, p. 39.
1876—Apocope couesii *Yarrow*, v. 5, Zool., U. S. Geog. Surv. W. 100th Mer. 1875, p. 648, pl. xxvii, f. 2, 2 *a*.
1876—Apocope couesii *Jordan & Copeland*, Bull. Buffalo Soc. Nat. Hist. p. 149. (Name only.)
1878—Apocope couesi *Jordan*, Cat. Fishes N. A. p. 426.

Many specimens agreeing perfectly with the original account of *Apocope vulnerata*, and so closely with *Apocope couesi* also, that I have ventured to add that name to the synonymy of *vulnerata*. In the accounts of these species given by Cope and Yarrow in the Report of Lieutenant Wheeler's Explorations, are some discrepancies. On page 645, the scale-formula of *vulnerata* is stated to be 15—70—12; that of *couesi* 13—80—10. On page 646, that of *vulnerata* is 12—65—12 to 14 ?; and on page 648, that of *couesi* is 14—67—12. I have assumed that the latter accounts are the most correct; and, if so, I find no sufficient difference between *vulnerata* and *couesi*. If, however, *couesi* really has 80 series of scales, it may be referred to *ventricosa*. My specimens are less than two inches in length. The lateral line, which is somewhat interrupted, includes from 67 to 70 scales.

The types of *vulnerata* were from Provo and Logan, Utah; those of *couesi* from Camp Apache, Arizona. It is probable that the species is widely distributed.

Wherever found, the species of this genus, as in the present instance, exist in great numbers. Indeed, were it not so, their extermination would be very rapid, as not only are they preyed upon by many birds, but they also form the food of the several larger species of fish.

No.	Locality.	Collector.	Date.
8	Horse Lake, Modoc County, California	H. W. Henshaw	July 9, 1877
37	Warner Lake, Lake County, Oregon	do	Sept. 14, 1877

APOCOPE VENTRICOSA Cope.

1874—Ceratichthys ventricosus *Cope*, Proc. Am. Philos. Soc. Phila. 1874, p. 133.
1876—Apocope ventricosa *Cope*, vol. v, Zool., U. S. Geog. Surv. W. 100th M. 1875, p. 648, pl. xxviii, f. 1, 1 *a*.
1876—Apocope ventricosa *Jordan & Copeland*, Bull. Buffalo Soc. Nat. Hist. p. 149. (Name only.)
1878—Apocope ventricosa *Jordan*, Catalogue Fishes N. A. p. 426.

Another very abundant species, readily distinguished from the preceding by its much smaller scales, there being more than 80 in the course of the lateral line. My specimens are more slender than is shown in Professor Cope's figure, but are otherwise similar. Professor Cope's specimens were from Arizona and New Mexico.

No.	Locality.	Collector.	Date.
37	Warner Lake, Lake County, Oregon	H. W. Henshaw	Sept. 14, 1877
17105	Lake Tahoe, California	do	—— —, 1876
17102	Truckee River, Washoe County, Nevada	do	—— —, 1876
15	Shinn's Ranche, Modoc County, California	do	July 15, 1877

Genus LEUCOS Heckel.

(*Algansea* sp. Girard. *Myloleucus* Cope.)

I accept this name provisionally for those species referred by Girard to *Algansea*, which however differ from the type of *Algansea*, *A. tincella*, in having the teeth 4—5, instead of 4—4. *Leucos* differs from *Leuciscus* only in having the teeth 4—5 or 5—5, instead of 6—5 or 6—6. The species of *Squalius* (*Cheonda*) have two rows of teeth, while those of *Myloleucus* have but one. The genera called by Girard *Cheonda*, *Tigoma*, and *Richardsonius*, are in my opinion equivalent respectively to the European *Squalius*, *Telestes* and *Alburnus*.

Professor Cope states that the teeth of *Myloleucus* are "5—4 in outer row." From this I inferred formerly that two rows were present in his typical species. Such appears, however, to be not the case. The statement is doubtless the result of a rigid definition of generic characters, the number of rows of teeth not being considered as a generic character *per se* by Professor Cope. I have recognized in the present collection the two species referred by Professor Cope to *Myloleucus*, but both of them appear to have received prior names from Dr. Girard.

LEUCOS OBESUS (Girard) Jordan.

1856—Algansea obesa *Girard*, Proc. Acad. Nat. Sci. Phila. p. 183.
1858—Algansea, obesa *Girard*, Pac. R. R. Expl. v. 10, p. 239.
1868—Leuciscus obesus *Günther*, Cat. Fishes Brit. Mus. v. 7, p. 244.
1878—Myloleucus obesus *Jordan*, Cat. Fishes N. A. p. 425.
1872—Myloleucus pulverulentus *Cope*, U. S. Geol. Surv. Montana, 1871, p. 475.
1876—Myloleucus pulverulentus *Cope & Yarrow*, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, p. 669.
1876—Myloleucus pulverulentus *Jordan & Copeland*, Bull. Buffalo Soc. Nat. Hist. p. 151. (Name only.)
1878—Myloleucus pulverulentus *Jordan*, Cat. Fishes N. A. p. 425.

This species seems to be the most abundant of the *Cyprinidæ* in the regions in which the present collections were made. An immense number of specimens are before me, ranging from half an inch to ten inches in length. The form varies considerably, large ones being considerably compressed, and with a more pointed snout than the smaller ones, in which the head is blunt and heavy. The scales are very uniformly 14—58—7. The lateral line is deflexed. The teeth are 4—5, with distinct grinding surface, although I notice some variation in this respect. The uppermost teeth, as dscribed by Girard, "stand boldly out above the surface of the bone." The length of the head is contained about four times in length, the depth of the body being not far from the same, 3½ to 4. I have seen none quite so deep as is represented by Girard. The insertion of the dorsal fin is nearly directly over the base of the ventrals. The coloration is rather dusky; the name *pulverulentus*, applied by Professor Cope, being very characteristic, most specimens being closely dusted with small black dots.

Without reference to other characters, this species may be distinguished from the other American species referred to *Leucos* by the following peculiarities of the scales:

a. Scales 12 to 14—58—7 .... *obesus.*
b. Scales 10 to 12—50—53—6 .... *formosus.*
c. Scales 8—50—5 .... *bicolor.*

All these species have the cleft of the mouth rather short and considerably oblique. The type of *obesa* Girard came from Humboldt River, Nevada. The types of *pulverulentus* Cope were from Warm Springs, Utah.

No.	Locality.	Collector.	Date.
502	Pyramid Lake, Nevada	H. W. Henshaw.	May —, 1877
503	........do	...do	May —, 1877
17106	Truckee River, Washoe County, Nevada	...do	—— —, 1876
17103	Carson River, Ormsby County, Nevada	...do	—— —, 1876
17105	Lake Tahoe, California	...do	—— —, 1876
17100	........do	...do	—— —, 1876
44	Eagle Lake, Lassen County, California (probably)	...do	—— —, 1877
12	Smoke Creek, Modoc County, California	...do	July 15, 1877
42	Eagle Lake, Lassen County, California	...do	July 4, 1877
10	Spring near Smoke Creek, Modoc County, California	...do	July 16, 1877

LEUCOS FORMOSUS (Girard) Jordan.

1856—Algansea formosa *Girard*, Proc. Acad. Nat. Sci. Phila. p. 183.
1858—Algansea formosa *Girard*, Pac. R. R. Expl. v. 10, p. 239.
1868—Leuciscus formosus *Günther*, Cat. Fishes Brit. Mus. v. 7, p. 245.
1868—Algansea formosa *Cooper*, Nat. Wealth Cal. by Cronise, p. 496.
1878—Myloleucus formosus *Jordan*, Catalogue Fishes N. A. p. 425.

My specimens indicate a species very closely related to *M. obesus*, but differing pretty constantly in the characters given in the preceding analysis. The scales are usually 11—50—7; the teeth are similar to those of *obesus*, or a trifle stronger, with broader grinding surface. The head is rather longer, 3¾ in length, and the body slenderer, the depth being rather less than one-fourth the length. The general appearance and coloration are the same; some specimens are closely speckled, others almost silvery. Girard's types of *formosa* came from the Merced and Mohave Rivers in Southern California.

This fish is extremely abundant in some localities, as at Washoe Lake, Nevada, where it forms the chief food for several species of diving birds that frequent its waters. As a table-fish it is considered to be of no value whatever, and is never captured for table use.

No.	Locality.	Collector.	Date.
17101	Washoe Lake, Nevada	H. W. Henshaw	....
17098	Kern Lake, California	......do	....

LEUCOS BICOLOR (Girard) Jordan.

1856—Algansea bicolor *Girard*, Proc. Acad. Nat. Sci. Phila. p. 183.
1858—Algansea bicolor *Girard*, Pac. R. R. Expl. v. 10, p. 238.
1868—Leuciscus bicolor *Günther*, Cat. Fishes Brit. Mus. v. 7, p. 245.
1878—Myloleucus bicolor *Jordan*, Cat. Fishes N. A. p. 425.
1877—Myloleucus parovanus *Cope*, Proc. Am. Philos. Soc. p. 136.
1876 Myloleucus parovanus *Cope & Yarrow*, v. 5, Zool., U. S. Geog. Surv. W. 100th M. 1875, p. 669, pl. 28, f. 3 *a*.
1876—Myloleucus parovanus *Jordan & Copeland*, Bull. Buffalo Soc. Nat. Hist. p. 151. (Name only.)
1878—Myloleucus parovanus *Jordan*, Cat. Fishes N. A. p. 425.

My specimens of this species are all quite young. They agree fully with Professor Cope's description and figure of *Myloleucus parovanus*, and differ from Girard's account of *Algansea bicolor* in those characters which vary with age. There can be little doubt, I think, of the propriety of considering *parovanus* as a synonym of *bicolor*. This species is very similar in color and appearance to the others. The type of *Algansea bicolor* is from Klamath Lake, Oregon; those of *Myloleucus parovanus* from Parowan, Utah. Others have been obtained in Beaver River in Southwestern Utah.

Since the above was written, I have examined the types of Girard's *Algansea obesa*, *formosa*, and *bicolor*, and I have no doubt of the correctness of the identifications here made. The scale-formula in the type of *obesa* is 12—58—7; of *formosa*, 10—53—6; of *bicolor*, 8—50—5.

No.	Locality.	Collector.	Date.
34	Warner Lake, Lake County, Oregon	H. W. Henshaw	Sept. 5, 1877

Young specimens of some species of *Telestes* were obtained in Pitt River, California. The species can, however, not be ascertained. The remains* of several individuals of some large species, with very small scales, were picked up on the shores of Kern Lake. These, also, I have been unable certainly to identify, as the teeth are entirely lost. Kern Lake contains vast numbers of these fish, with, according to report, one or two other species. At some seasons they may readily be taken with hook and line, but in summer they retreat from the accessible parts of the lake into deep water; hence our inability to obtain specimens other than the remains above alluded to.

Genus COREGONUS Linnæus.

COREGONUS WILLIAMSONI Gir.

Coregonus williamsoni Girard, Proc. Ac. Nat. Sci. Phila. 1856, 136.—Girard, U. S. Pac. R. R. Expl., Fishes, 326, pl. 66.—Günther, Cat. Fishes Brit. Mus. vi, 187.—Cope & Yarrow, Zoöl. Lieut. Wheeler's Surv. W. 100th Mer. v, 682.—Cope, U. S. Geol. Surv. Terr. 1870, 433, and 1871, 469.—Cope, Proc. Ac. Nat. Sci. Phila. 1874, 132.

This fish appears to be of not uncommon occurrence in certain portions of the Western interior. It was secured by the Expedition in 1872 at Utah Lake, and its presence elsewhere in the Territory ascertained. It appears to live habitually in such lakes as permit a run in the spawning season into the cold clear mountain streams. At Lake Tahoe it was found very abundantly in October, being met with at that season in all of the few small streams that issue into the lake from the adjoining mountains, as Trout Creek and Truckee River. This month and later is their spawning season, and as they pass up many are intercepted by the Indians, who find a market for considerable numbers in the settlements and logging camps about the lake. Having constructed a suitable net of mosquito-netting, which is affixed to a long pole, the Indian, accompanied by one or two squaws, proceeds to the stream where it is sufficiently narrow for his purpose. Placing the net at the head of one of the deep sandy-bottomed pools which are found at every turn of the stream, he awaits quietly till all the fish near by have been frightened into it by the squaws, who advance from below and beat the water with sticks. With a sudden scoop he usually empties the pool, taking perhaps from six to a dozen fish from each. All that we saw caught in this manner were quite small, averaging perhaps ten inches in length, but they attain a much larger size. Farther to the north we heard of a fish called the "Whitefish," which was said to inhabit Pitt River, and which was probably this species.

The *Coregonus couesi* resembles somewhat the present species, from which, however, it appears to be sufficiently distinct.

Family SALMONIDÆ.

Genus SALMO Linnæus.

(Subgenus *Salar* Valenciennes.)

(*Salar* and *Fario* Girard.)

SALMO IRIDEUS Gibbons.

Pacific Coast Brook Trout.

1855—Salmo iridea *Gibbons*, Proc. Cal. Ac. Nat. Sc. p. 36.
Salar iridea *Girard*, Proc. Ac. Nat. Sc. Phila. p. 220, 1856.
Salar iridea *Girard*, Pac. R. R. Expl., Fishes, p. 321, 1858, pl. 73, f. 5, and pl. 74.

* These remains prove to belong to *Orthodon microlepidotus* (Ayres) Grd.

Salar irideus *Jordan*, Catalogue Fishes N. A. p. 431, 1878.
Salmo irideus *Günther*, Cat. Fishes Brit. Mus. vi, p. 119, 1867.
Salmo iridea *Suckley*, Monograph Genus Salmo, p. 129, 1874.
Salmo irideus *Jordan & Copeland*, Check List, p. 144, 1876.
Salmo irideus *Hallock*, Sportsman's Gazetteer, and of writers on fish and fish-culture generally.
Salmo irideus *Jordan*, Man. Vert. ed. 2d, p. 358, 1878.
Salmo irideus *Jordan*, Proc. U. S. Nat. Mus. i, 76, 1878.
Salmo rivularis *Ayres*, Proc. Cal. Ac. Nat. Sc. p. 43.
1856—Fario gairdneri *Girard*, Proc. Ac. Nat, Sc. Phila. p. 219 (not *Salmo gairdneri* Rich., a species with the "caudal fin semilunate" and "no hyoid teeth"; hence neither the present fish nor *S. clarkii* Rich.).
Fario gairdneri *Girard*, Pac. R. R. Expl., Fishes, p. 313, pl. 71, f. 1–4, 1858.
1858—Fario newberrii *Girard*, Proc. Ac. Nat. Sc. Phila. p. 224, 1858 (substitute for *gairdneri*).
Salmo newberrii *Suckley*, Monograph Genus Salmo, p. 159, 1874.
Salmo newberryi *Jordan & Copeland*, Check List, p. 144, 1876.
1858—Fario clarkii *Girard*, Proc. Ac. Nat. Sc. Phila. p. 219 (not *Salmo clarkii* Rich.).
Fario clarkii *Girard*, Pac. R. R. Expl. Fishes, p. 314, pl. 71, f. 5–8, 1858.
1860—Salmo masoni *Suckley*, Nat. Hist. Washington Terr. p. 345 (substitute for *clarkii*).
Salmo masoni *Suckley*, Monograph Salmo, p. 134, 1874.
Salmo masoni *Jordan & Copeland*, Check List, p. 144, 1876.
1860—? Salmo gairdneri *Suckley*, Nat. Hist. Washington Terr. p. 331 (not of Richardson).
? Salmo gairdneri *Suckley*, Monograph Salmo, p. 114, 1874.
1867—Salmo purpuratus *Günther*, Cat. Fishes Brit. Mus. vi, p. 116, 1867 (in part; probably not of Pallas, whose specimens came from Siberia, = *Salmo mykiss* Walbaum, = *Salmo muikisi* Bloch, both names prior to Pallas, who gives "Mykiss" as the vernacular name of *purpuratus*).

No new information having been obtained in regard to this abundant species, it is necessary only to refer to it here. The synonymy has been elsewhere fully discussed.* Mr. Henshaw adds the following: This is the common "Brook Trout" of the small mountain streams of the Pacific slope, and up to an altitude of 9,000 feet it is the rare exception to find a suitable stream that is not well stocked with it. Upon many of them, as the tributaries of the South Fork of the Kern River, these trout are found in very great abundance, each pool and rapid numbering its finny denizens by the score. They may be taken in any sort of weather, at any hour of the day, by almost any kind of bait. During the heat of the day, they frequent almost entirely the deeper pools, lying under overshadowing rocks or in the shade of some convenient log. In early morning or late afternoon, they come out and run more into the shallows and rapids, under which circumstances they bite best and afford the finest sport. Like the average brook trout, the species rarely attains any considerable size, ranging from four to eight or more inches in length. Their colors are usually very bright, and for beauty this species takes rank among the foremost of its kind, and has been well called the "Golden Trout." In this respect, however, it is subject to the usual variation obtaining in the family, the change of color not only accompanying a difference in locality, but being plainly discernible in individuals taken in different parts of the same stream not far distant. In fact, as a specific character, color in this family seems to be at its lowest value. The character of the bottom and water itself has much to do with this, and I remember to have fished in a small rivulet on one of the sub-alpine meadows not far from Mount Whitney, whose sluggish waters flowed over a bottom of dark mud, in which the color of the trout simulated very closely its hue; they had lost nearly all the flashing iridescent tints characterizing the same species caught but a few hours before in another stream, and had become dull and somber-hued. Accompanying this change of color was a correspondingly noticeable difference in habits and motions, and the several dozen trout caught that evening for supper were taken out by the hook with the display of very little more gaminess than would be noticed in so many Horned Pout. On the contrary, in the clear rapid current of the mountain stream, a flash of sunlight is scarcely quicker than the gleam of gold and silver seen for a single instant as the whirling waters are cut by one of these trout as he makes a rush from his lurking place for some chance morsel which is being borne past him. The Western trout are rarely as shy as their relatives of Eastern waters, and because of their numbers and the consequent scarcity of food are apt to be less fastidious; yet, even when most abundant, due caution must be used if one would be successful, and not every one can catch trout, even in the West. With the proper care in concealing one's self, a pool may be almost decimated ere the alarm will be taken, and I have seen fifteen fair-sized trout taken from a single small pool in quick succession.

