PROGRESS REPORT

GEOGRAPHICAL AND GEOLOGICAL EXPLORATIONS AND SURVEYS

WEST OF THE 100TH MERIDIAN.

1872.

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James E. Mills

ENGINEER DEPARTMENT, UNITED STATES ARMY.

PROGRESS-REPORT

UPON

GEOGRAPHICAL AND GEOLOGICAL

EXPLORATIONS AND SURVEYS

WEST OF THE ONE HUNDREDTH MERIDIAN,

IN 1872,

UNDER THE DIRECTION OF

BRIG. GEN. A. A. HUMPHREYS,

CHIEF OF ENGINEERS, UNITED STATES ARMY,

BY

FIRST LIEUT. GEORGE M. WHEELER

CORPS OF ENGINEERS, IN CHARGE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1874

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., July 11, 1874.

SIR: Lieut. George M. Wheeler, Corps of Engineers, has submitted a report upon the progress of the explorations under his charge in 1872.

As the report contains interesting and valuable information, I have to recommend that it be printed at the Government Printing-Office, and that 2,500 copies be furnished upon requisition for the use of this Office.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier-General and Chief of Engineers.

Hon. WILLIAM W. BELKNAP, *Secretary of War.*

Approved by the Secretary of War July 15, 1874.

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LETTER OF TRANSMITTAL.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL AND GEOLOGICAL EXPLORATIONS AND SURVEYS
WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., January 5, 1874.

SIR: I have the honor to forward herewith the following progress-report relating to the operations under my charge during the field season of 1872.

The skeleton map herewith has delineated upon it limiting lines of the sheets for the topographical atlas prepared as a part of the results from the survey of the territory west of the one hundredth meridian, and the lines of routes followed by expeditions for explorations and surveys since the commencement of the present century.

I respectfully invite attention to the suggestions contained in this report relating to the subject of irrigation, so far as, at the present time, the survey under my charge can take cognizance of it; also to the remarks relative to the opening of wagon-routes in the interior by the General Government. I would further ask special consideration of the manner proposed for the consolidation of the organization of the survey into its several branches, having an executive head for each.

The changes needed for the establishment of a unit of force, as applied to the present *personnel*, will be but slight, while results attendant upon a more thorough unification of a body of official and civilian assistants interested in their labors will be very great.

All of which is respectfully submitted.

Very respectfully, your obedient servant,

GEO. M. WHEELER,
Lieutenant of Engineers, in charge.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army.

INTRODUCTION.

It is proposed to present in this progress report—

1st. A short chapter devoted to the analyzation of the results under their separate and systematic heads.

ERRATA.

Page 10, sixteenth line from top, for "character of the details gathered in topography," read "character of the topographical details gathered."
Page 10, thirty-fourth line from top, for "an interval," read "intervals."
Page 11, eleventh line from bottom, after "good," read "has resulted."
Page 17, twentieth line from top, for "free, milling," read "free milling."
Page 28, second line from bottom, read "great" after the word "fall."
Page 29, fifteenth line from top, for "Utah," read "Sevier."
Page 30, eleventh line, for "cultivated," read "cultivable."
Page 31, twenty-second line from bottom, for "is 1,443,360," read "is approximately 1,443,360."
Page 31, fourteenth line from bottom, for "for Nevada," read "for portions of Nevada," &c.
Page 36, twenty-first line from bottom, before the words "the areas," elide "of."
Page 37, eighteenth line from top, for "although," read "and."
Page 38, fifth line from bottom, for "Elvado," read "El Vado."
Page 47, second line from bottom, for "Myers," read "Negus."
Page 48, top line, for "Myers," read "Negus."
Page 53, twentieth line from bottom, for "———," read "seventy-five."
Page 54, twenty-fifth line from top, for "ichthyology," read "ichthyology."
Page 54, eleventh line from bottom, for "*Milospiza*," read "*Melospiza*."
Page 54, tenth line from bottom, for "*Pipeto*," read "*Pipelo*."
Page 54, seventh line from bottom, for "Campy torhynchus," read "Campylorhynchus."

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officers and civilian assist-
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of the Chief of Engineers,
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manner was intrusted with

Company D, Second United
ım Companies B, C, D, E, F,
;ah.
idan, commanding Military Division of the Missouri, through the commanding general of the Department of the Platte, Brig. Gen. E. O. C. Ord.

Second Lieut. W. A. Dinwiddie, Second United States Cavalry, from whose company the cavalry escort was taken, accompanied the survey in charge of the escort and as quartermaster to the expedition. He has as well in various ways co-operated with the professional undertakings of the season.

Second Lieut. Wallace Mott, Eighth United States Infantry, was in charge of the infantry troops, forming part of the escort, in addition to which duties he, in several cases, assisted in astronomical and meteorological observations.

At many times during the season each of these officers was placed in executive charge of a field-party.

The Medical Department provided for the wants of the parties, one surgeon and one hospital-steward; the former, Dr. H. C. Yarrow, has acted both as surgeon and naturalist, taking charge of the operations in both spheres of duty. Hospital-Steward T. V. Brown, a member of the expedition of 1871, performed, in addition to his accustomed military labors, those of an observer with meteorological instruments.

CIVILIAN PERSONNEL.

J. H. CLARK, *assistant observer and computer.*
E. P. AUSTIN, *assistant observer and computer.*
WILLIAM W. MARYATT, *assistant observer and computer.*
LOUIS NELL, *chief topographer.*
JOHN E. WEYSS, *chief topographer.*
GILBERT THOMPSON, *assistant topographer.*
HENRY CRUGER, *assistant topographer.*
WILLIAM M. ORD, *assistant surveyor.*
M. S. SEVERANCE, *meteorologist and ethnologist.*
WILLIAM KILP, *meteorological observer.*
F. R. SIMONTON, *meteorological observer.*
C. D. GEDNEY, *meteorological observer.*
G. K. GILBERT, *chief geologist.*
E. E. HOWELL, *assistant geologist.*
H. W. HENSHAW, *collector in natural history.*
WILLIAM BELL, *photographer.*
FRANCIS KLETT, *principal clerk and assistant topographer.*

The Quartermaster's Department furnished a partial outfit, consisting of mules, wagons, and certain other material. Subsistence stores were purchased from the Commissary Department at cost price. The Ordnance Department supplied the necessary arms and equipments.

By a subdivision of the two main parties, four separate working-parties were constantly employed, these often admitting of further division for special purposes.

The aggregate length of the several lines in the vicinity of which these parties have prosecuted the survey is found, by reference to the published lists of camps, distances, &c., to be six thousand one hundred and twenty-seven miles. For the purposes of supply and making connections in face of very grave physical obstacles, it became necessary for the several parties to traverse two thousand and sixty-seven miles additional. The area examined and mapped exceeds, by a small amount, fifty thousand square miles, or equal to about three thousand square miles more than New York, or four thousand square miles more than Pennsylvania; and differing little from the combined areas of Maine, New Hampshire, and Vermont, or more than treble the aggregated areas of Massachusetts, Connecticut, and Rhode Island.

The season's area joins along its northern line that of the fortieth parallel survey under King, and joins on the southeast with that of Major Powell near the Colorado. This area had been traversed before by a number of exploration-parties in various directions; of these the following have published their maps under the auspices of the Corps of Topographical Engineers, viz: Frémont, in 1844; Stansbury, in 1849; Gunnison, in 1853; and Beckwith, in 1854.

The reconnaissance line from Camp Mohave, Arizona Territory, to Santa Fé, New Mexico, of the Ives Colorado River expedition appears on the maps thus published at the Office of Explorations and Surveys of the War Department.

The original map prepared from the data collected by the expedition under Captain Simpson, of the Corps of Topographical Engineers, in 1859, in Utah and Nevada, is now on file at the Engineer Department, but has never been published.

Escalante, as early as 1776, entered these latitudes from the south, and from the notes of his journal a plotting of the line of his march was made in the Bureau of Topographical Engineers. (See Warren's Memoir, p. 35.)

One of Bonneville's parties, in 1833, while returning to the vicinity of Great Salt Lake from Monterey, Cal., crossed the northern portion in a northeasterly direction, but upon the map afterward published their route is not laid down. (See Warren's Memoir, pp. 31–34.) These parties seldom, if ever, left any monuments whereby to trace rigidly their routes.

I desire to state that thanks are due to the several officers and civilian assistants engaged upon the work, without whose individual sympathy with their duties the operations of the season could not have been brought to so successful a termination.

CHAPTER I.

ASTRONOMICAL — TOPOGRAPHICAL — METEOROLOGICAL — GEOLOGICAL — COLLECTIONS IN NATURAL HISTORY — PHOTOGRAPHY — MISCELLANEOUS.

ASTRONOMICAL.

In the greater share of the field-season three separate and independent parties were engaged in carrying out observations for the determination of latitude and longitude, with the utmost exactness attainable, with complete sets of field-instruments, using the telegraph for the signals needed in the comparison of local times. Mr. E. P. Austin occupied the main or connecting station, at Salt Lake City; Messrs. Clark and Maryatt the other stations, from which signals were sent. Their reports are herewith, marked Appendixes A and B.

The following stations were occupied, and the necessary observations completed:

1. Beaver, Utah.
2. Gunnison, Utah.
3. Pioche, Nev.
4. Cheyenne, Wyo.
5. Laramie, Wyo.
6. Fort Fred Steele, Wyo.

Observations were commenced at Green River, Wyoming, but were not completed. Field astronomical observations, by officers in executive charge of the parties, were conducted at numerous stations throughout the area occupied, wherever practicable, as checks for latitude. Comparisons for time were also made, when the telegraph-line was accessible, in parts of Southern and Southwestern Utah. Lieutenant Marshall submits a report in regard to their number and position. Preliminary reductions from the astronomical work were at once made upon the return from the field, and the results immediately placed upon the maps, and used in connection with reductions from field topographical notes.

In accordance with a comprehensive and systematic plan proposed for the order of sequence for an astronomical report, these results will be aggregated, and furnish the material that is to appear in volume II of the reports.

The bearing that the determination of the astronomical co-ordinates of the above and other points has upon the establishment of the "astronomical base," and the gradual development of what may be termed an astronomical triangulation over the entire area west of the one hundredth meridian, will be discussed in a separate report.

TOPOGRAPHICAL.

In this department, labors were successfully carried on by five topographers in as many distinct parties. Their efforts for the season in the measurement of bases at the main stations, in the occupation of a great number of secondary triangulation stations, and, in turn, the subsidiary points along a large number of mountain ranges, have aggregated a mass of material more than sufficiently elaborate for the construction of the topographical sheets on a scale of one inch to eight miles as proposed. Their labors, one and all, are worthy of commendation. In special cases, for the expression of certain geological and allied features, more details have been gathered, and the results can be expressed upon a larger scale. However, the scale above mentioned, which will also be adopted for the larger portion of the geological atlas, will be ample for the delineation in color of the surface exposure of the different geological formations noted. Details obtained with

regard to the geological profiles of mountain and valley structures will be expressed in their proper places in a series of profile maps.

Upon returning from the field, the topographers immediately commenced the reduction of field notes on a scale of one inch to two miles, which reductions, in the hands of the office draughtsmen, were afterward transferred to the finished atlas sheets.

The areas covered topographically during the year have exceeded fifty thousand square miles, and lie in Western and Southwestern Utah, Eastern Nevada, and Northwestern Arizona. The length of lines in the vicinity of which surveys have been made is six thousand one hundred and twenty-seven miles.

In addition, the number of miles necessary to be traveled, for the purpose of supplying parties, and in making connections, have been two thousand and sixty-seven miles. The plan of moving in parallel parties, along practically north and south lines, taking advantage of the natural features of the country, has materially facilitated in the accomplishment of so great results.

BELKNAP PEAK.

Plate I is a small section of atlas-sheet No. 59, and illustrates, by means of the photo-lithographic process, the character of the details gathered in, in topography.

The peak in question, to which I have taken the liberty of affixing the name of Belknap, after the Hon W. W. Belknap, Secretary of War, because of his generous support of projects for exploration and survey in the interior, is approximately 11,680 feet above sea-level. It is the highest point of the Beaver range, Utah, and one of the most commanding peaks in this section of territory.

The Beaver range is here crossed, so to speak, by a diagonal eruptive belt of rhyolitic lava, and the peak in question is of volcanic material.

The view from the south gives a fine relief; this peak having a very clear definition, noticeably higher than the one called "Old Baldy" by the residents of Beaver Valley and vicinity. It is some what higher than the latter point, and from the town of Beaver it hides Belknap Peak from view. From the southeast and north this point is remarkably prominent.

The title of "Old Baldy" so well expresses the peculiar shape and bare surface of this mountain mass that it has been deemed fit to retain its name when applied to the point first mentioned.

An explanation has been deemed necessary in order that there shall be no confusion of terms.

METEOROLOGICAL.

At the main astronomical stations, meteorological observations, consisting of a full series obtained by the use of cistern and aneroid barometers, detached thermometers, anemometers, and rain-gauges, have been conducted. These series extend over an interval of from fifteen to thirty days. At several field-stations hourly series have been prosecuted, over an interval of from five to seven days. The remainder of the meteorological work was carried on in connection with the topographical lines of travel, and the results are of practical value in the determination of the relative profiles of the different routes, and for the determination of altitude positions for the map.