No.	Locality.	Collector.	Date.
17104	Near Mount Whitney, Inyo County, California	H. W. Henshaw	—— —, 1875
17096	Ojai Creek, Ventura County, California	do	—— —, 1875

* "Notes on a Collection of Fishes from Clackamas River, Oregon. By David S. Jordan, M. D."—Proc. U. S. Nat. Mus. i, 75, 1878.

SALMO TSUPPITCH Richardson.

Tsuppitch Trout. Black Trout of Lake Tahoe.

1836—Salmo tsuppitch *Richardson*, Fauna Bor. Am., Fishes, p. 224.
Salmo tsuppitch *DeKay*, New York Fauna, Fishes, p.—, 1842.
Salmo tsuppitch *Storer*, Synopsis, p. 197, 1846.
Salmo tsuppitch *Herbert*, Frank Forrester's Fish and Fishing, Suppl., p. 39, 1850.
Salmo tsuppitch *Suckley*, Nat. Hist. Wash. Terr. p. 327.
Salmo tsuppitch *Günther*, Cat. Fishes Brit. Mus. vi, p. 118, 1867.
Salmo tsuppitch *Suckley*, Monograph Salmo, p. 111, 1874.
Salmo tsuppitch *Jordan*, Man. Vert. ed. 2d, p. 358, 1878.
Salmo tsuppitch *Jordan*, Proc. U. S. Nat. Mus. i, 72, 1878.

A specimen has been lately received at the National Museum from Clackamas River Oregon, which I regard as belonging to the species to which the name of *Salmo tsuppitch* was given by Richardson. In the present collection are many more specimens more or less closely similar to the Oregon one, and which, in default of material for a full comparison, I consider specifically identical with it. The species *tsuppitch* as thus defined is closely related to *Salmo clarkii* and to *Salmo henshawi*, from both of which it may be distinguished by the want of hyoid teeth and by the smaller and more conical head.

With *henshawi* it agrees most closely, and if old specimens of the latter, as may perhaps be possible, shed or absorb their hyoid teeth, there may be some difficulty in distinguishing them. The color and general appearance of the two (in spirits) are remarkably similar; but Mr. Henshaw informs me that they are readily distinguishable in life, *S. henshawi* being known to the fishermen as Silver Trout; *S. tsuppitch* as Black Trout. From *S. irideus* and *S. spilurus*, both of which are destitute of hyoid teeth, *S. tsuppitch* is readily separated. It is intermediate between the two and closely related to neither.

The following description was taken from the Clackamas River specimen:

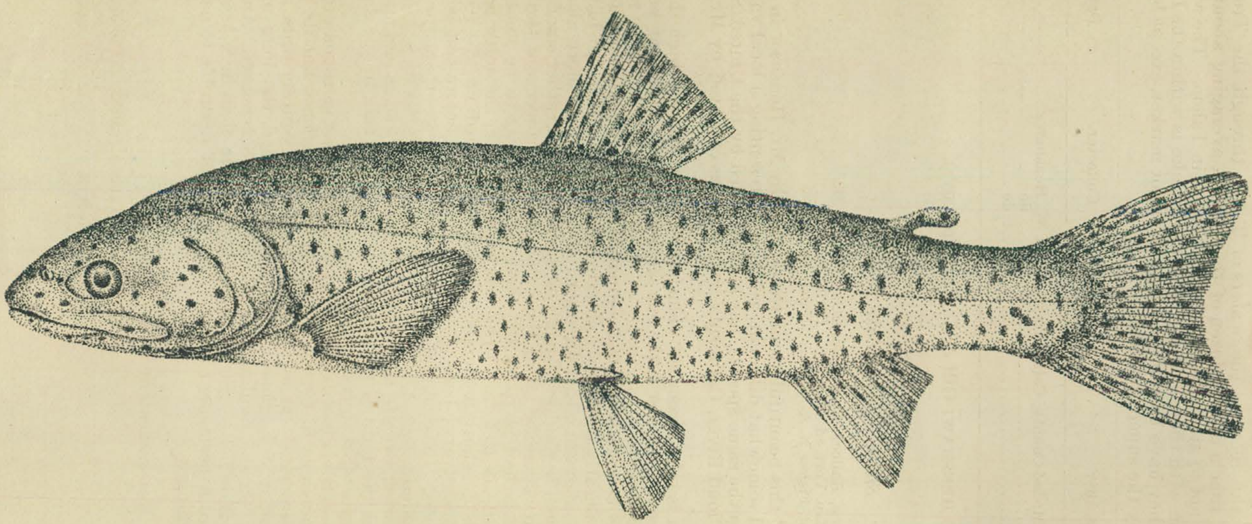
Body elongated, somewhat compressed; the dorsal region moderately elevated; head rather small, pointed and lengthened, its form quite distinctly conic, less convex than in *S. pleuriticus*, the top rather narrow and slightly keeled; mouth moderate, not large, with rather weak teeth; the maxillary comparatively narrow and not extending much beyond eye; opercle more prolonged backward than in *S. pleuriticus*, making the head appear longer; pectoral fin smaller than in *S. pleuriticus*.

Scales small, silvery, 28—180—29; caudal fin short, rather faintly forked, but more so than in *S. pleuriticus* or *S. clarki;* adipose fin rather small; color dark above; head, body, and upper fins with small, round, black spots, mostly very numerous, and as plentiful anteriorly as behind; fins all small, the dorsal of the usual *Salar* pattern; a few spots on the belly.

Measurements.

	Clackamas River.	Kern River.
Length	12 inches.	12 inches,
Depth	.23½ of length.	.25 of length.
Head	.24½	.26
Interorbital space	.07	.07½
Maxillary	.10	.12
Mandible	.15	.17½
Dorsal rays	2, 11	2, 12
Anal rays	2, 10	2, 10
Scales	28—180—29	165 to 175

This trout appears to be quite widely distributed, and specimens were obtained by the expedition at several localities far distant from each other. In the North Fork of Kern River, upon the Pacific slope, it appears to be the only species, and to be replaced in the other and smaller branches of the river by the *S. irideus*. It attains a large size both in this stream and in Lake Tahoe, where it is also very abundant. It appears to be unusually voracious even for a trout, and very few small fish of its own kind are found in the stream, they keeping in the small tributary water-courses until able to protect themselves from their larger brethren, which even here attain a weight of seven pounds. Visiting the North Fork in October, after it had been well fished out during the summer to supply the mining towns, we found no little difficulty in catching the trout, all the ordinary baits failing to entice them into biting. Upon dissecting a four or five pounder which had fallen prey to a spoon bait, the secret was out, for no fewer than five mice were found in his belly, all captured the night before. Acting upon this hint, no further trouble was had, and a cast made with a small mouse as bait into a pool tenanted by a large fish was sure to be rewarded by a rise and strike. Immense quantities of drift-wood along shore explain the presence of the mice (*Hesperomys leucopus*), and the trout coming at night into shallow water to feed succeed in seizing them in some unexplained way. In Lake Tahoe this species is distinguished from the succeeding by the popular name of "Black Trout," on account of its very dark colors. Its method of capture and habits while in the lake appear to be identical with those of the following species, and under that will be detailed. It is the belief of all the fishermen on the lake that the "Black Trout" spawn only in the streams mak-



SALMO HENSHAWI — GILL & JORDAN.
LAKE TAHOE, NEVADA.

AM. PHOTO-LITHO. CO. N.Y. (OSBORNE'S PROCESS.)

ing into the lake, notably the Truckee River, their passage up for this purpose occurring in May, June, and July—June being the special month. At this season many are speared during the run, the Indians especially taking advantage of the opportunity. Such is not the case with the Silver Trout (*S. henshawi*), which is said never to be found in the streams. During the last part of May, while on a visit to Pyramid Lake, which with Winnemucca Lake receives the waters of Tahoe through the Truckee River, we caught in a short time a couple dozen of these trout, averaging about two pounds each. They appear not to attain so great a size here as in Tahoe. The waters of Pyramid Lake fairly teem with these fine fish, and as the lake is within the limits of the Indian reservation, they have been protected, fishing for market, except by the Indians, being prohibited by the superintendent.

No.	Locality.	Collector.	Date.
161	Tributary of Pitt River, Modoc County, California	H. W. Henshaw	—— —, 1877
......	Lake Tahoe, California	......do	—— —, 1876
......	Kern River, California	......do	—— —, 1875

SALMO HENSHAWI Gill & Jordan (sp. nov.).

(Plate 4.)

Silver Trout of Lake Tahoe.

1877—Lake Tahoe Trout, *Henshaw*, Hallock, Sportsman's Gazetteer, p. 342.
1878—Salmo henshawi *Jordan*, Man. Vert. ed. 2d, p. 358. (Brief notice.)
1878—Salar henshawi *Jordan*, Cat. Fishes N. A. p. 431. (Name only.)

Several fine specimens of this beautiful trout were taken by Mr. Henshaw in Lake Tahoe. Another individual somewhat different, perhaps representing a local variety, but apparently belonging to the same species, has been received by the United States National Museum from McCloud River, California, where it was collected by Mr. Livingston Stone.

The following description is taken from Mr. Henshaw's specimens, of which the one numbered 17,086 in the Museum Register is the one measured, and which may be considered as the type of *Salmo henshawi:*

Body elongate, not greatly compressed; head comparatively slender and long-acuminate, its upper surface very slightly carinated; muzzle somewhat pointed, but bluntish at the tip; head not convex above in either direction; maxillary rather short, about as in *S. clarki*, not reaching much beyond eye; teeth on vomer usual, a rather small, narrow, but distinct patch of teeth on the hyoid bone, the patch narrower and the teeth smaller and more closely set than in *S. clarki;* these teeth appear to be sometimes deciduous. Dorsal fin small, its last rays $\frac{2}{5}$ the height of the first, the outer margin even, as in *S. irideus*. Caudal fin short, moderately forked; scales medium, 27—160—27.

Color rather dark, the sides silvery; back about equally spotted before and behind; sides with rather distant spots. In some, the belly is also spotted; in others, the spots are quite sparse and very round.

Top and sides of head spotted, even to the end of snout. Dorsal and caudal spotted.

From *S. clarki* it differs in the form of the head, in the forked tail, in the smaller patch of hyoid teeth, and somewhat in color.

The specimen from McCloud River is still more elongated and rather more compressed; head very large and long, much as in typical specimens of *S. henshawi*, but its upper slope is even more nearly horizontal; mouth wide. The maxillary rather wide, reaching beyond eye, larger than in *S. henshawi*. Head slightly keeled, the long muzzle deeper than in *S. henshawi*. Caudal similarly forked. Colors of *S. henshawi*. Anterior spotting profuse; some spots on belly. Scales averaging smaller than in *S. henshawi*. This specimen may indicate a permanent variety, but it is not desirable to name it until more is known concerning it.

Measurements of Salmo henshawi.

	(17086, Lake Tahoe.)	(20832, McCloud River.)
Length	13 inches.	15½ inches.
Depth	.26½ of length.	.20 of length.
Length of head	.25½	.25½
Top of head	.15	.17
Interorbital space	.07	.07
Maxillary	.11	.12
Mandible	.15	.16½
Snout	.06	.07
Orbit	.04½	.04
Dorsal rays	2, 11	2, 10
Anal rays	2, 10	2, 11
Scales	27—160—27	37—184—37

This beautiful trout is universally known about Lake Tahoe as the "Silver Trout" in distinction from the preceding, from which it may be known at a glance—at least such is the case in the fall, the time of our observations—by peculiarities of color alone. Its prevailing tint when freshly taken from the water is of a rather pure silvery-white, the sides showing traces of golden reflections. The black spots are larger, more irregularly shaped, and more numerous than in the "Black Trout," and on the back become aggregated into a broad black band. The belly is white, not smoky-brown, as in the other, and is marked with numerous small black spots. The color is variable to some extent in both species, and perhaps at other seasons the distinct colors of the two fish might not be maintained, although we have never seen specimens that appeared at all doubtful; hence we are inclined to attribute a greater degree of constancy to the respective markings of these two fishes, as they occur together in Lake Tahoe, than is usually to be found in the various species of the family. The Silver Trout is said to spawn in the gravel beds of the lake, and not to accompany the other species on its periodical journey up the Truckee. At Lake Tahoe, the capture of trout, as followed by the fishermen for market, is rather peculiar in that trolling supersedes all other methods. We had no opportunity to test them with the fly, but were told that it had been tried, with but poor success. On several occasions, the ordinary spoon bait was used, such as is employed successfully in the East with Pickerel, and which elsewhere in the West we have found to be fairly successful with trout, but here it proved of little value. The tackle which experience has shown to be the best, and which is in almost universal employ upon the lake, is very similar to the ordinary trolling apparatus used upon the East coast for Bluefish, and consists of an oblong-oval, flat piece of lead either run on to the shank of a good-sized hook or placed upon the line immediately above it. The hook is always baited with a fresh "Silver-sided Minnow," the bright lead serving merely to attract the attention of the fish to the bait. The wonderful transparency of the water renders the use of a long line, 150 feet or more, imperative, as the trout are too shy to be trolled in very near the boat. With the above simple equipment, the fisherman is ready for work, and in season it is only necessary to troll leisurely over the fishing-grounds upon a calm day, and good fishing is assured, as the trout are very numerous and eager for the bait. Nearly all the fish are caught between the green and blue water, the former color indicating the shallower parts, the blue the deep. The sharpness of definition of this dividing line is quite remarkable, deep water succeeding shallow with cliff-like abruptness.

It is during the spring months that the trout take the bait most eagerly, and great numbers are then caught. As summer comes on, they bite less readily, and during the late fall good catches are rarely made.

Besides the trolling method, still-fishing is sometimes resorted to, chiefly by visitors and amateurs. At several points in the lake not far from shore may be seen jutting out from the water the tops of immense pines that have been stranded in water from 50 to 150 feet deep. The boats are made fast to one of these, and with much the same apparatus as above described good strings of trout are taken, a morning's catch in season averaging from a dozen to thirty. The fish caught in this manner average smaller than those hooked by trolling, although 3 and 4 pounders are by no means rare, while occasionally much larger ones are taken.

Regarding the extreme size attained by the Tahoe Trout we are able only to furnish statements made by others. Ten-pound fish are certainly not rare, and the positive assertion is made by all the fishermen whom we have questioned on the subject that a 28-pound Silver Trout is on record as having been caught here, the weight having been ascertained upon the scales. Trout of this size must be extremely uncommon, to say the least, although it is but proper to state that the testimony upon this point came from too many and too reliable sources to be doubted.

Carson City, 16 miles distant from the lake, affords a market for large quantities of fish, which readily bring about 18 cents per pound. The chief supply, however, goes to Virginia City and the other mining towns, where they sell for from 18 to 25 cents per pound.

SALMO PLEURITICUS Cope.

Rio Grande Trout.

Salmo pleuriticus Cope, U. S. Geol. Surv. Montana, 1871, 471.—Cope, Proc. Am. Philos. Soc. Phila. 1874, 132.—Cope & Yarrow, Zoology U. S. Geog. Survs. W. 100th M. v, 693.
Salmo spilurus subsp. *pleuriticus* Jordan, Proc. U. S. Nat. Mus. i, 74, 1878.

Several young specimens of this widely distributed and abundant species were secured. The extension of its range west of the Sierra Nevadas is rather unexpected. The prevalent theory that most of the species of trout have a narrow local range is hardly supported by a study of our Western forms. In nearly all cases where a series of lakes or rivers near together are supposed each to be inhabited by its peculiar "species," it will be found on comparison of specimens that these "species" can never be certainly distinguished, but that they are really based on fishermen's impressions, different ways of "rising to the fly," color of flesh, or oftener on nothing at all. Such a series is made by *Salmo namaycush*, the Great Lake Trout; *Salmo confinis*, the Trout of Lewis Lake; *Salmo adarondacus*, the Trout of the Adirondacks; *Salmo pallidus*, the "Longe" of Lake Champlain; *Salmo symmetricus*, the Trout of Lake Winnepiseogee; and, finally, *Salmo toma*, the "Togue" of the lakes of Maine. On examination of specimens supposably representing each of these nominal species, I am utterly unable to distinguish any of them. They are all trifling or imaginary varieties of the widely distributed *Salmo* (or rather *Cristivomer*) *namaycush*. There are but two of our American salmon which any one has any good reason to believe are of narrow geographical range, viz, *Salvelinus oquassa*, of the Rangeley Lakes, and *Cristivomer siscowet*, of Lake Superior, and that either of these does not occur to the northward no one is certain.

The fishes termed *Salmo spilurus* and *Salmo pleuriticus* by Professor Cope are usually, but not always, readily distinguishable by the size of the scales and the form of the head. I consider the former a permanent mountain variety of the latter, which is far the more widely distributed form. As, however, the name *spilurus* has priority of a few lines, we should in strictness call the two "*S. spilurus*" and "*S. spilurus* var. *pleuriticus*." Although *spilurus* is evidently the "variety," and *pleuriticus* the species, we can hardly say so in our nomenclature.

This trout was abundant in the South Fork of Kern River, beyond which statement nothing can be said of its distribution on the West coast, or of its relative abundance as compared with the *S. irideus*, the distinctness of the forms not having been recognized at the time of collection.

No.	Locality.	Collector.	Date.
17107	South Fork of Kern River, Kern County, California......	H. W. Henshaw.......	—— —, 1875

Family PERCIDÆ.

Genus AMBLOPLITES Rafinesque.

(Subgenus *Archoplites* Gill.)

AMBLOPLITES INTERRUPTUS Girard.

California Perch.

Centrarchus interruptus Gd., Proc. Acad. Nat. Sci. Phila. 1854, v. 7, 129; *ib.* 1856, v. 5, p. 99.—Günther, Cat. Acanth. Fishes in Brit. Mus. v. 1, p. 257.
Centrarchus maculosus Ayres, Proc. Cal. Acad. Nat. Sci. 1855, v. 1, p. 8; *ib.* Proc. Bost. Soc. Nat. Sci. 1855, v. 1, p. 8.
Ambloplites interruptus Gd., Expl. and Surv. for R. R. Route to Pac. 1857, v. 6, Abbott's Route, p. 9; *ib.* 1858, v. 10, Fishes, p. 10, pl. 2, f. 1-4; *ib.* v. 16, Whipple's Route, 1858, p. 48; *ib.* v. 10, Williamson's Route, 1858, p. 83.
Archoplites interruptus Gill, Proc. Acad. Nat. Sci., Phila. 1861, [v. 13,] p. 165.—Cooper, Nat. Wealth Cal. by Cronise, p. 487.—Jordan, Bull. U. S. Nat. Mus. No. 10, 1877, 34.