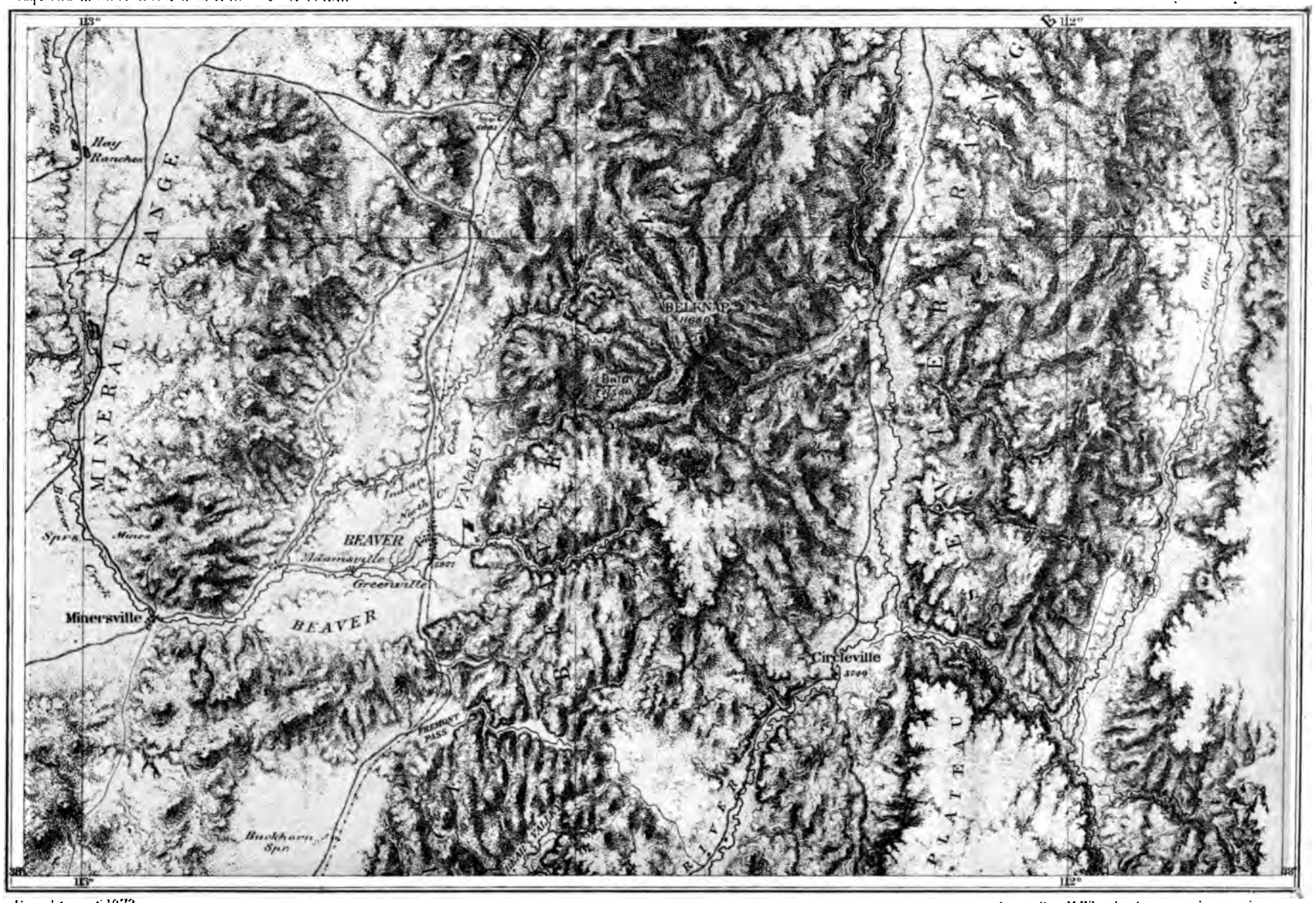
A large mass of material has accumulated in this department; the results from it, in a digested form, with the plates, showing graphically the general oscillations of the barometric column, its horary changes, combined with monthly and other means, will be embraced in volume III of the published quarto series of the survey.

GEOLOGICAL.

The following assistants have carried on their labors in this department during the season: Messrs. G. K. Gilbert and E. E. Howell. The progress report from the former is herewith, and marked Appendix D.

It is proposed from year to year to so combine the *personnel* of the several field-parties as to be able to make as soon as possible a connected geological survey as well as a topographical one.

The time heretofore allowed to the geologists has not been sufficient for such a purpose.

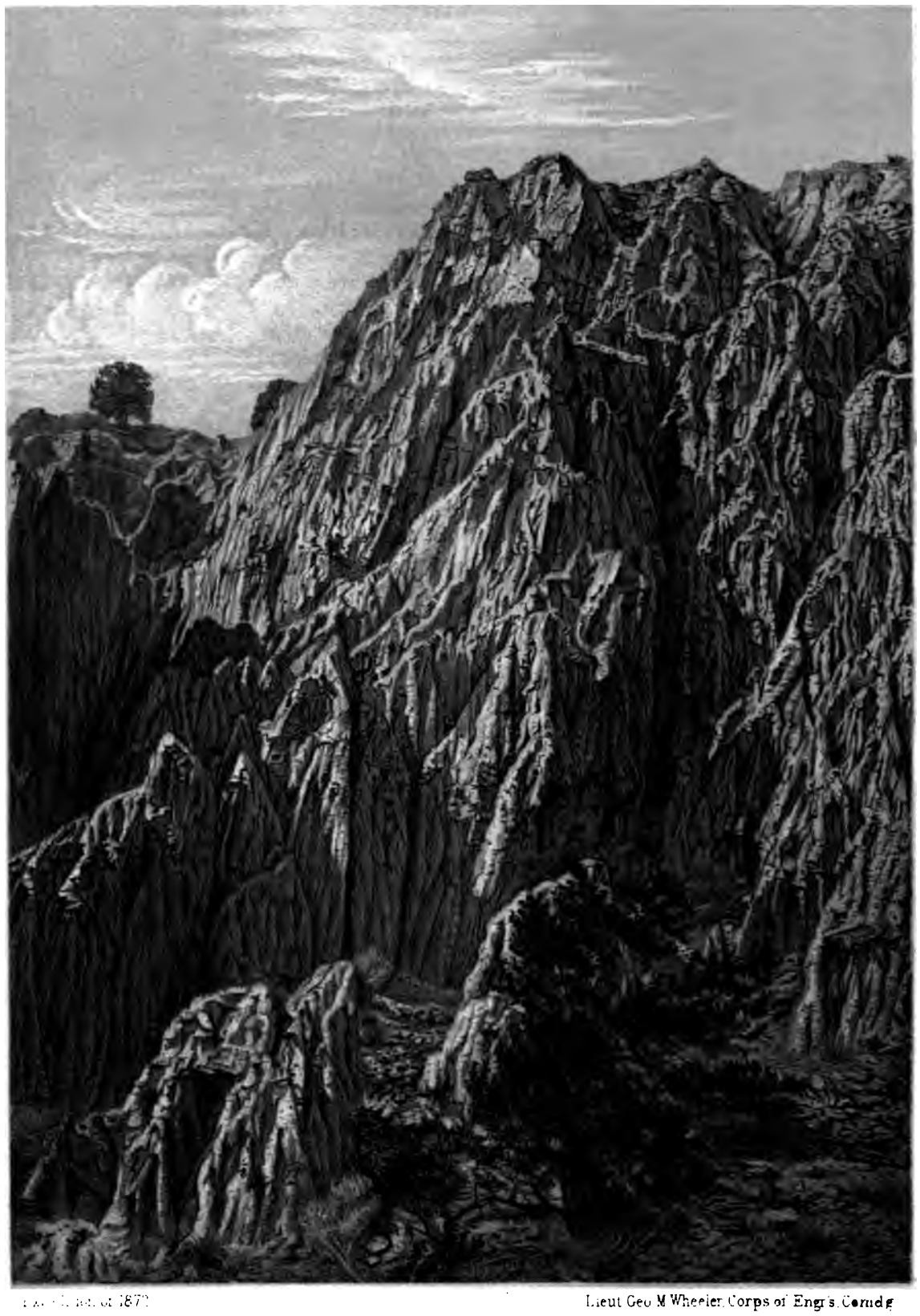


Expedition of 1872

Lieut Geo M Wheeler Corps of Engrs Chief

CAMP AT BEAVER. BELKNAP PEAK AND VICINITY. UTAH.

Scale 1 [illegible]



Lieut Geo M Wheeler Corps of Engrs Comdg

RAIN SCULPTURE-SALT CREEK CAÑON-UTAH

However, it is believed that their results will not prove without value as an aggregation, systematically expressed, to the knowledge of the geological forms found in our western territory.

The results of the years 1871 and 1872 will together form the greater part of volume IV, proposed for publication.

I will here state that in volume V. it is intended to embrace a report upon the vetebrate and invertebrate fossils (also upon the fossil plants) collected by the survey up to the close of the field-season of 1873.

In Plate II is represented a very peculiar style of sculpture, executed by rain in half consolidated sands and conglomerates and in the softest water-rhyolites. The material, in this instance, is a local sand and gravel deposit, at the eastern base of Nebo Peak, Utah. Similar fluted escarpments are to be seen at numerous localities in Nevada and Arizona as well as in Utah; but in more humid regions I am acquainted with none of purely natural origin. Steep earth slopes, laid bare in railroad-cuttings, are sometimes carved by the rain in similar fashion; but the frost soon destroys its work. In the dry air of our desert States and Territories, however, a steep escarpment rarely remains saturated with water long enough to be disintegrated by freezing.

It is in the presentation of such subjects as these that the camera affords the greatest aid to the geologist; only with infinite pains could the draughtsman give expression to the systematic heterogeneity of the material, and, at the same time, embody in his sketch the wonderfully convoluted surface, so suggestive of the folds of heavy drapery.

But to photography the complicated is as easy as the simple, the novel as the familiar. The negative once secured, the observer may at any time, and at his leisure, restudy the view, of which a hurried visit has given him but a first impression; and more than this, he is enabled to publish its lesson, or its story, with the vividness that pertains to all graphic illustration, and with a guarantee of accuracy afforded only by the work of the sun.

[NOTE.—Taken from the MS. of Mr. Gilbert's finished report.]

COLLECTIONS IN NATURAL HISTORY.

The duties of this department were intrusted to Acting Assistant Surgeon H. C. Yarrow, United States Army, and H. W. Henshaw, civilian-assistant. At times they have received a trifling amount of voluntary aid from certain other members of the expedition.

A report from Doctor Yarrow will be found marked Appendix E.

PHOTOGRAPHY—MISCELLANEOUS.

In photography we have had the assistance of Mr. William Bell, an artist from Philadelphia, through whose valuable and energetic services have been obtained a series of landscape and stereoscopic negatives, illustrating many geological and other features in Utah and in the Grand Cañon of the Colorado. I would here mention that Mr. Bell has successfully used the dry-plate process with negatives prepared by himself, and is worthy of commendation for his interest and industry in his attempt to perfect this process.

I will also state some of the practical uses which may result from the application of the art of photography as an auxiliary in our interior surveys.

It has been considered that the professional uses of photography, as an adjunct to a survey of this character, are few, so far comparatively little good beyond that which is of general interest as expressive of the scenic features of specified areas. The material data gathered from its use apply only to the departments of geology and natural history.

In these departments, where, as is well understood, we are obliged to leave the field of exact science, the special value that comes from a geological series of photographs results in the determination of a relative comprehension of the size and contour of the rock-beds and of the general features of the topography of the country.

Should we, by the application of skilled labor and the refinement of instruments, be able to give a value to the horizontal and vertical measurements upon a photographic picture, at once the subject changes and an addition to positive data is gained. I have faith that this matter may be so far advanced from its present stage as to secure these features. Should this prove so or not, I

would recommend, in connection with the continuance of the survey, that, as soon as possible, a permanent photographic outfit be attached to it, which, at reasonable expense for field and office purposes, would annually increase the effectiveness of these branches of the survey, and may be made of large practical value in the preparation of material for the publication of maps and illustrations, should it be deemed at any time advisable, determined by the wants of other branches of the War Department, to organize a photographic establishment connected with the War Department, having an assistant in charge and several practical photographers, who could be detailed to expeditions moving in the interior.

It is probable that the entire needs of the department, and this survey included, could be met at no very great expense by the facilities that would be offered through such an establishment. Should this subject meet with favorable consideration, a report, accompanied by specified estimates, may be at any time submitted proposing the requirements for such an establishment.

In ethnology, Mr. M. S. Severance has collected certain data, as has also Dr. H. C. Yarrow. A full report containing these investigations will appear in volume I, or the general volume, which is to embrace the detailed reports of the officer in charge and of the executive officers of the survey; also, the records of mining examinations, involving chapters upon various subjects included within the scope of the survey.

Plate III is a lithographic representation from a camera-negative taken while in the field. It is a section of one of the many side-cañons that open into the Main or Grand Cañon of the Colorado, and shows what photography may do in securing profiles, local in their character, of peculiar structures.

Expedition of 1872. Lieut Geo M Wheeler, Corps of Engr's, Comdg

CAÑON OF KANAB WASH-COLORADO RIVER-LOOKING SOUTH.

CHAPTER II.