Numerous specimens of this abundant species, the only fresh-water Percoid found west of the Rocky Mountains, are contained in the collection. The characters distinguishing this fish from the Rock Bass of the East (*Ambloplites rupestris*) are quite numerous, but none of them are independently of generic value. I hardly see that *collectively* their value should be generic. True generic characters cannot be made by adding up specific characters.

No.	Locality.	Collector.	Date.
17091	Kern Lake, Kern County, California......................	H. W. Henshaw	—— —, 1875

Family COTTIDÆ.

Genus URANIDEA DeKay.

(Subgenus *Potamocottus* Gill.)

URANIDEA GULOSA (Girard) Jordan.

Cottopsis gulosus Girard, Proc. Acad. Nat. Sci. Phila. v. 7, 1854, 129; *ib.* Exp. and Surv. for R. R. Route to Pacific, 1857, v. 6, p. 10; *ib.* Expl. and Surv. for R. R. Route to Pacific, Fishes, p. 53.—Cooper, Nat. Wealth Cala. by Cronise, 1862, p. 492.
Potamocottus gulosus Gill, Proc. Acad. Nat. Sci. Phila. [v. 14,] 1862, p. 332.
Pegedichthys gulosus Jordan & Copeland, Bull. Buff. Soc. Nat. Sci. 1876, v. 2, p. 139.

A single large specimen in poor condition. It agrees closely with Girard's *Cottopsis gulosus*, being evidently *not* a species of *Cottopsis*. It much resembles the Eastern

Uranidea (Potamocottus) meridionalis. In fact, from the examination of this single specimen, I am unable to see that it differs at all. *Uranidea vheeleri* Cope seems to be slimmer, with a longer head and shorter anal.

No.	Locality.	Collector.	Date.
19	Jesse's Valley, Modoc County, California	H. W. Henshaw	Aug. 9, 1877

The species of this curious family are rather rare in Western collections, for the reason that owing to their peculiar habits they are not easily found unless one knows just where to look for them. They probably exist in nearly all the lakes and streams of size throughout the West where the bottom is suited to them, pebbly or sandy bottom being the best. During the day they lie closely hidden under the rocks or sunken logs, only occasionally venturing out, when they are to be seen hugging close to the bottom and almost motionless. They appear, in fact, to be nocturnal rather than diurnal in habits; and at Fallen Leaf Lake, near Tahoe, we remember to have seen them make their appearance in considerable numbers just at nightfall, swimming then boldly in along shore. They are very sluggish in motions, and, when frightened, swim only a few feet, and then settle snugly down on the sand or among the rocks, with the evident intent of eluding search by reason of their inconspicuousness, their colors being nicely adjusted to the tints that habitually surround them.

URANIDEA VHEELERI Cope.

Uranidea vheeleri Cope, Proc. Am. Philos. Soc. Phila., v, 1874, p. 138; Rep. Plagiopt. and Ichthyol. Utah, p. 12.—Cope and Yarrow, v. 5, Zoology U. S. Geog. Surv. W. 100th M. 1875, 696 (orig. desc.).
Pegedichthys vheeleri Jordan & Copeland, Bull. Buffalo Soc. Nat. Sci. 1876, v. 2, p. 139.

This species was first described from Utah, where it was collected by the expedition. It has since been taken at Camp Harney, Oregon, by Capt. Chas. Bendire, U. S. A., and it doubtless occurs elsewhere in that region. The single specimen secured approaches very closely to the *U. gulosa*, and may be the same. It seems to differ in the slenderer body, the head being 3½ in length, without caudal, instead of 3, as in *gulosa*. There are no prickles behind the pectorals, while these are present in *gulosa*. The isthmus is a trifle broader.

Family GASTEROSTEIDÆ.

Genus GASTEROSTEUS Linnæus.

GASTEROSTEUS PLEBEIUS Girard.

Gasterosteus plebeius Girard, Proc. Acad. Nat. Sci. Phila. 1854, v. 7, p. 147.—Ayres, Proc. Cal. Acad. Nat. Sci. 1855, v. 1, p. 40 (from San José); *ibid.* 1855, v. 1, p. 48 (name only).—Gd., Expl. and Surv. for R. R. Route to Pac. 1858, v. 10, Fishes, p. 86.—Günther, Cat. Fishes in Brit. Mus. 1859, v. 1, p. 2 (d. s.).—Cooper, Nat. Wealth Cal. by Cronise, 1868, p. 491.—Sauvage, Nouv. Arch. Mus. d'Hist. Nat. Paris, 1874, t. 10, p. 18, pl. 1, fig. 10.

Numerous specimens of a small Stickleback, agreeing perfectly with *Gasterosteus plebeius* Girard, not quite so well with *Gasterosteus inopinatus* Girard and *Gasterosteus microcephalus*, and still less with *Gasterosteus pugetti* Girard. It does not differ from any of the four in any essential point, however, or in any way to suggest that the four descriptions published by Girard are descriptions of species rather than of specimens. It is probable, therefore, that *microcephalus*, *pugetti*, *inopinatus*, and *plebeius* are one and the same species, for which the oldest name, *microcephalus*, is to be retained. My specimens have four distinct thoracic plates, behind the last of which the body is naked. In some, the ventral spines extend beyond the "*os innominatum*"; in others, the spines are shorter than the bone. The sides of the specimens are silvery, barred and mottled like a young trout or parr.

No.	Locality.	Collector.	Date.
17092	Ojai Creek, Ventura County, California	H. W. Henshaw	—— —, 1875

The locality below given is the only one where we have ever seen this Stickleback. It was numerous enough in this small stream, being there found with the *Salmo irideus* as its only inhabitants.

APPENDIX K 1.

LIST OF MARINE FISHES COLLECTED ON THE COAST OF CALIFORNIA, NEAR SANTA BARBARA IN 1875, WITH NOTES BY DR. H. C. YARROW, ACTING ASSISTANT SURGEON U. S. A., AND H. W. HENSHAW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
June 1, 1878.

SIR: The following list includes such species of the fishes collected on the coast of California during the season of 1875 as we have been able to identify. A number of other species were secured, but have not been introduced here, as, differing more or less from accepted forms, it has been deemed advisable, before pronouncing definitely upon them, to wait for Professor Gill's "*Revision of the Fishes of the West Coast of the United States*," now in course of preparation. The fishes obtained form a portion of the marine collections made by the natural-history party, which was especially organized for the purpose of exploring the neighborhood of Santa Barbara for Indian antiquities. No thorough investigations in this direction could be attempted, which is the more to be regretted as the waters about Santa Barbara and the contiguous islands are extremely rich in marine life, but the collections were limited to such as could be made without interfering with the main purpose of our visit. Through the courtesy and at the suggestion of Captain Taylor, of the Coast Survey steamer Hassler, a visit was made to the island of Santa Cruz by Mr. Henshaw for the express purpose of using the Hassler's seine, a rich haul being anticipated in the shallow water of one of the small bays of the island. Unfortunately, unpropitious weather interfered very seriously with the plan, and but few pecies rewarded such efforts as were possible under the circumstances.

We are indebted to Mr. Paul Schumacher, at that time exploring the mounds on Santa Cruz Island at the instance of the Smithsonian Institution, for many specimens in the collection. Owing to the obliteration of most of the labels, we are unable to credit him or the other collectors in full.

Very respectfully, your obedient servants,

H. C. YARROW.
H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

PLEURONECTIDÆ.

PLATICHTHYS sp.

A few specimens of flounders were taken in nets near La Patera, north of Santa Barbara, which we have not determined.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17063	1046	La Patera	July, 1875	Dr. H. C. Yarrow	4

PAROPHRYS VETULUS Grd.

A single specimen, from same locality as preceding.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17064	1020 F	La Patera	July, 1875	Dr. H. C. Yarrow	1

BLENNIIDÆ.

HETEROSTICHUS ROSTRATUS Grd.

A peculiar and readily recognized species from the extreme length of the dorsal fin, which reaches from the occiput nearly to the caudal. The anal is also very long. The lateral line is arched above the pectorals. Color yellowish-brown above with transverse brownish blotches. Is quite abundant near Santa Barbara and esteemed as an excellent table-fish, but to our taste is far inferior to some of the other species.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17021	1018 A	Santa Barbara	July, 1875	H. W. Henshaw	2
17022	1020 B	......do	....do	Mr. Schumacher	1
17023	1070 F	......do	....do	Dr. H. C. Yarrow	2

BATRACHIDÆ.

PORICHTHYS NOTATUS Grd.

Color in life dark bluish-violet; belly and sides silvery ashy-white. The four series of pores on each side resemble spots of gold. There is a dark patch beneath each eye. Abundant near Santa Barbara. Although repulsive in appearance, this species is justly esteemed as a most delicate and edible food-fish. Bites readily at the hook.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17046	1020	Santa Barbara	July, 1875	Dr. H. C. Yarrow	5

COTTIDÆ.

CLINOCOTTUS ANALIS (Grd.) Gill.

This is an abundant species along the coast, and, at low tide, may be found in almost every little pool, where it hides beneath the rocks and among the sea-weeds. Like other members of the family, its colors are protective, the hues corresponding so closely with surrounding objects that it needs careful scrutiny to detect the fish. Doubtless this fact is of use as enabling the fish to seize its unwary prey.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17059	964	Santa Cruz Island	June, 1875	H. W. Henshaw	2
17060	848	......do	....do	Dr. O. Loew	2

SCORPÆNIDÆ.

SEBASTOMUS ROSACEUS (Grd.) Gill.—Rosy Rock Cod.

Fishes of this genus are called on the coast "Rock Fish" or "Rock Cod," and vary in size from 1 to 4 pounds. The flesh is fine-grained and excellent, and many are caught for the market by the Italian fishermen, who readily dispose of all they can take. They abound in localities in the vicinity of the Santa Barbara Channel islands, and are easily taken with hook and line, the best bait being either crawfish (lobster, so called) or the fleshy parts of *Haliotis*. Occasionally they are caught by trolling.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17057	1011 A	Santa Barbara	July, 1875	Dr. H. C. Yarrow	1
17040	1011 B	......do	....do	H. W. Henshaw	1

LABRIDÆ.

PIMELOMETOPON PULCHRER (Ayres) Gill.

This large and beautiful species is quite common on the southern coast of California, and specimens were seen at Santa Barbara which had been taken near San Miguel Island in the channel. Dr. Streets, U. S. N., secured one specimen on the coast of Lower California 27 inches in length, 7 inches in height.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17042	....	Santa Barbara	July, 1875	Yarrow & Henshaw	2

POMACENTRIDÆ.

HYPSYPOPS RUBICUNDUS (Grd.) Gill.

Tolerably common. A single beautiful specimen secured, which was bright red in life.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17043	1017 B	Santa Barbara	July, 1875	Dr. H. C. Yarrow	1

CHROMIS ATRILOBATUS Gill.

A few specimens collected near Santa Barbara. Is rather uncommon.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17042	....	Santa Barbara	July, 1875	Yarrow & Henshaw	1

SCOMBRIDÆ.

At Santa Barbara, in July, a number of specimens belonging to this family were taken by hook and line, off the wharf, by boys. They were called "Pompano"; but, as none could be purchased, we have not been able to identify the species.

SCIÆNIDÆ.

MENTICIRRUS UNDULATUS (Grd.) Gill.—King-fish.

Color above ashy silvery-white, with brownish-white spots forming undulatory bands; beneath, of a metallic yellow.

This species appears to be tolerably abundant along the coast, as near Carpenteria, below Santa Barbara, and numbers were frequently seen in the boats of the fishermen. The largest noted were about 10 inches in length.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17039	1017	Santa Barbara	July, 1875	Dr. H. C. Yarrow	1

SERRANIDÆ.

PARALABRAX CLATHRATUS Grd.

Color brown above, with a purplish shade; below, dull whitish. A series of dark blotches along the sides and back.

Abundant near the islands in Santa Barbara Channel, where generally found in close proximity to the rocks. We had no difficulty in getting them to take the hook when baited with mussel or shellfish. Our slender supply of hooks and lines was, however, entirely exhausted in vain attempts to land one of these large and voracious fish, their strength proving equal to every emergency.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17037	946	Santa Cruz Island	June, 1875	H. W. Henshaw	6
17038	C	Santa Barbara	July, 1875	Dr. H. C. Yarrow	7

SPHYRÆNIDÆ.

SPHYRÆNA ARGENTEA Grd.

Color bluish-black above; white on sides; beneath, yellowish with a dark lateral line: silvery reflections. Abundant near Santa Barbara and to the southward. Are generally taken in nets or by trolling. Eaten by the poorer classes.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17035	1076 D	Santa Barbara	July, 1875	Dr. H. C. Yarrow	2
17036	1020 B	......do	....do	Yarrow & Schumacher	1

ATHERINIDÆ.

CHIROSTOMA CALIFORNIENSIS (Grd.) Gill.—California Smelt.

This beautiful species is extremely abundant in the vicinity of Santa Barbara, and, in fact, all along the coast. Great numbers are taken by the fishermen in nets and also by hook and line, immense hauls being sometimes made by the former method. They frequent the sandy and muddy bays from February to October, April being about the height of the season. They bite ravenously at any kind of bait, worms, mussels, &c. Specimens are occasionally taken weighing two pounds. They swim, in enormous schools, about 3 feet below the surface of the water.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17015	1020 A	Santa Barbara	July, 1875	Dr. H. C. Yarrow	3
17016	1019	......do	....do	H. W. Henshaw	4
17017	1076 G	......do	....do	......do	1
17018	1076 B	......do	....do	Dr. H. C. Yarrow	2
17019	945 A	Santa Cruz Island	June	......do	1
17020	....	Santa Barbara	July	......do	1

OXYJULIS MODESTUS (Grd.) Gill.

Color reddish-brown, lighter on the sides, yellowish-white beneath; a black spot at base of dorsal rays and a similar blotch at base of caudal fin.

Common along the coast; many are taken at Santa Barbara, inside the kelp, with hook and line and nets. Some specimens secured are much larger than any noticed by Girard.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17024	1076 A	Santa Barbara	July, 1875	Dr. H. C. Yarrow	1
17025	1076 C	......do	....do	......do	7
17026	1020 E	......do	....do		1
17027	1012	......do	....do	Dr. H. C. Yarrow	50

EMBIOTOCIDÆ.

The viviparous or Sapphire Perch, so called, are very numerously represented all along the Pacific coast, 15 or 16 distinct species being recognized. Most of them will take almost any kind of bait readily, but the smaller species bite the best.

EMBIOTOCA JACKSONI Agass.

Color dusky-brown above, with patches of rufous or yellowish-brown beneath.

Many are taken at the Santa Barbara wharf, in company with others of the genus.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17047	1018 B	Santa Barbara	July, 1875	Yarrow & Henshaw	1
17048	1814 B	......do	....do	Dr. H. C. Yarrow	2
17049	1076 C	......do	....do	......do	1
17050	988 A	......do	....do	......do	1

TÆNIOTOCA LATERALIS (Agass.) A. Agass.

A single specimen secured, thought to be of this species.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17051	....	Santa Cruz Island	July, 1875	H. W. Henshaw	1

CYMATOGASTER AGGREGATUS Gibbons.

This species, formerly known as *Holconotus rhodoterus* Girard, is by far the most abundant of the viviparous perches near Santa Barbara, and we have taken hundreds off the wharf at that place with the hook baited with lobster. It struck us as very peculiar that nearly all the individuals taken were females gravid with young, which at this time (July) appeared to have almost reached maturity. Upon gently squeezing the abdomen of fish just taken from the water, the genital sac escaped, and through the transparent membrane the young fish could be seen. Some of the sacs were cut open, and the young thrown into the sea, when they immediately swam away pursued by other species. This rather rude obstetrical operation did not seem to affect the general condition of the mother, who also swam briskly away when thrown into the water. The number of young in the pouch varies from 8 to 20. The genital orifice is behind the anus. As food, the viviparous perch may be compared in respect to flavor to the ordinary white perch of the Eastern waters, but the flesh is less fine and a trifle strong in flavor.

Color above varies from silvery gray to bluish gray, with transverse golden bars on the belly. It is generally supposed to arrive off the coast in May.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17028	1014	Santa Barbara	July, 1875	Dr. H. C. Yarrow	1
17029	745	Santa Cruz Island	June, 1875	H. W. Henshaw	3
17030	1073 B	Santa Barbara	July, 1875	Dr. H. C. Yarrow	8
17031	1076	......do	....do	......do	50
17032	1011	......do	....do	......do	45
17033	A	......do	....do	......do	1
17034	981 A	......do	....do	......do	75
17061	1073	......do	....do	......do	10

HYPERPROSOPON ARGENTEUS Gibbons.

Color ashy-brown above; sides and abdomen dull yellowish-white; fins yellow at bases, grayish near extremities.

Is generally found on the coast to the north of San Francisco. Is tolerably abundant. Our specimens were purchased of fishermen, and we are unable to say if this species will take the hook.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17052	B	Santa Barbara	July, 1875	Dr. H. C. Yarrow	1
17053	1076 H	......do	....do	......do	2

HOLCONOTUS RHODOTERUS Agass.

Color greenish-brown above, silvery on sides; obscure bars or band along sides.

Two specimens were procured from fishermen. Like the preceding, this fish is found farther to the north.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17054	1020 C	Santa Barbara	July, 1875	Yarrow & Henshaw	2

AMPHISTICHUS ARGENTEUS Agass.

Color olivaceous, presenting a somewhat mottled appearance; sides silvery; indistinct bars on the flanks. Resembles the preceding species, but differs in conformation of the lower lip, which is united, not free.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17055	1014 B	Santa Barbara	July, 1875	Dr. H. C. Yarrow	2

GALEORHINIDÆ.

TRIACIS SEMIFASCIATUS Grd.