MINING-DISTRICTS AND MINES—AMERICAN FORK, LITTLE COTTONWOOD, BIG COTTONWOOD, EAST TINTIC, SILVER BELT, AND WEST MOUNTAIN DISTRICTS, UTAH—MINE OF THE UTAH SILVER-MINING COMPANY, UTAH—CAMP FLOYD, OPHIR CLIFTON, NORTH STAR, STAR, ROCKY, LINCOLN, GRANITE, OHIO MINING, IRON SPRING, BEAVER LEAGUE, IRON, PINTO, AND MOUNT NEBO DISTRICTS, UTAH—SCHELL CREEK, RUBY HILL, SILVER MOUNTAIN, PIERMONT, BRISTOL, EAGLE, AND SAN FRANCISCO DISTRICTS, NEVADA—IRRIGATION—AGRICULTURE—ROUTES OF COMMUNICATION—SITES FOR MILITARY POSTS—TIMBER-LANDS—INDIANS—COLORADO CAÑONS.

MINING-DISTRICTS AND MINES.

During the season forty-eight mining-districts have been visited and examined; of these, twenty-five are in Utah, twelve in Nevada, and eleven in Arizona. The time at our disposal and the distribution of forces did not always admit of so thorough an examination as seems desirable. Where our labors have been, as it were, only a reconnaissance of the work, the preliminary information, quite geographical in its character, will give the necessary data, to which we may refer when larger developments at any given place shall seem to demand, on the part of the Government, more detailed surveys of superficial areas surrounding the mineral belt or of the underground workings. The class of questions to which it has been our attempt to give answers appears in the preliminary report for 1871. The following precious and economic minerals have been observed, viz: Gold, silver, copper, lead, iron, sulphur, gypsum, salt, chalk, bismuth, coal, &c.

A portion of the interesting facts connected with the results of our examinations will herewith be presented in regard to each district separately.

Leaving the terminus of the Utah Southern Railway as the extreme point within our area to which railroad-communication has been carried south from the fortieth parallel, and sensibly along the Salt Lake meridian, we find that the results of prospecting have discovered a large number of mineral districts in different parts of Utah. A stimulus to these discoveries was given by, and resulted from, the fact that large and valuable mineral properties had been found and had been worked in the Wahsatch and Oquirrh ranges that encircle the southern part of the Salt Lake Valley. Consequent to their discovery, location, and working, a large Gentile population appeared upon the scene, and distributed themselves over various districts discovered in the localities mentioned. They gradually traversed different ranges, extending southward and southwest in the hope of finding similar and larger deposits. The thriving mining-town of Pioche, Nev., thus became a center from which one prospecting party after another emanated into other parts of Southeastern Nevada, Southwestern Utah, and Northwestern Arizona.

In many cases the hopes of these adventurous men have been fulfilled, and among the large number of mining-districts discovered and located there are several, such as the Schell Creek, North Star, Ophir, Long Valley, and Hualapais districts, that bid fair to become permanent camps. In many other localities where the surface-exposures found seemed to promise largely, little mining-camps have either been deserted or a limited amount of work is kept up by the hardy pioneers, only to be suspended upon the exhaustion of their supplies.

In this way a scratching only of the surface is made; and, although it takes long to overcome the lost reputation of an abandoned district, still in most of these cases nothing has been done at all toward determining the problem whether or not a compensating amount of precious metals can be found after the requisite preliminary exploration. Where work has been carried to a considerable extent and mines opened along several levels, it may prove that the ores are so meager, and, because of the large cost of the transportation of supplies and material to and from the districts, and the high price of labor, it is not a profitable investment to continue mining farther.

In many cases, after the time necessary to push forward interior communication, and more

accurate and detailed knowledge of the vast mineral veins in many of these mountain-ranges shall have ensued, we may expect a resumption of labor, and that capital will naturally become more and more attracted to these localities. So far, most of the silver ores discovered in Utah belong to the smelting class, and the want of proper fluxing agents, as one cause, and the scarcity of timber and fuel as another, are becoming severely felt.

Beds of carbonate iron ores have been discovered in certain localities at the southern end of Salt Lake Valley, and a more thorough search ought to develop others. Small seams of fluor-spar ore have also been found in various parts of the Territory, and a number of beds of iron ore have been found. It is not feasible, generally speaking, to transport by wagons a natural flux over a distance greater than thirty miles. Local narrow-gauge railroads would, however, render accessible and valuable many of these beds.

The cost of charcoal is fast increasing, and its utility as a heating-power in fluxing is so much less than that obtained by using a large share of coke, that it has been found profitable to transport the latter material, of which a superior quality is made at Pittsburgh, Pa., for use in smelting, south of Salt Lake, and at Corinne, Utah. So far, none of the beds of coking bituminous coal that have been discovered in Utah have been made to appear valuable to take the place of coke, transported so great a distance and at large expense. It is understood that explorations through private sources are going on in connection with these coal-beds. Should they prove of considerable extent and of proper character, as doubtless they may, their future use in connection with the reduction of the argentiferous ores of Utah will become very important.

At the very interesting mining-district of Pioche, Nev., a critical contour survey was conducted with a view to the geological representation of the country rock and its connection with the different mineral bearing veins. This survey presents many interesting facts, and will admit of some valuable speculations in regard to the continuance of mineral bearing veins in other parts of the Ely Mountains.

AMERICAN FORK MINING-DISTRICT, UTAH.

This district was discovered and organized in July, 1870, and has been worked continuously since that time. The area covered by mineral croppings is about twenty-four square miles, *i. e.*, southeast and northwest about six miles, and four miles wide. The principal mines now worked are the Miller, Pittsburgh, Mary Ellen, Live Yankee, Silver Glance, United States, Champion, Major Evans, and Wild Dutchman. Miller, the mine bearing about north 80° east, is a series of deposits in galena and carbonate ores, and is entered in two places by tunnels. In one place the deposit runs north 20° east, at another nearly east. An immense body of ore is in sight. Forty-five men now take out fifty tons, the amount that can be smelted by the furnaces. The tunnel at highest level and nearly due north from the other followed ore all the way, and at a distance of about 45 feet has opened upon a large body. At the other, ore first occurs at a distance of 130 feet, then it inclines more to the north, following sensibly the trend of the deposit, thence swinging more to the north until barren ground is reached, which carries, however, a discolored seam that is expected to reach other pockets a little farther to the southward. At a lower level, in a ravine, a tunnel has been started and run for more than 300 feet, with a view to reaching bodies of the ore. On the eastern slopes of this spur, between American Fork proper and its northern branch, a tunnel has been started with the intention of working from that point, and has been run 220 feet. If successful, it is expected that a railroad will be carried there. The Miller mine-ledge lies along a prominent spur between American Fork proper and a creek coming in from the north and westward. Near the top of the ridge, from ravines of the ridge to the westward, even to the summit, prospects are found; *vide* Silver Glance, Live Yankee, &c. Pittsburgh is at the north end of the American Fork. The district has not been sufficiently developed to determine the general direction of lodes, deposits, and stratifications, nor the relations existing between the richness of the veins and the local character of the country-rock. There is a series of deposits running at various angles. The ores are smelting, though some milling ores have been found near the summit and opposite the Miller. Gold occurs, reaching as high as $25 to the ton of base bullion; seldom less than $20. The Miller Mining and Smelting Company have the only reduction works yet erected, consisting of