Representatives of this family were quite numerous at Prisoner's Harbor, Santa Cruz Island, being attracted inshore by the numerous carcases of sheep killed and thrown into the water. Young only were secured by the seine.

Smith. No.	Orig. No.	Locality.	Date.	Collector.	No. of specs.
17045	1076 C	Santa Barbara	July, 1875	Dr. H. C. Yarrow	1

Lieut. GEORGE M. WHEELER,
Corps of Engineers, in charge.

APPENDIX L.

REPORT UPON THE REPTILES AND BATRACHIANS COLLECTED DURING THE YEARS OF 1875, 1876, AND 1877, IN CALIFORNIA, ARIZONA, AND NEVADA, BY DR. H. C. YARROW, ACTING ASSISTANT SURGEON, U. S. A., AND H. W. HENSHAW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 30, 1878.

SIR: The collection of Reptiles and Batrachians upon which the following report is based was made in California, Arizona, and Nevada during the years 1875, 1876, and 1877, and, while not embracing a large number of species, has seemed of sufficient value and interest to render a brief paper necessary, which it is hoped may prove a slight contribution to our herpetological knowledge. Although no new species are described, and more or less of the forms have been collected in previous years by the expedition, yet quite a number of those enumerated have been secured by the collectors of the different parties for the first time in the history of the survey.

It will be found that some few facts have been noted regarding certain species, their habits and geographical distribution, that are new at least to us, and may be to others; they are given for what they are worth. With much diffidence, and we trust with becoming respect, we have deemed it proper to differ in some particulars with the fathers of American herpetology, Holbrook, Baird, Girard, and Cope, and earnestly hope that we have been able to conclusively show our reasons therefor; if we have erred we can at least claim the merit of having written according to our conscientious convictions and after a thorough and careful consideration of the many specimens in the suite of reptiles in the National Museum.

In going over several of the genera, especially of Serpents, we have followed the example of Professor Cope, and seen fit to reduce the number of species, and we earnestly believe with him that if more attention were paid to examining certain forms showing aberrant tendencies, instead of constantly striving to establish new species, better results and more philosophical would be the consequence. From this statement it is not to be inferred for a moment that we are inclined to throw doubts upon the very excellent herpetological work of earlier authors; for it is to be remembered that, at the time when many of the species were described, for instance, by Baird and Girard, in many instances only single specimens were available for study; hence no comparisons could be made, and perhaps individual peculiarities were mistaken for constant traits. As collections have increased year by year under the fostering hand of the general government, opportunities for study have correspondingly advanced, and we are now in better condition to determine generic and specific differences.

As matters of special interest in this paper, attention is invited to the notes regarding the genera *Pityophis*, *Bascanium*, and *Eutaenia*, and with regard to *Sceloporus*, as also some facts in connection with the *Phrynosomæ*, or "Horned Toads," so called. An item of interest is the occurrence, far to the eastward, of *Charina plumbea*, a curious serpent.

While it cannot be pretended that the synonymical lists are complete, it was intended that they should be so to the extent of the means at our disposal, and we believe all the more important references will be found therein contained.

A list of specimens follows each species, as well to indicate the exact locality whence obtained as to show by whom collected.

We are indebted to Prof. S. F. Baird, Prof. E. D. Cope, and to Mr. S. C. Brown of the Smithsonian Institution, for favors received while studying the collection, and to the assistants of the expedition who have contributed specimens to it.

Very respectfully, your obedient servants,

H. C. YARROW.
H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

ANURA.

BUFONIFORMIA.

BUFONIDÆ.

BUFO COPEI sp. nov. nobis.

Head subtriangular, broader than long; snout acuminate, protruding; head with well-marked groove, which extends to tip of snout; superciliary ridges strongly pronounced and terminating posteriorly in a slight knob; orbit bordered posteriorly by a similar ridge; upper jaw slightly emarginated; parotids medium, elongated, twice as long as broad, perforated by numerous small pores, situated well back on the shoulders; not approximated to the tympanum, which is circular and large; limbs long and comparatively slender; palm rugose; a single well-developed tubercle; first, second, and fourth fingers about equal in length, the third longest; hind limbs rather longer than head and body together; tarsus and metatarsus with small and smooth tubercles; body above covered with small and somewhat roughened tubercles; under parts finely papillated; metatarsal shovel large.

Colors.—A broad, median, yellowish-white stripe passes from the snout to anus, on either side of which are stripes and spots of the same varied with black; sides also conspicuously striped or barred; under parts densely maculated with irregularly shaped blotches and spots of black upon a ground-color of yellowish-white; the head and upper jaw are also variously barred; limbs marked transversely with black.

Habitat.—Hudson's Bay; James Bay.

This is the most brightly colored species of the genus inhabiting our territory, and presents, by reason of the contrasted tints, a very marked appearance. This is apparent in the alcoholic specimens, and in life the colors must be still more striking. Slight comparison only is necessary to show its distinctness from any other of our species. From *columbiensis*, the only other species recognized from the same region, it is to be distinguished not only by its very different pattern of coloration, but also by the presence of the well-developed temporal ridges, these being slightly indicated or entirely wanting in that animal; added to this are the shape of the head, the shape and position of the parotids, the somewhat slenderer limbs, the fewer and different tubercles, &c.

The development of the superciliary ridges seems to place the species near *lentiginosus*, from either of the five varieties of which it differs very decidedly.

A large number of specimens collected by Kennerly in the neighborhood of Hudson's Bay are in the Smithsonian collection. The extreme size attained by the species is probably represented, and there are many immature individuals. The largest specimens measure about three inches in length and five and one-half inches from tip of nose to end of outstretched hind leg. This extreme is much less than that attained by the *B. columbiensis* from the Columbia River region.

The occurrence of this highly colored Batrachian at a locality so far to the north as Hudson's Bay seems an apparent contradiction to the general law which is susceptible of such extensive application throughout the animal kingdom, under which the most brightly colored species of a family are of southern distribution and present marked contrasts to their more somberly tinted relatives of northern climes. In this instance the case is reversed, for all the other members of this family in the United States are uniformly dull-colored, and in no respect approach the bright tints of the present species.

One other equally marked exception to this law which we recall may be cited, the *Carabus vietinghovii*, a most highly colored beetle inhabiting the region of Hudson's Bay.

It is possible that in some comparatively restricted area in this high latitude not yet determined, there exist some climatic peculiarities which are the direct cause of this brilliancy of color in the two instances cited, and which may be of wider applicability than at present suspected; other species affected in a similar way may remain to be detected.

In this connection may be mentioned a similar tendency shown in several species of birds, which are mainly restricted to the Hudson's Bay region; thus the *Ægiothus linaria*, the *Bubo virginianus*, and the *Falco sacer* are each represented here by a darker, more richly colored race. These species doubtless inhabit such portions of this region only as are heavily timbered, and as a matter of course subject to considerable moisture. The changes brought about indicate conditions similar to those obtaining in the densely timbered coast regions of the Northwest.

Doubtless much of the brightness of tint seen in our Batrachian is the result of the extreme heat which prevails here during the very short summer, added to the effects of the local moisture.*

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* To this cause Lieutenant Carpenter attributes the bright colors of the *Carabus*. See Annual Report of this Survey, 1875, p. 302.

We take great pleasure in dedicating this species to Prof. E. D. Cope, whose labors have done so much toward advancing the science of herpetology.

BUFO HALOPHILUS Baird.

Bufo halophila Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1853, 301.—Bd. & Gd., U. S. and Mex. Bound. Surv. ii, Rept. 1859, 26, pl. 41, figs. 7–12.
Bufo halophilus Cope, Check-List N. A. Batr. and Rept. 1875, 27.

This appears to be the common toad of much of the west coast. In general appearance it much resembles the *B. columbiensis* of the Columbia River region and Montana, from which, however, it seems to be perfectly distinct. The numerous warty excrescenses on the upper parts of the latter are large and rough, and have much the same appearance and structure as the parotids. The second forefinger is considerably longer than the inner, just the reverse of which is true of *halophilus*, in which also the warts are smaller and smoother as well as less numerous.

Most of our specimens were obtained in midsummer from pools of water, and are nearly all very young. As is usual in this family, they are much spotted below, instead of being nearly or quite unicolored, as are the adults. This species was found to be very numerous about Lake Tahoe, and also near Virginia City, Nev., as well as along the California coast. Its range is thus extended across the mountains and east of the Sierra Nevada.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8691	Santa Barbara, Cal	1875	Dr. H. C. Yarrow	1
8693	Lake Tahoe	1875	H. W. Henshaw	1
8695	Virginia City, Nev	1875	......do	1
8698	Fort Tejon, Cal	1875	......do	1
8678	Santa Barbara, Cal	1875	......do	30
8699	......do	1875	Dr. H. C. Yarrow	3
8696	Lake Tahoe	1876	H. W. Henshaw	7
8681	......do	1876	......do	27

ARCIFERA.

HYLIDÆ.

HYLA.

HYLA REGILLA Baird.

Hyla regilla Bd. & Gd., Proc. Acad. Nat. Sci. Phila. vi, 1852, 174; 1853, 301.—Gd., Herp. U. S. Expl. Exped. 1858, 60.—Coop. & Suckl., Nat. Hist. Wash. Terr. 1859, 304.—Bd., P. R. R. Rep. x, 1859, 12, pl. 28, fig. 3.
Hyla scapularis Hallow., Proc. Acad. Nat. Sci. Phila. vi, 1852, 183.—Hallow., P. R. R. Rep. vol. x, 1859, 21.

A large suite of specimens of this species was secured in California, where it appears to be the prevailing form. In June, vast numbers of the young, in all stages, from the tadpole to the fully developed *Hyla*, were found in a stagnant pool upon Santa Cruz Island. At this season, they appear, young and old, to spend most of the time in the water. The variations in color to be observed here were quite remarkable, specimens exhibiting all the shades of green and brown to black, no two in fact appearing exactly comparable. Immersion in alcohol soon destroys the tints and they become more uniform. The exact configuration of markings varies also very much.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8682	Lake Tahoe	1876	H. W. Henshaw	24
8680	Santa Barbara, Cal	1875	....do	6
8686	Santa Cruz Island, Cal	1875	....do	40
8688	Santa Barbara, Cal	1875	....do	25
8692	Lake Tahoe	1876	....do	1
8701	Santa Barbara, Cal	1875	....do	7
8702	Mount Whitney, Cal	1875	....do	1
8703	Fort Tejon, Cal	1875	....do	4
8704	Los Angeles, Cal	1875	William Somers	1
8697	Fort Tejon, Cal	1875	H. W. Henshaw	1
9499	Lake Tahoe	1876	....do	7
9500	Southern California	1875	....do	1

HYLA ARENICOLOR Cope.

Hyla affinis Bd., Proc. Acad. Nat. Sci. Phila. 1854, 61 (not of Spix); *id.*, U. S. and Mex. Bound. Surv. Rep. ii, 1859, 29, pl. 28, figs. 4–7.
Hyla arenicolor Cope, Journ. Acad. Nat. Sci. Phila. 1866, 84; *id.*, Proc. Acad. Nat. Sci. Phila. 301; *id.*, Check-List N. A. Batrach. and Rept. 1875, 31.—Yarrow, vol. v, Zool., U. S. Geog. Surv. W. 100th M. 1875, 524.—Coues, *ib.* p. 630.

Apparently rare, as but a single specimen was secured.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8694	Southern California	1875	H. W. Henshaw	2

SCAPHIOPIDÆ.

SPEA.

SPEA STAGNALIS Cope.

Spea stagnalis Cope, *apud* Yarrow, vol. v, Zool., U. S. Geog. Surv. W. 100th M. 1875, 525.

Described by Professor Cope, as above cited, from New Mexico. A single *Spea*, secured at Santa Barbara in 1875, has been identified by Professor Cope as of this species, thus extending its range widely.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8699	Santa Barbara, Cal	1875	Dr. H. C. Yarrow	1

RANIFORMIA.

RANIDÆ.

RANA.

RANA TEMPORARIA AURORA (Bd.) Cope.

a. TEMPORARIA.

Rana temporaria Linn., Syst. Nat. ed. 10, p. 213, No. 13.—Shaw, Gen. Zool. vol. 3, p. 97, pl. 29.—Latr., Hist. Rep. t. 2, 150.—Daud., Hist. Rain. Gren. Crap. 16, pl. 15.—Cuv., Règne Anim. 2e éd. 96; t. 2, 105; et auctor.

b. AURORA.

Rana aurora Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 174.—Gd., Herp. U. S. Expl. Exped. 1858, 18, pl. 2, figs. 1–6.—Cope, Check-List N. A. Batrach. and Rept. 1875, 32.

Abundant in California.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8676	Santa Barbara, Cal	1875	H. W. Henshaw	1
8689	......do	1875	....do	1
8700	Fort Tejon, Cal	1875	....do	3

RANA PRETIOSA Bd.

Rana pretiosa Bd. & Gd., Proc. Acad. Nat. Sci. Phila. vi, 1853, 378.—Gd., Herp. U. S. Expl. Exped. vol. 20, 1858, pl. ii, figs. 13-18.—Cope, Check-List N. A. Batrach. and Rept. 1875, 32.

We assign provisionally a number of specimens to this form, their resemblance being closer than to any other with which we are acquainted. Our specimens are very dark in color (coming from a black, muddy, marshy pool in the mountains), and are of a yellowish-white on the under surface of the abdomen and legs.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8683	Southern California	1875	H. W. Henshaw	15
8684	......do	1875	....do	4
8685	Lake Tahoe	1876	....do	13
8687	Kern River, Cal.	1875	....do	6
8705	Lake Tahoe	1876	....do	1

OPHIDIA.

SOLENOGLYPHA.

CROTALIDÆ.

CROTALUS PYRRHUS Cope.

Caudisona pyrrha Cope, Proc. Acad. Nat. Sci. Phila. 1866, 308, 310.—Coues, vol. v, Zoology, U. S. Geog. Surv. W. 100th Meridian, 1875, 535, pl. 22.
Crotalus pyrrhus Cope, Check-List N. A. Rept. and Batrach. 1875, 33.—Streets, Bull. Nat. Mus. No. 7, 1877, pp. 39, 41.

Since 1866, when this species was first described by Professor Cope from a skin collected near Fort Whipple, Ariz., by Dr. E. Coues, U. S. A., two additional specimens have been secured, one by Dr. Thomas H. Streets, U. S. N., on Angel Island, Gulf of California; the other, a head only, from the Mojave Desert, Arizona, by Dr. O. Loew, late of this expedition. The specimen collected by Dr. Streets resembles greatly the colored plate in vol. v, Zoology, of this expedition, and is 3½ feet long. This gentleman informs the authors that on Angel Island the species is very numerous, but, being unrecognized at the time, only a single individual was secured.

Dr. Loew's specimen, No. 8666 (Nat. Mus. Reserve Series), is a small head, which corresponds entirely to the description given by Professor Cope. The colors, however, are faded and not distinctive. The habitat of this well-marked species is given as Central Arizona. It is probable, however, that the species is found generally dispersed along our southwestern border, and that it is by no means as rare as the few specimens secured would seem to indicate.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8669	Mojave Desert, Arizona	1875	Dr. O. Loew	1

CROTALUS CONFLUENTUS Say.

Crotalus confluentus Say, Long's Exp. Rocky Mts. ii, 1823, 48.—Baird & Girard, Cat. N. A. Rept. pt. 1, Serp., 1853, 8.—Bd. & Gd., Expd. Red River, La. 1853, 217, pl. 1.—Duméril & Bibron, Erp. Gen. t. vii, 1854, 1475.—Bd., P. R. R. Rep. x, 1859, 40; *id.*, U. S. and Mex. Bound. Surv. ii, Rept. 1859, 14.—Coop. & Suckl., Nat. Hist. Wash. Terr. 1869, 295.—Cope, Check-List N. A. Rept. and Batrach. 1875, 33.—Yarrow, vol. v, Zoology U. S. Geog. Surv. W. 100th Meridian, 530.—Coues & Yarrow, Bull. U. S. Geol. Surv. vol. iv, No. 1, 262.
Crotalus confluentis (sic) Harlan, Med. and Phys. Res. 1835, p. 135.
Caudisona confluenta Cope, App. Mitchell's Res. 1861, 122; *id.*, Proc. Acad. Nat. Sci. Phila. 1866, 307.—Allen, Proc. Bost. Soc. Nat. Hist. xvii, 1874, 307, 309.—Coues, vol. v, Zoology, U. S. Geog Surv. W. 100th Meridian, 604.

Crotalus lecontei Hallow., Proc. Acad. Nat. Sci. Phila. vi, 1851, 180; *id.*, Sitgreaves's Exp. Zuñi and Col. Riv. 1853, 139; *id.*, P. R. R. Rep. x, 1859, 18, pl. 3.—Heerm., P. R. R. Rep. x, 1859, 25.
Caudisona lecontei Cope, App. Mitchell's Res. 1861, 121.—Hayd., Trans. Am. Phil. Soc. xii, 1862, 177.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 307.
Caudisona confluenta var. *lecontei* Cope, Proc. Acad. Nat. Sci. Phila. 1866, 307.
Crotalus cineroeus (*sic*) Lec. *apud* Hallow., Sitgreaves's Exp. Zuñi and Col. Riv. 1853, 140.

An examination of specimens collected by the expedition shows clearly that but little dependence can be placed upon coloration as a specific character for this species, age as well as difference of locality being added to variations of a purely individual character to complicate the matter. The bright bands on the head differ greatly in different individuals as to distinctness of definition and depth of tint. The dorsal blotches also vary much, and are always more distinct in young individuals. In one specimen, No. 8598, Kern River, California, are seen tolerably large dorsal blotches, dentate posteriorly, and with, for the most part, quadruple serrations anteriorly. The spots are brownish-black on edges, the centers a light chestnut. Beneath each blotch on either side is a double series of deep chestnut spots, the last reaching the edges of the gastrogeges; toward the tail these spots coalesce and form irregular bands reaching to edge of ventral scales, with a series of spots between them. Each ventral scale is maculated posteriorly, the color fading toward head; 5 irregular blackish half bands on tail from anus to rattle. Superior labials 16 on right side, 15 on left; 27 rows of scales.