three blast furnaces, one 25 horse-power engine, and No. 10 blower, (the largest in the Territory.) Messrs. Hilleguist & Ward have erected a reverberatory furnace for melting the ores, consisting of furnace, reverberator, and another chamber with three openings that distribute the heat. The ore is matted as it is moved through the reverberatory chamber, introducing a small portion of sand and lime. They intend using hard cord-wood. The cost of three furnaces was $8,000; 25 horse-power engine, set up, $3,600; building, say, $8,000; Brady's crusher, blower, shafting, &c., $2,500; cost of reverberatory furnace, $4,200, more than ordinary expense in bringing the material up the cañon. Thirty thousand dollars should cover the cost of a three-blast furnace, engine, &c. For each furnace there would be required 3 melters, 3 helpers, 3 feeders, 2 laborers, 2 engineers, 1 blacksmith, 1 helper, and 1 carpenter. The average cost of mining the ore is $4 per ton. The Miller is working 45 men for 50 tons of ore. Average cost for smelting is $11 per ton. Coal is cheap and conveniences well arranged. The average cost of mining labor is $3 per day and board; laborers, $2 and $2.25 per day and board. The average cost of sinking a shaft in the Miller is $10 per foot. Transportation facilities might be increased by a proper tramway from the mine. It costs at present $4 per ton for hauling ore from the mine, a distance of four miles. There is no immediate chance of decreasing the price of labor. Grain costs 3½ cents; hay, $40 per ton. The sources of supply are the Mormon settlements in Utah County. The Miller mine has a small spring, permanent and near the mine. Great quantities of quaking-asp, fit for fuel and charcoal, are in the vicinity, and some timber from 16 to 20 inches, sawed at a mill (private property) at Forest City. The district contains 400 inhabitants. There is no regular stage-line. Freighting is done by the company and by Mormon teams, small wagons and two horses or mules. The roads are mountain trails and side-cut roads. The Uintah Ute Indians belonging to this section are supposed to be on their reservation. The American Fork Railway (narrow gauge) is in process of construction, running from American Fork on the Utah Southern to Forest City, about nineteen miles.

LITTLE COTTONWOOD MINING-DISTRICT, UTAH.

This district was organized August 15, 1868. An old district, called the Mountain Lake district, was located in 1866, and embraced the areas afterward known as American Fork, Big and Little Cottonwood districts, since which time areas from the western and eastern ends of Big Cottonwood have been cut off, and the Argent and Howland districts respectively have been formed. The latter very possibly covers also areas from other districts. Soldiers from Camp Douglass came into the cañon in 1864, and located several claims, after which, in 1866, Mountain Lake district was formed, with James Wall as the first recorder. The district has been worked continuously since that time. However, vigorous prosecution of developments did not begin until the summer of 1870. September 1, 1872, there were 1,450 locations on record, and about 250 locations on Mountain Lake books. The distance to railroad communication is about sixteen miles, down Little Cottonwood Cañon to Sandy station, on the Utah Southern Railroad, which point is twelve miles from Salt Lake City. The mining-ledges lie along the sides of main spurs of the mountains that trend sensibly westward from the main ridge; the principal locations in the vicinity of Emma, &c., being on the southeast face; while on the opposite side of Little Cottonwood Creek, they face toward the north. Most of the deposits occur in the northern part of the district. From Grizzly Flat, as far west as Flagstaff, the whole mountain is known as the Emma Hill. Still farther westward, we come to Frederick Hill and Davenport Hill, north and east from Grizzly Flat. In Vallejo the harder the rock the richer the ore, and *vice versa*. The metamorphosed mountain-limestone has no regular dip; the strike is to the eastward, the entire bed resting on quartzite. The ores are worked by the smelting process so far. In certain mines there are indications of a change towards milling ore. Galena ore averages to yield (according to Mr. McDonald) between $90 and $100. The ore in the Windsor mine is the most likely to change into milling ore. Assays show the presence of gold in the silver-bearing ores. In Superior Gulch certain silver-bearing ores near the surface have given as high as $40 per ton. The principal mines now worked are the Emma, Flagstaff, Davenport, South Star, Savage, Montezuma, Grizzly, Hiawatha, Last Chance No. 2, Highland Chief, Ohio, Frederick, Titus, Wellington, Pocahontas, Enterprise, Peruvian, Ida Brown, Lapham, and Lexington. The first sixteen are well developed

and paying mines. There are fifty or sixty others partially developed, showing good indications The Brown and Lapham are on Davenport Hill; shaft run 100 feet. The Lexington is much talked about, but is not supposed to be good. The Frederick is one of the most westerly mines in Little Cottonwood, and not far from the Reed and Benson, over the divide in Big Cottonwood. The Last Chance, Hiawatha, Montezuma, and Savage have been consolidated under the name of Windsor Utah Silver Mining Company, incorporated in Detroit or New York. On the Last Chance an incline of nearly 100 feet has been run, following ore nearly all the way, and opening into a wide body at the bottom, bearing north 20° east. The Hiawatha, an incline of 115 feet with little faults here and there, bearing north 10° east. The ore in most of the distance not so high a grade as in Last Chance and in Montezuma; incline angle is 30°, a distance of 230 feet, much faulted, breaking up badly near bottom. A rich body of ore has been taken from the Eagle; incline slightly to the westward; distance, 80 feet. Farther east again comes the Savage, opened first by a vertical shaft 120 feet, giving good results as regards ore. A little farther to the east and down the hill, the Savage tunnel has been driven 260 feet, meeting a drift from the shaft at this point. The ledge pitches to the eastward, bearing north 30° to 35° east. Two wings have been sunk near the end, one 32, another 40, on the vein. A little farther on, a branch-tunnel to the westward will tap the three others. There are only furnaces here; the Flagstaff furnace at the mouth of the cañon; one blast furnace and no reverberatory. The Davenport is now building a smelter in that vicinity. At Sandy, the Saturn furnace, an English incorporation, and smelting only. Wellington furnace, at Tannersville, did not work very well. Vallejo has no furnace; they have sold their ore so far to the Saturn at Sandy. The average cost of mining the ore is on Grizzly, say, in gross, $4; Emma, $3.50; and Windsor, $5 per ton. The average cost of mining labor is from $2.50 to $3 per day and board. The average amount of ore that can be extracted per day by one man is four tons on the Grizzly and two tons on Windsor. Average cost of running a drift on a main vein is from $4 to $7 per foot. There is no chance for a decrease in cost of labor. Freight may be reduced but little, and is higher during the winter. Corn costs 2½ cents; hay, $40. The mountains in this cañon are scantily supplied with a sparse growth of pine and cedar; much of the latter is now being burned for charcoal, and coke will soon have to supply its place, and coal for fuel. No large timber of any great amount is noticed. The water comes from the north and south forks of Cottonwood Creek, that join near the town. It shows the beautiful clear mountain-water that comes from the melting of the snow. The district contains about 1,800 persons. There are numerous freight-lines, large and small, principally Mormon. The road from Sandy station to Alta is an entire up-grade, and much used both by heavy and light transportation. Considerable sand occurs at various intervals, and this, with the frequent occurrence of bowlders often entering the mouth of the cañon, makes it anything but comfortable. Lately $14,000 have been subscribed by the miners, but this will only repair the present road. Nothing short of a regular grade, well covered with gravel, will answer the purposes of the camp. The territorial legislature is averse to issuing charters to Gentile toll-roads, hence the difficulty. The road belongs to the county as far as the mouth, and thence has been made by private enterprise.