In larger and older specimens the dorsal blotches are lighter in color, the margins not so well defined, and the lateral rows of spots are very incomplete and almost obsolete. In one specimen, No. 9519, there are 18 superior labials on both sides, with 25 rows of scales; in another from same locality, No. 9519, there are 15 superior labials on left side, 16 on right, 25 rows of scales. In one the orbit is separated from the superior labials by 5 scales, in another by 4. Remarks on similar discrepancies between individuals of this species, often from the same locality, might be multiplied almost indefinitely.

The large island in Pyramid Lake, Nevada, is noted for the vast number of these reptiles residing there, and during the warm months they are so numerous that it is absolutely dangerous to walk about those parts of the island where they are colonized without exercising the greatest caution. In New Mexico, also, this species has been found to be very numerous by the expedition. In 1876, Lieut. C. M. Morrison encountered a colony of rattlesnakes, presumably of this species, under circumstances of interest, as giving us a clew to certain of their habits. The locality was a hill, appropriately named Rattlesnake Hill, in the southern part of the Territory. He places the number of rattlers seen during a day spent in occupying the summit as a topographical station as from 300 to 500, no fewer than 79 of the reptiles being killed in a little over an hour by the party of three. Toward sunset numbers were observed making their way in toward the rocks from the south, where perhaps they had been in search of food. Or it may be that the place was used by them for winterquarters, and those noticed on their way in were *en route* to join the company prior to the winter hibernation. This latter assumption is favored by the late date, October 5.* Mr. Morrison informs us that eggs were extruded from the bodies of several of the females as they were crushed with stones, and that by this means he was able to identify the sex and to note a very great discrepancy between the shape of the bodies of the females and males, those of the former being very much flattened. A statement of a similar colony is to be found in Kendall's Santa Fé Expedition, vol. 1, p. 160.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8598	Kern River, California	1875	H. W. Henshaw	1
9519	Pyramid Lake, Nevada	1877	....do	2

ASINEA.

COLUBRIDÆ.

OPHIBOLUS.

OPHIBOLUS GETULUS BOYLII (Linn.) Baird & Girard.

Ophibolus boylii Baird & Girard, Cat. N. A. Rept. pt. i, Serp., 1853, 82.—Bd., P. R. R. Rep. x, 1859, 2; *id.*, U. S. and Mex. Bound. Surv. ii, Rept. 1859, 20.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 315.
Lampropeltis boylii Cope, Proc. Acad. Nat. Sci. Phila. 1860, 255.

* This is a noteworthy fact, as midsummer has usually been supposed to be the reproductive season of these serpents.

Coronella balteata Hallow., Proc. Acad. Nat. Sci. Phila. 1853, 236; *id.*, P. R. R. Rep. x, 1859, 14.
Ophibolus getulus subspecies *boylii* Cope, Check-List N. A. Rept. and Batrach. 1875, 37.—Yarrow, vol. v, Zool., U. S. Geog. Surv. W. 100th meridian, 1875, 538.
Ophibolus getulus boylii Coues & Yarrow, Bull. U. S. Geolog. Surv. Terr. 1878, 283.
Ophibolus conjunctus Cope, Proc. Acad. Nat. Sci. Phila. 1861, 301.
Ophibolus getulus subspecies *conjunctus* Cope, Check-List N. A. Rept. and Bat. 1875, 37.

In specimen No. 8577, from Santa Barbara, Cal., the number of broad, white, transverse bands is 34; Baird and Girard state them to be 37. These bands on the top of the dorsum occupy 1½ or 2 entire scales, gradually widening to 3 or 3½ as they reach the ventrals. In young specimens the colors are very dark, and in some there are two small red spots between the occipital plates. In older and living specimens the dark sides and belly are of a lustrous greenish-black bronze, the white bands of a beautiful ivory-white.

Habitat.—Pacific Sonoran regions.

A careful comparison has been made between *O. getulus boylii* and *O. getulus conjunctus*, and while we consider the latter a well-marked variety of *boylii* we cannot admit the very slight characters brought forward by Professor Cope in his very meager notice of *conjunctus* to be distinctive of a separate race. Even admitting the fact that the margins of the scales in the white cross-bands are black-bordered, which is the principal, indeed the only, character given by Professor Cope as distinguishing this form, we consider this to be quite insufficient. As a matter of fact, specimens from Cape Saint Lucas, the habitat of this supposed variety, show considerable variation in this respect, and in some the dark margins are so slight that they may properly be referred to *boylii*. Specimens of the latter from typical localities also occasionally have the white scales margined slightly with black, which color is often found at their bases.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8577	Santa Barbara, California	1875	L. Shumacher	2

PITYOPHIS.

PITYOPHIS SAYI BELLONA (Baird & Girard) Cope.

a. SAYI.

Coluber melanoleucus var. *sayi* Harlan, Journ. Acad. Nat. Sci. Phila. v, 1827, 360; *id.*, Med. and Phys. Res. 1835, 123.
Coluber sayi Schl., Ess. Physiogn. Serp. 1837, 157. (Not *Coronella sayi* of Holbrook, or *Coluber sayi* of DeKay, which is *Ophibolus*.)
Pituophis sayi Bd. & Gir., App. Cat. N. A. Rept. 1853, 152 (in text under *Coluber sayi*, p. 151).—Kenn. *apud* Coop. & Suckl., Nat. Hist. Wash. Terr. 1860, 300, pl. 22.—Hayd., Trans. Amer. Phil. Soc. xii, 1862, 177.

b. BELLONA.

Churchillia bellona Bd. & Gir., Stansbury's Rep. Great Salt Lake 1852, 350.
Pituophis bellona Bd. & Gir., Cat. N. Am. Rept. 1853, 66, 157.—Günther *apud* Gray, Cat. Col. Snakes, 1858, 87.
Pityophis bellona Kenn. *apud* Bd., P. R. R. Rep. x, 1859, Williamson's Route, Reptiles, 42.—Kenn. *apud* Bd., U. S. Mex. B. Surv. ii, pt. ii, 1859, Reptiles, 18.—Bd., U. S. P. R. R. Rep. x, 1859, Beckwith's Route, Reptiles, 19.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 305.—Allen, Proc. Bost. Soc. Nat. Hist. xvii, 1874, 69.
Pityophis sayi var. *bellona* Cope, Check-List Bat. and Rep. N. A. 1875, 39.—Streets, Bull. U. S. Nat. Mus. No. 7, 1877, 40.
Pituophis affinis Hallow., Proc. Acad. Nat. Sci. Phila. vi, 1852, 181.—Hallow., Sitgr. Rep. Expl. Zuñi and Colorado R. 1853, 130, 146.
Pityophis sayi subsp. *bellona* Yarrow, vol. v, Zoology, U. S. Geog. Survs. W. 100th M. 1875, 540.
Pityophis sayi bellona Coues, vol. v, Zoology, U. S. Geog. Survs. W. 100th M. 617.—Coues & Yarrow, Bull. U. S. Geol. Surv. Terr. 1878, 282.
Pityophis mexicanus Dum. & Bib., Erp. Gén. vii, 1854, 236.—Günther *apud* Gray, Cat. Col. Snakes, 1858, 87.
Pityophis sayi subsp. *mexicanus* Cope, Check-List N. A. Batr. and Rept. 1875, 39.—Yarrow, vol. v, Zoology, U. S. Geog. Survs. W. 100th M. 539.
Coluber catenifer Blainv., Nouv. Ann. Mus. Hist. Nat. iii, 1834, pl. xxvi, figs. 2, 2 *a*, 2 *b*.
Pituophis catenifer Bd. & Gd., Cat. N. A. Batr. and Rept. 1853, 69.—Günther *apud* Gray, Cat. Col. Snakes, 1858, 87.—Gd., U. S. Expl. Exp. 1858, 135.
Pityophis catenifer Cope, Check-List N. A. Batr. and Rept. 1875, 39.
Pituophis wilkesii Bd. & Gd., Cat. N. A. Rept. i, 1853, 71.—Gd., U. S. Expl. Exped. Herp. 1858, 137, pl. ix, figs. 1, 7.—Coop. & Suckl., Nat. Hist. Wash. Terr. 1859, 300.

A thorough examination of the series of specimens each of *P. sayi bellona*, *mexicanus*, and *catenifer* leaves no doubt in our minds of the propriety of uniting these three as one form under Baird & Girard's name of *bellona*, thus leaving but two varieties, the one (*sayi*) inhabiting the Eastern region, the other (*bellona*) occupying the West generally. The characters given as distinguishing *catenifer* and *mexicanus* from the latter, of which they are supposed to be Southern varieties, appear to us too slight to warrant their separation, and to come quite within the range of individual variation. The scale-formula for the head varies greatly in this serpent (*bellona*), the upper labials in individuals of the same so-called species or varieties presenting a difference in number which has been given as indicating one or the other of these forms. The dorsal scales vary similarly in number, and no dependence, as a diagnostic feature, can be placed upon the number of carinated or smooth scales. Starting with the idea that each of these forms was peculiar to a more or less restricted region, we find individuals from the same locality presenting characters belonging to the three. Some specimens referrible to *catenifer* as regards coloration if casually examined are really, taking all the characters into account, nearest to *bellona*. It may be stated that Baird and Girard mention as one of the specific points of *P. catenifer* that the four outer rows of dorsal scales are smooth. The type-specimen was from San Francisco, and as examined by us presents seven rows of smooth scales, the upper labials on one side being nine, on the other eight. It is to be noticed, however, that the number of smooth scales varies in different portions of the body, a fact apparently not recognized by these authors, the number of carinated scales decreasing toward the tail. Thus in this type it is true that near the tail there are but four rows of smooth scales, but toward the upper part of the body, near the neck, the number increases to seven or eight. This statement applies equally to the other two forms.

This beautiful and aberrant form was found to be tolerably common in California and Nevada, but none were seen approaching the great size (six feet two inches) of the specimens secured in Colorado in 1874. The Californians know this serpent as the Gopher or Bull Snake, and it is said to do good service in the destruction of their great pest, the Ground Squirrel, *Spermophilus beecheyi*.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8592	Santa Barbara, Cal	1875	H. W. Henshaw	1
8582	..........do	1875	....do	1
8590	Kernville, Cal	1875	....do	1
8670	..........do	1875	Dr. H. C. Yarrow	1
8591	Mojave Desert, Ariz	1875	Dr. O. Loew	1
8594	Southern California	1875	H. W. Henshaw	1
8593	Santa Barbara, Cal	1875	Dr. H. C. Yarrow	1
9521	Hovey Lake, Cal. (east slope)	1877	H. W. Henshaw	1

BASCANIUM.

BASCANIUM CONSTRICTOR FLAVIVENTRIS (L.) Cope.

a. CONSTRICTOR.

Coluber constrictor Linn., Syst. Nat. i, 1766, 385.—Gm., Linn. Syst. Nat. ed. xiii, i, iii, 1788, 1109.—Shaw, Gen. Zoology, 464.—Merr., Tent. 1820, 108.—Latreille, Hist. Nat. Rept. 1825, iv, 178.—Daudin, *ibid*, vi, 402.—Lac., Hist. Nat. Serps. t. ii, 309.—Fitzinger, Neu. Class. der Rept. 1826, 57.—Harl., Journ. Acad. Nat. Sci. Phila. v, 1827, 348: Med. and Phys. Res. 1835, 112.—Schl., Ess. Phys. Serp. Descr. 1837, 133, pl. iv, figs. 3, 4.—Storer, Rep. Rept. Mass. 1839, 225.—Holbr., N. A. Herp. iii, 1842, 55, pl. xi.—Thomps., Hist. of Vermont, 1842, 117.—DeKay, New York Fauna, Rept., 1842, 35, pl. x, fig. 20.
Natrix constrictor Merr., Syst. der Amphib. 1820, 108.
Hieropis constrictor Bon., Fn. Ital. ii, 1841.
Coryphodon constrictor Dum. & Bib., Erp. Gén. vii–i, 1854, 183.—Günther *apud* Gray, Cat. Coll. Snakes, 1858, 109.
Vipera nigra Catesb., Nat. Hist. Carolin. ii, 1743, 48, tab. xlviii.
Black snake, Kalm, Reise N. A. ii, 1764, 202.—Penn., Arct. Zool. Suppl. ii, 1792, 92.
Bascanion foxii Bd. & Gd., Cat. N. A. Rept. 1853, 96.
? *Bascanion fremontii* Bd. & Gd., Cat. N. A. Rept. 1853, 95.

b. FLAVIVENTRIS.

Coluber flaviventris Say, Long's Exp. Rocky Mts. ii, 1823, 185.
Bascanion flaviventris Bd. & Gd., Cat. N. A. Rept. 1853, 96.—Bd., U. S. & Mex. Bound. Surv. ii, Rept. 1858, 20.
Coryphodon flaviventris Hallow., Proc. Acad. Nat. Sci. Phila. 1856, 241.
Bascanion vetustus Bd. & Gd., Cat. N. A. Rept. 1853, 97.—Gd., Herp. U. S. Expl. Exp. 1858, 127, pl. viii, figs. 12, 19.—Cooper, P. R. R. Rept. xii, pt. ii, 1860, 301.
Bascanium constrictor subsp. *vetustum* Cope, Check-List N. A. Batrach. and Rept. 1875, 40.—Yarrow, vol. v, Zoology, U. S. Geog. Survs. W. 100th M. 1875, 541.

A critical study of the very large series of *Bascanium constrictor* in the Smithsonian reveals a very extensive geographical range for this species. Except in the single particular of color, a point to be adverted to presently, we find specimens from various parts of the far West, as Utah, New Mexico, California, Oregon, and elsewhere, that appear to be absolutely identical with others from the typical habitat of the species, the Eastern and Southern States. Taking the number of the superior labials, their relation to the eye and the relative position of the lower postorbital as guides, perhaps the most reliable given, we find that in these particulars Eastern specimens vary very much. Baird and Girard give the number of upper labials as 7, but frequently there are 8 (more rarely 6), and when this is the case the position of the center of the orbit with relation to the 4th upper labial no longer holds good, while the lower postorbital is found over the 5th, or between it and the 6th, instead of, as given, over the 4th; or it may occasionally be found over the 3d, there being in this case but 6 upper labials, or one less instead of one additional. Very frequently the number of superior labials varies on different sides of the same individual, there being in some specimens 6 and 7 respectively, in others 7 and 8, the position of the orbit and orbital plates, both interiorly and posteriorly, varying accordingly. Variations similar in character and degree are found in Western examples, both in those which have been considered and marked *B. constrictor* and in others labeled *vetustum*. The characters upon which the distinctions appear for the most part to have been made are the relations the orbit and orbital plates bear to certain of the maxillary shields, but, as stated above, these our examinations have shown to be utterly unreliable, some individuals indeed bearing upon one side the characters of one form, those of another on the opposite. For the same reasons, the characters given as distinguishing *flaviventris* and *vetustum* have no specific value *inter se*, being based upon individual variations. So far, then, as external individual characters go we are not able to find any firm basis upon which to separate Western and Eastern specimens.

Taking up the series now with reference to color alone, we find a quite marked and constant difference between Eastern and Western specimens. The dark coloration, pitchy-black above, greenish-black below, so characteristic of the snake as seen in the Eastern region, seems to be extremely rare or altogether wanting in the West, although, as nearly as we can judge from their very brief description, it was simply a black *B. constrictor* which was made the type of Baird and Girard's *B. fremontii*. If so, this specimen furnishes the only example we have of the occurrence of *constrictor* in its typical condition of color in the far West. It is more likely to have been an abnormally colored individual, as we have numerous specimens from California, the locality of the specimen in question, all of them corresponding in color to the usual Western type. This may be stated to be olive-brown above, beneath yellow. The precise shades vary much, the brown above having often a greenish tinge, the yellow below fading to a greenish-white. Considerable variation also obtains in Eastern examples, and some, especially after long immersion in alcohol, become decidedly brownish or bluish. Young individuals are also usually lighter than adults, Baird and Girard's *B. foxii* being founded upon immature specimens varying thus. Comparing the Eastern and Western series together, the difference is a very striking one, amply sufficient, we think, to justify the retention of a Western variety. Baird and Girard's *B. flaviventris* being evidently based upon a typically colored Western specimen, this name must be retained as the earliest. It is a matter of interest to note the fact that the black *B. constrictor* extends as far to the west as Kansas, and that from Kansas, also, we have specimens of the light-colored, yellow-bellied Western form, about here apparently occurring the division between the two races.

The constancy shown in this species in the number of dorsal scales is noteworthy, 17 being the invariable number found in every specimen examined irrespective of the region where obtained. The variety *flaviventris* is very numerous in many portions of the West, and is there universally distributed, but is perhaps most numerous in the near vicinity of the water-courses. Only one of the many seen was, however, brought in.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
9522	Honey Lake, California	1877	H. W. Henshaw	1

Bascanium flagelliforme piceum Cope.

?*Bascanium flagelliforme piceum* Cope, MS.
Bascanium flagelliforme subsp. *piceum* Cope, Cat. Bat. and Rept. N. A. 1875, p. 40.

A specimen consisting of the head and part of the body collected in Arizona has been doubtfully referred to this form, of which no description has yet appeared. So far as coloration goes, our specimen shows little difference from *B. testaceum*.

BASCANIUM TÆNIATUM LATERALE (Hallow.) Cope.

Bascanium tæniatum Hallow., subspecies *laterale* Hallow., Cope, Check-List N. A. Rep. and Batrach. 1875, 40.—Yarrow, vol. v, Zoology, U. S., Geog. Survs. W. 100th M. 1875, 543.

This beautiful and characteristic serpent is quite numerous in Southern California. Peculiarities of color seem tolerably constant in this variety.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8595	Fort Tejon, Cal	1875	H. W. Henshaw	....
8597	Santa Barbara, Cal	1875	....do	....

BASCANIUM TÆNIATUM TÆNIATUM (Hall.) Cope.

Leptophis tæniata Hallow., Proc. Acad. Nat. Sci, Phila. vi, 1852, 181.
Leptophis tæniatus Hallow., Sitgreaves's Exp. Zuñi and Col. Riv. 1853, 133-146.
Masticophis tæniatus Baird & Girard, Cat. N. A. Rep. pt. 1, Serp., 1853, 103.—Bd., P. R. R. Rep. x, 1859, 20, pl. ii; *id.*, P. R. R. Rep. 1859, x, p. —.—Coop. & Suckl., Nat. Hist. Wash. Terr. 1860, 302.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 305.
Drymobius tæniatus Cope, Proc. Acad. Nat. Sci. Phila. 1860, 561.
Masticophis schottii Baird & Girard, Cat. N. A. Rept. pt. 1, Serp., 1860, 163.—Bd., U. S. and Mex. Bound. Surv. ii, 1859, 20. (*Leptophis lateralis* Hallow., Proc. Acad. Nat. Sci. Phila. 1853, 237, and *Masticophis ornata* Baird & Girard, Cat. N. A. Serp., should probably be added to this list as a synonym.)