BIG COTTONWOOD MINING-DISTRICT, UTAH.

[From notes furnished by M. S. Severance.]

This district was discovered in 1864, and located, as the Big Cottonwood mining-district, March 17, 1870. It has been worked continuously ever since. The area covered by mineral croppings is about forty square miles. The ores found are smelting. Assays show the presence of small percentages of gold in the silver-bearing ores. The principal mines now worked are the Reed and Benson, Comet and Robert Emmet, (near the Reed and Benson,) Marine, Pannacca, and Kingsberg, (Mineral Fork,) Sailor's Jack, Provo, McDougall, and Homeward Bound, (Kesler's Peak,) Richmond, Theresa, Congress, Davenport, Wellington, Highland Chief, Prince of Wales, and Wandering Boy, (Silver Fork,) Beckwith, Casper, and Wahsatch, (Honeycomb,) Ontario, Mullen Zook, Evergreen, (South Fork of Mineral Fork,) Mountain Lake, Brighton, Day, Bemoth, and Mastodon, (Silver Lake,) Elgin, Eclipse, Scott, and Golden Era, (Scott Hill,) and Maxfield. There is one smelting-furnace, the Hawk-Eye, not running at present.

The average cost of mining labor is about $2 to $3 and board per diem. Hay costs about $1.50 per hundred-weight, and $35 per ton for hauling; grain, about 4 cents per pound, and 1 cent per pound for hauling; all from the valley below. There are six saw-mills, and there is plenty of wood for charcoal and fuel. Water is supplied by the Big Cottonwood; it has to be carried to Kesler's Peak and Reed and Benson. There are 400 or 500 inhabitants in the district. There is one stage-line from Salt Lake direct, which brings mail and express matter. Private parties, principally Mormons, do the freighting. The country-roads are fair. No Indians in the vicinity.

EAST TINTIC MINING-DISTRICT, UTAH.

[From notes by Lieut. W. L. Marshall.]

This district was discovered and organized December 13, 1869, and has been worked continuously since that time. The mineral croppings cover about one-third of the area of the district, or about 32,000 acres. Shape irregular, with trend of longer axis north and south. The mining-ledges are generally on foot-hills to main range, on both slopes. The trend of mountains is north and south, ridges and foot-hills east and west, and ledges perpendicular to axis of foot-hills and secondary ridges. The general direction of lode-deposits and stratification varies from northeast and southwest to northwest and southeast or northerly and southerly. Lodes mostly perpendicular, or, when not perpendicular, dip to the west under angles of from 75° to 85°. No relation is found to exist between richness of vein and character of country-rock. Where the country-rock is stratified, lodes conform to stratification, save where breaks perpendicular to strata-planes occur. The ores are both free, milling, and smelting. Not worked in the vicinity, but sold to other parties for reduction elsewhere. Gold is shown principally in the cupreous ores in quantities varying from a mere trace up to $43,000 per ton. The principal mines now worked are the Mammoth, prospected to a depth of 250 feet; vein from 11 to 42 feet in width; average assay, $130 per ton in copper, $162.86 in silver, and from $76 to $507 in gold. Ore principally malachite, and red oxide of copper, with silver and free gold. The Mammoth Copperopolis, on same ledge as the above and of the same character, $450,000 in ore, shipped for reduction.

Eureka.—Four lodes, separated by from 15 to 25 feet of limestone; five shafts sunk from 60 to 95 feet deep; 10,000 tons ore on the dump; average assay, $180 per ton; $150,000 of ore sold; about to erect mills and smelting works; ores are carbonates, chlorides, quartz, and cupreous.

Swansea.—Argentiferous galena.

Sunbeam.—Argentiferous galena and yellow carbonate of lead and silver.

Chicago.—Cupreous ores of silver, with free gold.

Joe Bowers.—Argentiferous galena.

The Morning-Glory, Diamond, and Black Dragon.—Cupreous ores of silver and argentiferous carbonate of lead.

There are many other claims and ledges in the district, many of them very promising, but not so far developed as the above. Sixteen ledges of argentiferous carbonate of lead and quartz ores had just been discovered at Homansville, averaging $20 per ton at the surface. There is one mill, (not completed,) 24 stamps, (800-pound stamp,) 75 horse-power engine, 2 boilers, 2 smelters, unfinished. The cost of a 10-stamp mill erected would be $40,000. An ordinary smelting-furnace costs nearly the same, including transportation and expense of construction. The average cost for mining the ore is from $4 to $6 per ton; mining labor averages $3.50 to $4 per diem. One man can extract about 2 tons of ore per day. The average cost of running a drift on a main vein is $10 per foot; grain costs 3 to 4 cents per pound; hay, $25 per ton; no facilities for raising farm-produce. There is a good stock range. The sources of supply are the Mormon settlements in Juab and Utah, Utah Territory. There is plenty of wood for fuel, but no good timber on the mountains and foot-hills. Timber is hauled more than thirty miles from the Wahsatch at a cost of 4½ cents per foot. Water is limited; about Eureka and Homansville are several good springs; elsewhere in the district water can be found by sinking wells in the cañons from 30 to 95 feet. The district contains 600 inhabitants. There is one stage-line, (Wells, Fargo & Co.,) but no regular freight-lines. At present, it is fifty miles to the terminus of the Utah Southern Railroad, which will eventually run within twenty-four

miles of the district. A project is on foot to build a narrow-gauge road from Salt Lake to Eureka The country-roads are rather rough in the mountains, but generally good. There are no Indians in the vicinity.

SILVER-BELT MINING-DISTRICT, UTAH.

[From notes furnished by Lieut. W. L. Marshall.]

This district was discovered March 27, 1872, organized July 25, 1872, and was worked continuously up to September, 1872. At present it is nearly deserted. It is two hundred miles to the terminus of the Utah Southern Railroad. The nearest route is by Beaver and Fillmore. The area covered by the mineral croppings is about 1,800 acres in Bullion and Chloride Cañons. Trend of longer axis is north and south; shape is irregular. The mining-ledges lie on the west side of the main range in secondary ridges, which trend east and west. The general direction of lodes, deposits, and stratifications is northwest and southeast; country-rock, quartzite veins, dips under various angles from east to west, generally nearly vertical. Very few assays have been made, and no relation has been discovered between richness of vein and local character of the rock; the ore is base and could be melted or roasted. Assays do not show the presence of gold in any of the silver-bearing ores. The mines are not developed, as a rule; barely sufficient work having been performed to enable the miners to hold their claims.