Found to be rather common in New Mexico, Nevada, and California. Coloration not so constant as in the preceding form. The *Masticophis schottii* Baird & Girard belongs here, being based upon a specimen found in Texas.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
9498	Walker's Basin, Cal	1875	H. W. Henshaw	1
9520	Carson City, Nev	1877	....do	1

EUTAENIA.

EUTAENIA HAMMONDII Kennicott.

Eutainia hammondii Kennicott, Proc. Acad. Nat. Sci. Phila. 1860, 332.—Cope, Check-List N. A. Batr. and Rept. 1875, 41.

We cannot consider the species of this genus as settled as yet upon any permanent basis, and, notwithstanding the large number of so-called species and subspecies at present admitted, the difficulties in the way of the identification of any large number of individuals, even from the same locality, are often very great. Individual variation seems to be carried to extreme limits in this group, and, as a result, it appears to be almost impossible to fix upon any set of characters which are sufficiently stable to permit specific limits to be trenchantly defined. It is possible, however, by means of an artificial key, such as the one according to Professor Cope, in Vol. V, Zoology, of this expedition, to relegate the majority of specimens to one or the other of the recognized forms, although if the results obtained by a strict application of the key be accepted, there arises much confusion as regards the geographical areas occupied by a number of the forms, there apparently being, in the light of its determinations, no systematic law governing their distribution.

But for the present we can do no better than accept the key provisionally as the best exponent of the genus yet given us, leaving to the future any attempt to better it. The determinations of the species of this genus mentioned in the present report have been made in accordance with it.

The above species is one characterized by having the lateral line on the 2d and 3d rows of scales, 21 rows of scales, and 8 superior labials. It belongs in the same section as *E. marciana*, *vagrans*, *angustirostris*, and resembles most nearly the latter, from which it appears to be distinguishable. We find the character "dorsal stripe weak or wanting" an unstable one, as some individuals, unquestionably referable here, have it well marked. The various species of *Eutaeniæ* are to some extent at least fish-eaters, and we have always found them most abundant about such small pools and streams as harbored minnows and the small fry of larger species. We once found a *Eutaenia* at Eagle Lake in the act of swallowing a good-sized minnow that he had just seized.

This species is found tolerably abundant in various portions of the Southwest.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8586	Southern California	1875	H. W. Henshaw	2
8604	Mojave Desert, California	1875	Dr. Loew	1
9525	Eagle Lake, California	1877	H. W. Henshaw	1

EUTAENIA MARCIANA Baird & Girard.

Eutaenia marciana Baird & Girard, Cat. N. A. Rept. pt. 1, Serp., 1853, 36; *id.*, Marcy's Exp. Red River, La. 1823, 221.—Bd., U. S. and Mex. Bound. Surv. ii, Reptiles, 1855, 17.—Bd., P. R. R. Rep. Whipp. Route, vol. x, 1859, 41.—Cope, Check-List N. A. Rept. and Batrach. 1875, 41.—Yarrow, vol. v, Zoology, U. S. Geog. Survs. W. 100th Meridian, 1875, 555.

Two specimens in the collection from Mojave Desert we refer to this species. They compare well with the characters given. This form resembles *hammondii* quite closely, but differs in the possession of distinct lateral spots. Our specimens possess no light dorsal lines, a character of much variability and of little diagnostic importance so far at least as this form is concerned.

Comparatively rare in California, except im the southern portion.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8578	Los Angeles, Cal	1876	William Somers	1
8584	Mojave Desert, Cal	1875	Dr. O. Loew	1

EUTAENIA ELEGANS Baird & Girard.

Eutainia elegans Bd. & Gd., Cat. of N. A. Rept. 1853, p. 34.—Bd., P. R. R. Rep. vol. x, Will. Route, 1857, 10.—Cope, Check-List N. A. Bat. and Rept. 1875, p. 41.
Tropidonotus trivittatus Hallow., Proc. Acad. Nat. Sci. 1853, 237; *id.*, P. R. R. Rep. vol. x, 1859, Will. Route, 13.

This species resemble somewhat *E. proxima.* The dorsal band is ochraceous yellowish-white, the lateral stripes greenish-white. According to Baird and Girard, the number of dorsal scales may vary from 19 to 21. This is illustrated in our specimens, in two of which there are 21 rows, in another but 19.

Quite numerous in Southern California and on the eastern slope between California and Nevada.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8579	Lake Tahoe, Nevada	1876	H. W. Henshaw	1
8587	Southern California	1875	....do	1
8580	......do	1875	....do	1
9565	Eastern California	1877	....do	1

EUTAENIA SIRTALIS PARIETALIS (Say) Cope.

a. SIRTALIS.

Coluber sirtalis Linn., Syst. Nat. i, 1766, 383.—Gm., Linn. Syst. Nat. ed. xiii, i, iii, 1788, 1107.—Latreille, Hist. Nat. Rept. t. iv, 1825, 69.—Harl., Journ. Acad. Nat. Sci. Phila. v, 1827, 352.—Shaw, Gen. Zool. vol. iii, pt. ii, 535.—Daudin, Hist. Nat. des Rept. t. vii, 146.—Storer, Rept. Mass. 1839, 221.
Natrix sirtalis Merrem, Syst. des Amphib. 1820, 132.
Tropidonotus sirtalis Holbrook, N. A. Herp. iv, 1842, 41, pl. xi.
Coluber bipunctatus Latreille, Hist. Nat. Rept. t. iv, 1825, pl. xxx, fig. 2.
Tropidonotus bipunctatus Schlegl., Ess. Phys. Serpt. 1837, 320.—Dum. et Bib., Erp. Gén. 1854, 582.
Tropidonotus taenia DeKay, N. J. Fauna Rept. 1842, 43, pl. 13, fig. 27.

b. PARIETALIS.

Coluber parietalis Say, Long's Exp. Rocky Mts. i, 1823, 186.—Harln., Journ. Phila. Acad. Nat. Sci. v, 1827, 349.
Eutainia parietalis Bd. & Gd., Cat. N. A. Rept. 1853, 28.
Eutænia sirtalis subsp. *parietalis* Cope, Check-List N. A. Batr. and Rept. 1875, 41.
Eutænia sirtalis parietalis Coues & Yarrow, Bull. U. S. Geol. Surv. Terr. 1878, 276.
Eutainia ornata Bd. & Gd., U. S. and Mex. Bound. Surv. ii, pt. ii, 1859, Reptiles, 16, pl. 9.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 305, 306.—Cope, Check-List N. A. Batr. and Rept. 1875, 41.—Coues, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 613.

Specimens of this snake, five in number, are all from California and Nevada, and answer well to the description of the species. It is worth noting that several of these specimens were found with *E. elegans* in the same hole under the roots of a dead stump. This would appear to indicate a rather closer companionship than usually obtains between reptiles of different species.

Along the shores of the large island in Pyramid Lake vast numbers of *Eutaeniæ* are found, comprising this and, in all probability, several other recognized varieties. During the heated part of the day, the mossy tracts in the tepid, shallow water of the little inlets were thronged with them, as they swam in gentle undulations over the smooth surface or idly basked on the heated rocks along shore. In no other locality have we ever seen them in such numbers. When disturbed, they swam boldly out into open water or sought the bottom and hid themselves under the rocks. Though not in the true sense of the word "water-snakes," the various *Eutaeniæ* are all thus quite aquatic in their habits, and in fact it has been our experience to rarely find them except in close proximity to river, pool, or marsh.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8585	Lake Tahoe, Nevada	1876	H. W. Henshaw	2
8588	......do	1876	......do	11
9564	Eastern California	1877	......do	....

BOIDÆ.

CHARINA.

CHARINA PLUMBEA (Bd. & Gd.) Cope.

Wenona plumbea Bd. & Gd., Cat. N. A. Rept. 1853, 139.
Charina plumbea Cope, Check-List N. A. Batr. and Rept. 1875, 43.
Wenona isabella Bd. & Gd., Cat. N. A. Rept. 1853, 140.

The single specimen in the collection is of interest as extending to a certainty the range of this West-coast species across the mountains to the eastern border of California. The habitat of this snake has been doubtfully given by Professor Cope as including Nevada, but upon what authority we do not know. That such is the case seems now extremely probable, as our specimen was procured but a few miles distant from that State.

This specimen is referable to the form described by Baird and Girard as the *Wenona isabella*. It has two pairs of frontals only, instead of three, as given for *plumbea*, but a slight tendency to the bifurcation of the anterior pairs shows the slight reliance attaching to this as a character. Certain other slight variations in the arrangement of the head and maxillary scales partake of the nature of individual variation. The reduction of this nominal species to a synonym of *plumbea* as per Cope's *op cit.* is, we believe, perfectly justifiable.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
9563	Eagle Lake, California	1877	H. W. Henshaw	1

SAURIA.

PLEURODONTA.

LEPTOGLOSSA.

SCINCIDÆ.

EUMECES.

EUMECES SKILTONIANUS Bd. & Girard.

Plestiodon skiltonianus Bd. & Gd., Stansbury's Rep. Grt. Salt Lake, 1852, 349, pl. iv, figs. 4–6; *id.*, Proc Acad. Nat. Sci. Phila. vi, 1852, 69.—Bd., P. R. R. Rep. vol. x, 1859, Rep. 18; *id.*, Will. and Abbott's Route, p. 9.
Eumeces quadrilineatus Hallow., Proc. Acad. Nat. Sci. Phila. vii, 1854, 94; *id.*, P. R. R. Rep. vol. x, Williamson's Route, 1859, 10.
Eumeces skiltonianus Cope, Check-List N. A. Batr. and Rept. 1875, 45.

Two specimens of this species are in the collection from Southern California, probably from near Los Angeles.

List of specimens.

No.	Location.	Date.	Collector.	No. of specs.
8627	Southern California	1875	H. W. Henshaw	2

TEIDÆ.

CNEMIDOPHORUS.

CNEMIDOPHORUS GRAHAMII Bd. & Gd.

Cnemidophorus grahamii Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 128.—Bd., U. S. Mex. Bound. Surv. ii, 1859, Rept. 10, pl. 32, figs. 1–6.—Cope, Check-List N. A. Batr. and Rept. 1875, 45.—Coues, vol. v, Zool., U. S. Geog. Survs. W. 100th M. 1875, 603.

A single specimen only of this species has been collected by the expedition; this in the neighborhood of Los Angeles, and we are of the opinion that it is somewhat rare here. The species has been taken at Fort Tejon.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8634	Los Angeles, California	1875	William Somers	2

CNEMIDOPHORUS SEX-LINEATUS (Linn.).

Lacerta sex-lineata Linn., Syst. Nat. t. i, 364.—Gmelin, Syst. Nat. Linn. t. iii, 1074.—Harlan, Med. and Phys. Res. 144.
Six-lined lizard, Shaw, Gen. Zool. vol. iii, pt. i, 240.
Ameiva sex-lineata Holbrook, N. A. Herp. ii, 1842, 109.—DeKay, Zool. N. York, 1842, 30.
Cnemidophorus sex-lineatus Dum. & Bib., Hist. Nat. des Rept. t. v, 131.—Cope, Check-List N. A. Batr. and Rept. 1875, 45.—Yarrow, vol. v, Zoology, U. S. Geog. Survs. W. 100th M. 1875, 557.
Cnemidophorus gularis Bd. & Gd., Proc. Acad. Nat. Sci. Phila. vi, 1852, 128.—Bd. & Gd., Marcy's Rep. Exp. Exped. Red Riv. 1852, 227, pl. x, figs. 1–4.—Bd., U. S. and Mex. Bound. Surv. ii, pt. ii, 1859, Reptiles, 11, pl. 34, figs. 1–6; *id.*, P. R. R. Rep. x, 1859, Whipple's Route, Reptiles, 38.
Cnemidophorus sexlineatus var. *gularis* Cope, Proc. Acad. Nat. Sci. Phila. 1866, 303.
Cnemidophorus sexlineatus gularis Coues, vol. v, Zoology, U. S. Geog. Survs. W. 100th M. 1875, 602.
Cnemidophorus guttatus Hallow., Proc. Acad. Nat. Sci. Phila. 1854, 192; *id.*, P. R. R. Rep. x, 1859, 23.

This is a species of widespread distribution, being found in the Sonoran and Austro-Riparian regions and extending to the east coast. There seems to be but little difference between specimens from eastern and western localities. The western are perhaps a trifle lighter in color. In one, No. 8761, from Arizona, the dark bands between the light are maculated with light spots, a peculiarity well shown in the young, but seldom seen in adults.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8630	Southern California	1875	J. Hasson	1
8631	Los Angeles, California	1875	W. Somers	1

CNEMIDOPHORUS TESSELLATUS TIGRIS (Bd. & Gd.).

a. TESSELLATUS.

Ameiva tessellata Say, Long's Exp. Rocky Mts. ii, 1823, 50.
Cnemidophorus tessellatus Bd., P. R. R. Rep. x, Gunnison's Route, 1857, 18.

b. TIGRIS.

Cnemidophorus tigris Bd. & Girard, Proc. Acad. Nat. Sci. Phila. 1852, 69.; *id.*, Stansb. Rep. Exp. Great Salt Lake, 1853, 338.—Bd., U. S. and Mex. Bound. Surv. ii, pt. ii, 1859, Reptiles, 10, pl. 33.
? *Cnemidophorus marmoratus* Bd. & Gir., Proc. Acad. Nat. Sci. Phila. 1852, 128.
? *Cnemidophorus undulatus* Hallow.,Proc. Acad. Nat. Sci. Phila. 1854, 94; *id.*, P. R. R. Rep. x, Williamson's Route, Reptiles, 8.
Cnemidophorus tessellatus subsp. *tigris* Cope, Check-List N. A. Batr. and Rept. 1875, 46.
Cnemidophorus tessellatus tigris Coues, vol. v, Zoology, U. S. Geog. Survs. W. 100th M. 1875, 604.

It is by no means improbable that the *Ameiva tessellata* of Say was based upon an accidental color-variety, and that *tigris* represents the normally colored form. In this case the two should, of course, be united. With no specimen, however, of *tessellatus* before us for comparison, we feel constrained to follow Cope in recognizing the two as distinct forms. Baird, in vol. x, P. R. R. Rep., Beckwith's Route, describes a lizard as being doubtfully the *A. tessellata* of Say, this, so far as we know, being the only specimen which has been referred to that form since Say's time.

Specimens of *tigris* in the Smithsonian collection show much variation in the arrangement of the spots and bands, their number, &c. In some individuals these approach the *tessellatus* type, as described; in others they are more nearly like the typical *tigris*. Some of the latter exhibit four or five well-marked light dorsal bands with dark interspaces; while in others the lines are obliterated, the tendency being toward wavy transverse bands of black and yellow, which are more or less broken up into irregularly shaped spots.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8633	Fort Tejon, California	1875	H. W. Henshaw	1

DIPLOGLOSSA.

GERRHONOTIDÆ.

GERRHONOTUS.

GERRHONOTUS SCINCICAUDUS Skilton.

Tropidolepis scincicaudus Skilton, Am. Journ. Sci. vii, 1849, 202, figs. 1–3.
Elgaria scincicauda Bd. & Gd., Stans. Rep. Salt Lake, 1842, p. 348, pl. iv, figs. 1–3.—Gd., Herp. U. S. Expl. Exp. 1858, 210.
Gerrhonotus scincicaudus Cope, Check-List N. A. Bat. and Rept. 1875, p. 47.

This species was found extremely numerous in the vicinity of Santa Barbara, as also upon the island of Santa Cruz. The differences between several of the admitted species of this genus, as at present defined, are so slight that it appears probable to us that the number will have to be reduced. This species is very pugnacious and will bite fiercely if handled.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8622	Santa Barbara, Cal	1875	Dr. H. C. Yarrow	3
8624	......do	1875	....do	2
8625	......do	1875	....do	4
8626	Santa Cruz Island, Cal	1875	H. W. Henshaw	2
8623	Los Angeles, Cal	1875	L. Brown	....

IGUANIA.

IGUANIDÆ.

HOLBROOKIA.

HOLBROOKIA MACULATA Girard.

Holbrookia maculata Girard, Proc. Am. Assoc. iv, 1850, 51, 201; *id.*, Marcy's Rep. Red Riv. 1852, 223; *id.*, Stans. Rep. Great Salt Lake, 1853, 342.—Bd., U. S. and Mex. Bound. Surv. ii, Rept. 1859, 8; *id.*, P. R. R. Rep. x, 1859, 18, 38; *id.*, *ib.* x, 1859, Whipple's Route, Rept. 38.—Hayd., Trans. Am. Philos. Soc. xii, 1862, 177.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 313.—Coues, vol. v. Zool., U. S. Geog. Surv. W. 100th Meridian, 1875, 601.
Holbrookia affinis Bd. & Gd., Proc. Acad. Nat. Sci. Phila. vi, 1852, 125.—Bd., U. S. and Mex. Bound. Surv. ii, pt. ii, Rept. 8.
Holbrookia maculata subspecies *maculata* Girard—Cope, Check-List N. A. Batrach. and Rep. 1875, 47.—Yarrow, vol. v, Zool., U. S. Geog. Surv. W. 100th Meridian, 1875, 563.

A beautiful specimen from Fort Tejon, Cal., differs in no respect from the typical form. Apparently not so common as in the interior.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
9283	Fort Tejon, Cal	1875	H. W. Henshaw	....

CALLISAURUS.

CALLISAURUS DRACONTOIDES VENTRALIS (Hallow.) Cope.

Callisaurus dracontoides Blainv., Nouv. Ann. des Mus. p. 26.
Homalosaurus ventralis Hallow., Proc. Acad. Nat. Sci. Phila. vi, 1852, 179; *id.*, Sitgreaves's Exp. Zuñi and Col. Riv. 1854, 117, pl. 6.
Callisaurus ventralis Bd., U. S. and Mex. Bound. Surv. ii, pt. ii, 1859, Reptiles, 8.
Callisaurus dracontoides subspecies *ventralis* Cope, Check-List N. A. Bat. and Rept. 1875, 47.
Callisaurus dracontoides ventralis Coues, vol. v, Zool., U. S. Geog. Surv. W. 100th Meridian, 1875, 600.

This species resembles, in certain points, both *Crotaphytus* and *Holbrookia*, but is so characteristically distinct as to be readily recognizable. Coloration of our specimen from the Mojave Desert seems to be normal. An additional and constant color-mark not noted in the original description is a broad blackish stripe which passes from the posterior and inner border of the knee to the body, thence down the tail for about an inch, where it gradually fades away.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8638	Mojave Desert, Cal	1875	Dr. O. Loew	1

CROTAPHYTUS.

CROTAPHYTUS COLLARIS (Say) Holbrook.

Agama collaris Say, Long's Exp. Rocky Mts. ii, 1823, 252.—Harlan, Med. and Phys. Res. 1835, 142.
Crotaphytus collaris Holb., N. A. Herp. ii, 1842, 79, pl. 10.—Bd. & Gir., Marcy's Rep. Exp. Red Riv. 1853, 222.—Bd., U. S. and Mex. Bound. Surv. ii, pt. ii, 1859, Reptiles, 6; *id.*, P. R. R. Rep. x, 1859, Gunnison's Route, Reptiles, 19, pl. 24, figs. 1*a–e*; *id.*, *ib.* Whipple's Route, Reptiles, 38.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 302; *id.*, Check-List N. A. Batrach. and Rep. 1875, 47.—Yarrow, vol. v, Zoology. U. S. Geog. Surv. W. 100th M. 1875, 565.—Coues, *ib.* 600.

This well-marked species is one of the most abundant and characteristic lizards of the Southwestern Territories.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8628	Fort Mojave, Ariz.	1875	W. Somers	....
8629	Santa Barbara, Cal	1875	Dr. H. C. Yarrow	1
9549	Mojave Desert, Cal	1875	Dr. O. Loew	1

CROTAPHYTUS WISLIZENII Baird & Girard.

Crotaphytus wislizenii Baird & Girard, Proc. Acad. Nat. Sci. Phila. 1852, 69; *id.*, Stans. Rep. Exp. Grt. Salt Lake, 1852, 340.—Bd., U. S. and Mex. Bound. Surv. ii, 1859, Reptiles, 7; *id.*, P. R. R. Rep. x, 1859, Gunnison's Route, Reptiles, 17; *id.*, P. R. R. Rep. x, 1859, Whipple's Route, Reptiles, 37.—Coop. & Suckl., Nat. Hist. Wash. Ter. 1860, 294.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 303; *id.*, Check-List N. A. Batrach. and Rep. 1875, 48.—Yarrow, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 566.—Coues, *ib.* 599.
Crotaphytus (Gambelia) wislizenii Bd., U. S. and Mex. Bound. Surv. *loc. cit.* in text.
Crotaphytus gambelii Bd. & Gir., Proc. Acad. Nat. Sci. Phila. 1852, 207; *id.*, Sitgreaves's Exp. Zuñi and Col. Riv. 1853, 115, pl. 5.
Crotaphytus fasciatus Hallowell, Proc. Acad. Nat. Sci. Phila. 1852, 207.

Habitat more northerly than the preceding. This species is extremely abundant on the sandy sage-brush desert in the region of Pyramid Lake, Nev., and in a day's ride scores may be seen along the road. They are extremely quick in movements, and when startled speed over the sand with marvelous celerity. They may be readily secured by the use of a long pliant switch or whip. The specimens from this locality all agree in presenting an unusually dark phase of coloration, the spots on the back being larger and blacker than in any others we have seen. This may be due in part to the loss of color in older alcoholic specimens.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8632	Southern California	1875	J. A. Hasson	1
9516	Pyramid Lake, Nev	1877	H. W. Henshaw	1

DIPSOSAURUS.

DIPSOSAURUS DORSALIS Bd. & Gd.

Crotaphytus dorsalis Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 126.
Dipsosaurus dorsalis Hallow., Proc. Acad. Nat. Sci. Phila. 1854, 92.—Bd., U. S. and Mex. Bound. Surv. 1859, 8.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 310; *id.*, Check-List N. A. Bat. and Rept. 1875, 48.—Coues, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 599.

But a single individual of this southern species has been obtained by the expedition.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8635	Mojave Desert, Cal	1876	Lieut. E. Bergland	1

UTA.

UTA ORNATA Baird & Girard.

Uta ornata Baird & Girard, Proc. Acad. Nat. Sci. Phila. 1852, 126.—Bd., U. S. and Mex. Bound. Surv. pt. ii, 1859, Reptiles, 7.—Cope, Check-List N. A. Bat. and Rep. 1875, 48.—Yarrow, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 568.—Coues, *ib.* 597.
Uta ornata var. *linearis* Bd., *l. c.* (Los nogales).

The relationship of Cope's *U. thalassina* and *U. graciosus* to the present species requires to be investigated, as the descriptions imply a rather close approach. Our specimens of the *U. ornata* from the Mojave Desert region show considerable differences in coloration from specimens collected in previous years in Utah, &c.; so marked, in fact, are they that at first we were inclined to consider them to be distinct. Baird's and Girard's description indicates a rather highly colored species—"reddish-brown above, with transverse elongated black patches all along the upper part of the body." This applies to the usual style found in Utah, and also to some from the Mojave Desert; others, however, from the last locality are of a clear ashy-gray color, variably marked with narrow transverse black bands.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8665	Southern California	1875	Dr. H. C. Yarrow	2
8666	Mojave Desert, Cal	1875	Dr. O. Loew	2
8667	Fort Mojave, Ariz	1875	William Somers	1
8668	Southern California	1875	J. A. Hasson	1

UTA STANSBURIANA Bd. & Gir.

Uta stansburiana Bd. & Gir., Proc. Acad. Nat. Sci. Phila. vi, 1852, 69; *id.*, Stans. Rep. Exp. Grt. Salt Lake, 345, pl. 5, figs. 4–6.—Bd., U. S. and Mex. Bound. Surv. ii, pt. ii, 1859, Reptiles, 7; *id.*, P. R. R. Rep. Reptiles, x, 1859, Whipple's Route, 37.—Cope, Check-List 1875, 48.—Yarrow, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 568.—Coues, *ib.* 596.

The color-variation in this species is very considerable indeed, being exceeded, if equaled, by no other of the family. The males are readily distinguishable from the depth of color, a bluish cast pervading the whole body. The chin and throat are strongly bluish, in decided contrast to the greenish-yellow of the under parts generally. A double row of black spots is usually found along the back.

The markings of the females are more irregular, the lighter tints prevailing. The sides are usually broken up by whitish maculations. Below, the yellow is paler and the chin of a lighter blue. Both sexes have a conspicuous bluish spot on the side just posterior to the fore leg. In the original description, we find no mention made of the carinated character of the scales of the dorsal region. All specimens, however, possess this as a constant feature. The carinæ become best marked as the tail is approached, and gradually become obsolete close to the neck.

Young.—So entirely different in appearance are the young, when only from 2 to 3 inches long, that their identity would scarcely be suspected. Below they are greenish-yellow, the chin presenting no contrast of blue. Above, two series of continuous black spots inclose median lighter spaces. On either side of these, running from the eye down the body, is a conspicuous stripe of light yellow, 5 scales wide, below which is a series of illy-defined black spots. Anterior to and above the shoulder is a conspicuous roundish black spot. The spot on side of body back of fore leg is wanting. We find several specimens in the collection which well exhibit one extreme of color to which the species is subject; these, if only correlated with special locality, might properly be considered to represent a variety. This, however, is not the case. These are of a light-brown color, the upper surface being distinctly marbled with numerous light greenish-blue spots; the tail banded with same.

This species is very abundant throughout Southern California, Arizona, and Nevada.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8614	Santa Cruz Island, Cal	1875	H. W. Henshaw	1
8615	Virginia City, Nev	1876	William Somers	1
8616	Santa Barbara, Cal	1875	H. W. Henshaw	10
8617	......do	1875	......do	5
8619	Santa Cruz Island, Cal	1875	......do	2
8620	Southern California	1875	J. A. Hasson	3
8621	Mojave Desert, Cal	1875	Dr. O. Loew	3
8639	Southern California	1875	H. W. Henshaw	1

SCELOPORUS.

SCELOPORUS POINSETTII Bd. & Gd.

Sceloporus poinsettii Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 126.—Bd., U. S. and Mex. Bound. Surv. pt. ii, 1859, Rept. 5, pl. 29, figs. 1-3.—Cope, Check-List N. A. Batrach. and Rept. 1875, 48.—Yarrow, vol. v, Zool., U. S. Geog. Exp. W. 100th M. 1875, 573.—Coues, *ib.* p. 595.

This species was found in Southern Arizona by the expedition, where it is by no means rare. The specimen taken was mislaid, and no mention was made of it in the previous report; hence we introduce it here.

In comparing specimens of this well-marked form from Texas, the original locality of the species, with others collected in Arizona, we note a quite decided difference in the amount of carination of the scales of the back. Although in the original description the scales are given as smooth, we find in specimens from Texas, otherwise quite typical, a faint keeling, which in most Arizona specimens is seen to be quite pronounced.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8610	Santa Rita Mountains, Arizona	1874	H. W. Henshaw	1

SCELOPORUS CLARKII Bd. & Gd.

Sceloporus clarkii Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 127.—Bd., U. S. and Mex. Bound. Surv. pt. ii, 1859, Reptiles, 5.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 310; *id.*, Check-List, 1875, 49.—Coues, vol. v, Zool., U. S. Geog. Surv. W. 100th M. 1875, 594.
Sceloporus clarkii subsp. *clarkii* Yarrow, vol. v, Zool., U. S. Geog. Surv. W. 100th M. 1875, 575.
Sceloporus magister Hallow., Proc. Acad. Nat. Sci. Phila. 1854, 93.

A single specimen obtained in Nevada, where it appears to be a not very common lizard. The relationship between this form and the *spinosus* of Wiegmann is a close one, and as a result of future investigation the two may require to be united.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
9518	Nevada	1877	H. W. Henshaw	1
8674	Southern California	1876	Lieut. E. Bergland	1
8672	Mojave Desert	1876	Dr. O. Loew	1
8663	Fort Craig, New Mexico	1874	Dr. Boughter	1

SCELOPORUS UNDULATUS THAYERI (Bd. & Gd.) Cope.

a. UNDULATUS.

Lacerata undulata Daudin, Hist. Nat. des Rept. iii, 384.
Stellio undulatus Latreille, Hist. Rept. ii, 1802, 40.
Lacerata hyacinthina et fasciata Green, Proc. Acad. Nat. Sci. Phila. i, 349.
Uromastyx undulatus Merrem., Syst. des Amphib. 57.
Agama undulata Harlan, Med. and Phys. Res. 1853, 140.—Daudin, Hist. Nat. des Repts. t. iii, 384.
Tropidolepis undulatus Cuvier *apud* Griffith, ix. 126.—Cuvier, Règ. Anim. t. ii, p. 38.—Gray, in Griff. An. King. vol. x, 43.—Holbrook, N. A. Herp. iii, 51, pl. viii; ii, 73, pl. 9, 2d ed. 1842.—Dum. & Bib., Hist. Nat. des Rept. t. iv, 298.—DeKay, Zool. N. Y. 1842, 31.—Tenney, Man. Zool. 1866, 296.
Sceloporus undulatus Gravenhorst, Nov. Acta, xviii, 768.—Wiegmann, Isis, 1828, 369.—Bd., P. R. R. Rep. x, Whipple's Route, 1857, 37.—Gd., Herp. U. S. Expl. Exped. 1858, 379, pl. xix, figs. 15-21.
Sceloporus undulatus subsp. *undulatus* Cope, Check-List N. A. Batr. and Rept. 1875, 48.—Yarrow, vol. v, Zoology, U. S. Geog. Surv W. 100th M. 1875, 573.

b. THAYERI.

Sceloporus thayerii Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 127 (orig. descr.).—Bd., U. S. and Mex Bound. Surv. 1859, 6.
Sceloporus undulatus subsp. *thayerii* Cope, Check-List N. A. Batr. and Rept. 1875, 49.
Sceloporus occidentalis Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 175.—Gd., Herp. U. S. Expl. Exped. 1858, 383.—Bd., P. R. R. Rep. x, Gunnison's Route, 1857, 17.—Bd., P. R. R. Rep. x, Abbott's Route, 1857, 9.—Cooper, Nat. Hist. Wash. Terr. 1859, 293.
Sceloporus frontalis Bd. & Gd., Proc. Acad. Nat. Sci. Phila. 1852, 175.—Gd., Herp. U. S. Expl. Exped. 1858, 38, pl. xix, figs. 1, 7.
Sceloporus longipes Bd., Proc. Acad. Nat. Sci. Phila. 1858, p. —.—Bd., P. R. R. Rep. x, Gunnison's Route, 1857, 17.

Prevailing over much of the Middle and Pacific regions is a lizard comparable in every respect, in fact, presenting no very apparent tangible characters separating it from the *S. undulatus* of the Eastern United States. The form from Texas described by Baird and Girard as *S. thayerii* appears to apply here, and it was reduced by Cope in his check-list to a sub-species of *undulatus*. Accepting the name *thayeri* as applicable to the Western variety of *undulatus*, we identify as such a large suite of lizards collected by the expedition in various portions of California and Nevada. About the only real difference—and this is to be observed rather as an average than as characterizing every individual specimen—is one of color, California specimens being very brightly colored, the usual blue patches along the sides and under the chin occasionally overspreading nearly the whole belly and throat. In such individuals, if the scales of the back be removed, a strong bluish cast will be found to tinge also the skin. It should be remarked that typical specimens of *S. undulatus* absolutely identical with more eastern specimens are found in Utah, Nevada, New Mexico, and Arizona.

In Vol. V, Zoology, of this expedition, Professor Cope described a new species of *Sceloporus* from Utah, which he called *smaragdinus*. As compared with what we term *thayeri*, this form appears to possess a longer, stouter body; the tail is broader at base and shorter. The scales of *thayeri* are perhaps proportionately larger. So far as the scale-formula of the head is concerned, we can find little or no difference, and are strongly inclined to the opinion that it will not prove to be distinct from *thayeri*.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8657	Mojave Desert	1875	Lieut. E. Bergland	1
8659	Mount Whitney, Cal	1875	H. W. Henshaw	4
8658	Southern California	1875	....do	2
8608	......do	1875	....do	12
8660	......do	1875	....do	4
8673	Los Angeles, Cal	1875	W. Somers	2
8661	Lake Tahoe, Cal	1876	H. W. Henshaw	1
8662	Santa Barbara, Cal	1876	....do	2
8608	California	1876	....do	1

SCELOPORUS CONSOBRINUS Bd. & Gd.

Sceloporus consobrinus Bd. & Gd., Marcy's Exped. Red Riv. 1853, 224, pl. 10, figs. 5—12.—Bd., P. R. R. Rep. x, 1859, Whipple's Route, Reptiles, 37; *id.*, U. S. and Mex. Bound. Surv. pt. ii, Reptiles, 5.—Hayd., Trans. Am. Phil. Soc. xii, 1862, 303.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 303.—Cope, U. S. Geol. Surv. Montana, 1872, 468.—Allen, Proc. Bost. Soc. Nat. Hist. xvii, 1874, 69.—Cope, Check-List N. A. Batrach. and Rept. 1875, 49.—Yarrow, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 574.—Coues, *ibid.* 594.—Coues & Yarrow, Bull. U. S. Geol. Surv. Terr. vol. 4, No. 1, 1878, 287.

An abundant species throughout the West and Southwest. This species varies much in coloration.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8606	Olancha Peak, Cal	1875	H. W. Henshaw	3
8607	Southern California	1875	......do	2
8609	Mojave Desert, Cal	1875	Dr. O. Loew	5
8643	......do	1875	......do	1
8664	Virginia City, Nev	1875	William Somers	1
8482	Apache, Ariz	......	Dr. O. Loew	1
9548	Fort Wingate, N. Mex	1874	H. W. Henshaw	1

PHRYNOSOMA.

PHRYNOSOMA PLATYRHINUM Girard.

Phrynosoma platyrhinus Girard, Stans. Rep. Exp. Grt. Salt Lake 1853, 361-363, pl. vii, figs. 1-5.—Cope, Proc. Acad. Nat. Sci. Phila. 1866, 302.
Doliosaurus platyrhinus Girard, Herp. U. S. Exp. Exped. 1858, 407.—Bd., P. R. R. Rep. x, 1859, Gunnison's Route, Reptiles, 18.
Phrynosoma platyrhinum Cope, Check-List N. A. Batrach. and Rept. 1875, 49.—Yarrow, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 577.—Coues, *ib.* 594.

Great numbers of this species were noticed on the sandy, desert-like valleys between Reno and Pyramid Lake, Nevada. It was not seen again, although doubtless it occurs at intermediate points, until far to the northward a few were taken on a sandy, alkaline desert near Warner Lake, Oregon. This is probably the extreme northern locality from which the species is recorded. After an examination of a great number of specimens we find the under surface of the body unicolor, save the chin, throat, and tail, which are spotted.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
9519	Pyramid Lake, Nev	1877	H. W. Henshaw	6

PHRYNOSOMA MACCALLII Hallowell.

Anota M'Calli Hallow., Sitgreaves's Exp. Zuñi and Col. Riv. 1853, 127, pl. 10 (type of genus).—Hall., Proc. Acad. Nat. Sci. Phila. vi, 1852, 182.
Doliosaurus mc'callii Gir., Herp. U. S. Exp. Exped. 1858, 408.—Bd. U. S. and Mex. Bound. Surv. ii, pt. ii, 1859, Reptiles, 9, pl. 28, figs. 4–6.
Phrynosoma maccallii Cope, Proc. Acad. Nat. Sci. Phila. 1866, 310; *id.*, Check-List 1875, 49.—Coues, vol. v, Zoology, U. S. Geog. Surv. W. 100th M. 1875, 593.

Notwithstanding the fact that a number of the species of this group described by the earlier authors have been thrown out or retained only as varieties, it seems probable that the number will require still further reduction, as certain ones of the accredited species run remarkably close to each other.

In external form the above is one of the most characteristic of the family, the long limbs and tail and attenuated body giving it a peculiar appearance. The absence of external auditory apertures caused Hallowell to separate it under the genus *Anota.* Strictly speaking, however, these are not entirely wanting, as is the case in the genus *Holbrookia*, but in most, perhaps all, specimens the ear is indicated by a slight depression in the skin, which is covered by very minute granular scales.

This species is very abundant in the Mojave Desert, and is the least highly colored of the group, as also one of the most constant in markings. Several specimens were taken near Virginia City, Nev., which indicates an extreme point in its northern dispersion.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8649	Mojave Desert	1875	Dr. O. Loew	2
8650	Virginia City, Nev	1875	William Somers	3
8651	Mojave Desert	1875	Dr. O. Loew	1
9195	do	1875	do	1

PHRYNOSOMA CORONATUM Blainville.

Phrynosoma coronatum Blainv. in Nouv. An. Mus. d'Hist. Nat. iv, 1835, 285, pl. 25, figs. 1 *a, b, c.*—Dum. & Bibron, Herpt. Gén. iv, 1837, 318.—Holbrook, N. A. Herp. 2, 1842, p. 97, pl. 13.—Girard in Stans. Exp. Grt. Salt Lake, 1852, 360, pl. 8, figs. 7, 12.—Hallow., Sitgreaves's Rep. Zuñi and Col. Riv. 1853, p. 122.—Cope, Check-List N. A. Batrach. and Rept. 1875, 50.
Phrynosoma blainvillii Gray in Beechey's Voy. to Pacif., Zoology, 1839, 96, pl. 29, fig. 1 (young); *id.*, Cat. Liz. Brit. Mus. 1845, p. 228.
Batrachosoma coronatum Fitz., Syst. Rep. i, 1843, p. 79.—Girard, Herp. U. S. Expl. Exp. 1858, p. 400.
Phrynosoma solaris Gray, Brit. Mus. Cat. Lizards, 1845, p. 229.

Very numerous in many sections throughout Southern California, and one of the most beautiful and well marked of the group; is readily distinguishable, except from *blainvillei*, by the four rows of large sub-mental scales.

List of specimens.

No.	Locality.	Date.	Collector.	No. of specs.
8645	Mojave Desert, Cal	1875	Dr. O. Loew	2
8646	Santa Barbara, Cal	1875	Dr. H. C. Yarrow	2
8647	Mojave Desert, Cal	1875	Dr. O. Loew	1
8648	Santa Barbara, Cal	1875	H. W. Henshaw	1

As of interest in this connection we may mention the *P. cornutum*, which has been taken in California. In this species the scales on the inferior surface of head are slightly keeled; the spotting on belly is very variable, sometimes present in immature specimens and almost wanting in fully adult ones. Femoral pores rarely well developed, sometimes very indistinct or wanting. A continuous band of at least three rows of large carinated scales passes across the breast from elbow to elbow. This latter is a character which appears to be absolutely constant and quite diagnostic of the species.

The *P. planiceps* of Hallowell, from Texas and the "southern Sonoran region," appears to present no characters that should distinguish it from *cornutum*, and we have no hesitancy in placing it as a synonym under the latter. Upon communicating our opinion to Professor Cope, he informs us that he recently has been led to the same conclusion by the examination of specimens of supposed *planiceps* from Texas, its original locality. Below is appended the synonymy.

Agama cornuta Harl., Journ. Acad. Nat. Sci. Phila. vol. 4, ii, 1825, pl. 20, vi, 1, 1829, 14; Med. and Phys. Res. 1835, 141, figs. 1-2.—Griff. in Cuv. Animal Kingd. 9, 1831, 216 (fig.).
Phrynosoma cornutum Girard, Stans. Rep. Exp. Great Salt Lake, 1852, 360, pl. viii, figs. 1-6.—Hallowell, Sitgreaves's Rep. Exp. Zuñi and Col. Riv. 1853, 119.—Bd., U. S. and Mex. Bound. Surv. pt. ii, Reptiles, 1859, 9; *id.*, P. R. R. Rep. x, 1859, 38.—Cope, Check-List N. A. Batrach. and Rept. 1875, 49.—Yarrow, vol. v, Zool., U. S. Geog. Surv. W. 100th Meridian, 1875, 579.
Phrynosoma cornuta Gray, Syn. Rept. in Griffith's Animal Kingd. vol. 9, 1831, 45; *id.*, Cat. Liz. British Mus. 1845, 229.—Holbr., N. A., Herp. ii, 1842, 87, pl. xi.
Taypaya cornuta Cuv., Règ. Animal, 2e éd. vol. 2, 37.
Lacerta tapayaxin Barton, Med. and Phys. Journ. vol. 3.
Phrynosoma harlanii Wieg., Herp. Mexico, pt. i, 54.—Duméril & Bibron, Erpét. Gén. vol. 4, 1837, 314.
Phrynosoma bufonium Wiegmann, in Oken's Isis, xxi, 1828, 367.—Gray, Synop. Rept. in Griff. Animal Kingd. 9, 1831, 45.
Phrynosoma orbiculare Holbr., N. A. Herp. ii, 1842, 93, pl. 12.
Tropidogaster Fitz., Synop. Rept. i, 1843, 79.
Tapayaxin Bart., Med. and Phys. Journ. iii.
Phrynosoma planiceps Hallow., Proc. Acad. Nat. Sci. Phila. 1852, 178; *id.* in Sitgreaves's Rep. Exp. Zuñi and Col. Riv. 1853, 124.—Cope, Check-List N. A. Batrach. and Rept. 1875, 49.—Yarrow, vol. v, Zool., U. S. Geog. Surv. W. 100th Meridian, 1875, 579, pl. xxiv, fig. 1, 1 *a*, and 1 *b*.—Coues, *ib.* 593

APPENDIX M.

NOTES UPON THE FIRST DISCOVERIES OF CALIFORNIA AND THE ORIGIN OF ITS NAME BY PROF. JULES MARCOU.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., August 6, 1878.

SIR: Please find herewith a translation of "Notes upon the first discoveries of California and the origin of its name," by Prof. Jules Marcou, of Salins, Jura, France, which has been kindly furnished to the Chief of Engineers by the author, and I am to request that you will incorporate the same in your report for the last fiscal year. The map referred to in the "Notes" has been lithographed in this office, and the number required for your report will be supplied to you.

By command of the Acting Chief of Engineers.

Very respectfully, your obedient servant,

GEORGE H. ELLIOT,
Major of Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

[Translation.]

In the collection V of "*Lettres édifiantes et curieuses écrites des Missions Étrangères par quelques missionnaires de la Compagnie de Jésus, Paris*, 1724," is found a memoir touching the condition of missions recently established in California by Father François Marie Picolo, dated Guadalajara, Mexico, February 10, 1702. The approbation of the Sorbonne is dated February 17, 1705, and the privilege of the King bears the date of October 27, 1705. The memoir was not printed until 1724, and was published in 1725.

A map of the greatest importance in the history of California and of Arizona accompanies this memoir. This map is entitled "*Passage par terre à la Californie découvert par le Rév. Père Eusèbe François Kino, Jésuite, depuis* 1698 *jusqu'à* 1701, *où l'on voit encore les Nouvelles Missions des P.P. de la Compagnie de Jésus.*"

As the editor stated in the epistle or preface, the map of Father Kino demonstrated

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that California was not an island, but indeed a peninsula, which was contrary to the maps published at that period.

If we go back to the earliest geographical documents of the sixteenth century relating to the New World, it will be seen that Hernan Cortès, after his conquest of Mexico, or New Spain (as it was then called), fitted out in the harbor of Tehuantepec two vessels, named Conception and San Lazaro, to discover and reconnoiter lands in the South Sea, if any existed.

This voyage, which was made in 1533, had no further results than the reconnaissance of the land about the 23d degree of latitude, which forms part of the southeastern extremity of Lower California. The expedition was commanded by Capt. Diego Becerra (or Bezerra) de Mendoza, with the Biscaien, Ordoño, or Fortun Ximenès as pilot.

In 1535, Cortès, with three brigantines, set out from Chiametla, or Chametla (Jalisco), reconnoitered the bay of Santa Cruz (which bore later the name of Palmas Bay, and is now called Muertos Bay), and the river San Pedro and San Pablo, crossed the Mar Rojo (Red Sea), lost his vessel by shipwreck on the coast of Culvacan (Culiacan), in the State of Sinaloa; and it was only after much suffering and danger that Cortès regained the harbor of Acapulco.

Cortès, constantly preoccupied with the idea of penetrating the secrets of the South Sea, sent in 1539 Francisco de Uloa, with two vessels, to continue his discovery. Uloa followed and coasted all along the eastern shore of California, having reached about the 30th degree of latitude. He saw land on the right and left, and those on board began to agitate the question whether California was an *island*, as Cortès had thought it to be, or was really a *peninsula*.

Continuing to sail toward the north some 50 leagues farther, Uloa perceived that the water was changing color and becoming as white as lime; advancing 9 or 10 leagues farther on, he ascertained by sounding that the depth constantly diminished until at last he found only 5 fathoms, with a strong current of thick and muddy water; then going to the masthead, Uloa saw the land extended farther on, and on every hand a very low shore, which was scarcely perceptible, and, convinced that he could not advance farther to the north, he crossed to the other side to coast along the shore opposite to the one which he had just reconnoitered. After having doubled the southern point of Cape San Lucas, he went up along the western shore of Lower California as far as the 28th degree of north latitude.

There terminated the discoveries of Uloa; and it remained an open question whether this land was an island, as Cortès had designated it in his letter from the great city of Tenuxtitan (Mexico), to the Emperor Charles V, dated October 13, 1524, or whether it really belonged to the continent, as Uloa was inclined to believe.

In 1540, the viceroy, Don Antonio de Mendoza, sent out his celebrated military expedition, under the command of Francisco Vasquez Coronado, which was intended to support the flotilla commanded by Francisco d'Alarcon. The orders were to form a junction at the 36th degree of latitude, but the two expeditions did not communicate with each other.

Alarcon reached the head of the Gulf of California, and there he found a large river with a very rapid current, which he tried to ascend both in shallops and in boats.

After having ascended the river a distance estimated to be 80 leagues, he set up several crosses on the banks, and buried at their feet bottles in which were placed papers stating the year, month, and the day of his arrival. Alarcon named this river Bona Guia. After having waited some time he returned to his vessels and thence to the harbor of embarkation.

Thus Alarcon was the first who had the honor of discovering, and of ascending for several days, the Bona Guia, which is no other than the *Rio Colorado* of California. He thought he had ascended as far as the 36th degree, but there are evidently errors in his positions and distances, for the Rio Gila empties into the Colorado at about the 32d degree of latitude, and Alarcon never saw the mouth of that river, for if he had he would very certainly have made the fact known. As to thinking he could have reached the 36th degree in ascending the Colorado, that is to say, that he could have passed not only the mouth of the Rio Gila, but that of Bill Williams Fork, and the Virgin River, and that he did not stop until he got to the entrance of the Grand Cañon of the Colorado River, which is thirty-six degrees and some minutes of latitude, is altogether an impossibility.

Don Juan Rodriguez Cabrillo, a Portuguese captain in the service of the King of Spain, reconnoitered in 1542 and 1543 the whole of the western coast of California, which he ascended as far as the 44th degree of latitude, naming on his way Cape Mendocino (or Mendoza) in honor of the viceroy of New Spain.

Notwithstanding the discoveries of Uloa and Alarcon, many geographers maintained that California was an island, and the maps of the sixteenth and seventeenth centuries, and even of the commencement of the eighteenth, show various opinions upon this important geographical question. Upon some, California is indicated as a peninsula, upon others as an island, and generally the oldest maps of the sixteenth century are the most correct.

In like manner the map of the world, by Sébastian Cabot in 1544, that of Gérard Mercator in 1569, and that of Abraham Ortelius in 1570, all indicate that California is a peninsula. Even the maps of Michel Mercator in 1631, and of New France by the Jesuit father Louis Hennepin in 1683, make it a peninsula.

But from the beginning of the middle of the seventeenth century the idea that California was an island generally predominated. It is thought that the author who did the most to make that opinion prevail was the Dutchman Joannes Janssonius of Amsterdam, who, in his atlas of the maritime world, gave a map borrowed, as he says, from the Spaniards, in which California is represented as an island. All the geographers began to copy it. So upon the maps of North America, by Nicolas Sanson, from 1650 to 1669, we read the *island of California;* in like manner upon the maps of Jallot, 1674–1675; upon that of Potin of 1689, and upon that of William Berry (North America) published in 1680.

The geographer Du Val, in his maps of America in 1655, 1676, and 1679, shows the *island of California*, which he prolongs up to the Straits of Anian or Anien (which has later become the Straits of Juan de Fuca). Vanden-Aa, about the middle of the seventeenth century, gives also an island. Danckerts, of Amsterdam, in his *America Nova Descriptio*, 1661, represents, in like manner, California as an island, and so does the geographer Allard in the middle of the seventeenth century. The Dutch geographer Blaer, who represented California as a peninsula in 1662, made it an island in 1659 and in 1670.

New Mexico, by Coronelli in 1680, represents California as an island. The large and magnificent globe of the same geographer dedicated to Louis XIV in 1683, and which is preserved in the National Library at Paris, also shows California as an island. The same author writes upon a map published at Venice at the close of the seventeenth century, "*Isola di California.*"

Nicolas de Fer, who had made this error in a map in 1698, perpetuated it even up to 1717, when in his map entitled "*Amérique divisée selon l'étendue de ses principales parties,*" he still gives the island of California limited on the north by the North Strait and terminated at the south by *Cape St. Luc* (Cape Saint Lucas).

Of all the geographers at the close of the seventeenth and commencement of the eighteenth century, Guillaume Delisle, first geographer of the King of France, Louis XIV, is the one who has shown himself the most sagacious. In a letter to M. Cassini, without date, but which must have been written about the year 1698, and which was published at Amsterdam by Jean Fréderic Bernard in the "*Recueil de voyage au nord,*" Delisle shows a mind filled with sound criticism and a clear knowledge of facts touching California. Delisle, after having well considered the matter, stated that he thought it prudent to leave blank, as unknown, that part of the globe, and to make California "*neither an island nor a part of the continent,*" and to await something more positive before arriving at a decision. He did not have to wait a long time, for in his map of North America dated 1700, Delisle joined California to the continent, and he maintained that California was a peninsula in his map of 1702. It is evident that after the commencement of the year 1700 Guillaume Delisle must have received information of the discovery, by the Jesuit father Kino, of the passage by land from New Mexico to California which this missionary had made during the year 1698.

Beginning with the maps of Guillaume Delisle, the truth triumphed. Soon all map-makers adopted his opinion and made use of the famous discovery of Father Kino, joining California as a peninsula to the American continent.

The map of Father Kino is not only very important on account of its giving with considerable accuracy the head of the Mer Vermeille, or Gulf of California, but as locating and showing a great number of the villages, missions, pueblos, rivers, and mountains of Sonora and of New Mexico (the part known now as Arizona), and of Lower California, or, properly, Old California.

Having taken part in an expedition to California, in 1683, under the command of Admiral Don Fridoro d'Atondo, Father Kino explored a part of California, crossing it from the east to the west on the 26th degree of latitude, from Loreto to New Year's Harbor, following the Rio San Tomas, now the Rio de la Puríssima, and the Boca de la Puríssima. (See account of the landing of Spaniards in California in 1683, translated from the Castilian, in Vol. III of Collection of Voyages to the North, by J. F. Bernard, Amsterdam.)

I have already given the true origin of the name of California in a report on the geology of a portion of Southern California. (See Annual Report upon Geographical Survey West of the One hundredth Meridian, 1876, by Lieut. George M. Wheeler, in the Report of the Chief of Engineers, Washington, 1876, page 386.)

Cortès and his companions, struck with the difference between the dry and burning heat they experienced, compared with the moist and much less oppressive heat of the Mexican *tierra caliente,* first gave to a bay, and afterward extended to the entire country, the name of *tierra California*, derived from *calida fornax,* which signifies fiery furnace, or hot as an oven. Hernan Cortès, who was moreover a man of learning (since he was a bachelor of law of the University of Salamanca), was at once strongly impressed with the singular and striking climatical differences presented by various parts of the empire of Montezuma, and it is to the great conqueror, Hernando Cortès, Marqués del Valle, to whom is due that remarkable and so very appropriate classification of the Mexican regions into *tierra fria, tierra templada, tierra caliente,* and *tierra California.*

The word *California* alone has passed into use to designate a purely political and geographical division, probably on account of the isolation and remoteness of this part of New Spain.

The excessive heat of the California peninsula is now well known, since thermometric observations have been made at Fort Yuma and at La Paz. These two localities, from one of which the name of California originally sprang, are the hottest parts of the two Americas.

The author who first employed the name of *California* was Bernardo Diaz del Castillo, an officer who had served under the orders of Cortès. He applied it only to a bay believed to be *Bahia de La Paz,* where Hernan Cortès repaired on leaving the bay of Santa Cruz. Thence the name was extended to the whole country nearly to the mouth of the Columbia River in Oregon.

The bay of Santa Cruz bears now the name of *Bahia del Muertos* on account of the massacre of the pilot Ordoño Ximenès, together with Captain Becerra de Mendoza and some twenty Spaniards, who were all killed by the Indians.

Upon the maps of the eighteenth century this bay is designated under the name of the *Bahia de los Palmas.*

Abraham Ortèlius, on his map of 1570, entitled "*America sive novi orbis nova descriptio,*" wrote at the point indicating Cape Lucas the name *C. Cali, formia,* with an *m* instead of an *n,* which was evidently an error of the engraver added to an error in position, since Cortès gave the name to a bay and not to a cape.

The same geographer, in the first edition of his atlas, *Theatrum Orbis Terrarum,* gives, in a map dated 1570, and entitled "*Tartario sive Magni Chami Regni,*" California as a peninsula with the name C. Californio, which is a new variation of the word California, with an *m* and an *o.* Moreover, Ortèlius wrote upon the coast at nearly its correct place the name of *Sierra Nevada.*

MAY 10, 1878.

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