The Flagstaff lode strikes north-northwest to south-southeast; dips to the west-southwest at an angle of 34°; width of vein, 2½ feet. An incline has been sunk about 50 feet. Only one assay has been made, which showed $126 per ton. The cost of a mill could not be ascertained. A 10-stamp mill will be erected near the sink of Pinto Creek within four months. The average cost of mining labor is $3 and board per diem; 500 pounds is the average amount of ore that can be extracted by one man in one day; the average cost of running a drift on a main vein is $20 per foot. At present there are no chances for a decrease in the expenses of any of the items incurred in mining industry. Hay costs $20 per ton, and grain $3 per hundred pounds. There are no farming facilities, and the sources of supply are the Mormon settlements to the east. There is no timber, but an abundance of cedar and juniper wood on the mountain-sides in the immediate vicinity. There is a spring (1-inch vein) about three miles north of the mines, and Antelope Spring is about six miles distant. Water can be struck by sinking wells in the desert from 60 to 75 feet. There are 12 inhabitants in the district. The country-roads are very good.

WEST MOUNTAIN DISTRICT, (BINGHAM CAÑON,) UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

This district was organized September 17, 1863. The mines lie along Bingham and confluent cañons on the eastern slope of the Oquirrh range. The general dip of the country-rock is westward, but it is locally much diversified; the deposits probably all conform to the bedding. The ores are base, of low grade, chiefly smelting; the silver-bearing ores show traces of gold only; gold is mined in gravel deposits of the cañon, but has not been found in lodes. The principal mines now worked are the Winamuck mine of the Utah Mining and Smelting Company, (limited,) Lucky Boy, Fanny Fern, Galena, Spanish, Saturn, Crœsus, and Last Chance.

The Winamuck mine, Winamuck County, (on the ground of Messrs. Daggett & Bristol,) is described as follows: Strike southeast; dip 33° northeast; foot-wall quartzite; hanging wall an altered sandstone impregnated with metalliferous minerals; vein-matter quartzose unoxidized ore, argentiferous galena, pyrite present as an impurity, slight copper-stains; thickness of vein 18 feet; average 5 to 6 feet; fissure-walls good, in places conspicuous. Principal body of ore reached is oxidized, the lead being in the form of an oxide, and the silver (supposed to be) in that of chloride. There are two tunnels on the vein, 450 and 500 feet; incline, 260 feet. Little Stocking, located on the south side of cañon, one mile below Monument. Mine was bonded by present owners, and after exploration, purchased of original locators (eighteen months ago) for $13,000; since which, it has been put in the English market. Twenty-five men are employed.

MINE OF THE UTAH SILVER-MINING COMPANY, (LIMITED.)

J. R. Murphy, superintendent. Located about two miles above the Monument. Strike north 30° east; dip 55° northwest; walls quartzite; vein-matter quartz; ore low-grade argentiferous galena; pyrites present. Depth of main shaft, 112 feet; total, tunnels and drifts, 170 feet—no admittance. There are two smelting-furnaces: Winamuck Smelter, Blake's crusher, 8 by 10 feed-stack; from feed-floor to base 16 feet; diameter at feed-hole, 4½ feet; diameter at tuyeres, 3½ feet; gradual taper down; six 2½-inch tuyeres; slag-flow 10 inches below blast; crucible 18 inches below slag-flow and 18 inches above foundations; crucible 42 inches across by 18 inc hes deep; 2 stacks; cold blast; No. 5 Roach blower; pressure 1½ inches mercury. A 25 horse-power engine runs the blast and crushers. Charge added about every eight minutes; stacks are in charge twenty-five to thirty days. To each ton of ore are added 803 pounds of hematite, 204 pounds of limestone, and 33 pounds of slag, with 68 bushels of charcoal, (probably a mistake.) The ore used ranges from 28 per cent. to 38 per cent. of lead; bullion runs from 100 to 300 ounces of silver per ton; average yield of ore in silver, 50 ounces per ton; lead worth $60 per ton on the ground; production, 5½ tons of bullion in each twenty-four hours. The bullion is shipped in part to Omaha and in part to New York via San Francisco. Total cost of a ton of ore reduced to bullion, $42. Hematite, for flux, comes from Rawlins, Wyo; limestone is hauled three miles from dry fork of Bingham Cañon. Fire-brick brought from Denver, Col.; cost on the ground, $160 per 1,000; 4 men on each shift of eight hours and 2 engineers. Daily assays are made of ore on the car, and again in compiling the charge; also of bullion and slag. Smelters of the Utah Silver-Mining Company, (limited.) The stacks are respectively 16 and 14 feet from feed-floor to tuyeres; larger, 4 feet 6 inches by 3 feet; smaller, 4 feet by 2¾ feet; eight 2½-inch tuyeres in larger, five in smaller; cold blast; pressure not above 1 pound per inch. The charge (150 per day) is 282 pounds ore, 70 pounds hematite, 16 pounds limestone, 90 pounds charcoal. The hematite comes from Rawlins, Wyo., and costs $25 per ton; limestone is close at hand, and costs $5 per ton; charcoal from Truckee and Weber, at 30 cents per bushel. The production is 5 to 6 tons base bullion; maximum yield of silver, 45 ounces per ton bullion. The average cost of mining labor is $3 to $4 per day. Fuel and timber in sufficient quantity is within the limits of the district, and water is abundant. There is a running stream through the cañon, used for hydraulic mining. The district contains from 300 to 400 inhabitants. There is one daily stage-line to Salt Lake City. The country-roads are good eastward, but very high grade; trails over the mountains westward.

CAMP FLOYD DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

This district was organized April 16, 1870, and worked continuously since that time. The nearest railroad communication is Lehi on the Utah Southern Railroad, distant about — miles. The ledges are near the head of a cañon opening to the west. The trend of the range is north and south; the general dip is northeasterly; the lodes dip with the strata; the ores found are free-milling. The principal mines now worked are the Sparrow-Hawk, Silver Cloud, Queen of the West, Mormon Chief, Silver Circle, and Star of the West. There is one 20-stamp mill, owned by the Camp Floyd Silver-Mining Company, (limited,) with one 123 horse-power engine; cylinder, 18-inch; stroke, 42 inches. The ore is dried before crushing; screens, 50 to the inch; 8 combination-pans, 4½ feet in diameter; 4 settlers, 7 feet in diameter. The mill was made by H. G. Booth & Co., furnished on contract by White & Allen, for $65,500. An Aikin furnace was also built, for $12,000, but proves unnecessary; the mill saves 88 per cent. of pulp-assay. Fuel costs $5 per cord; cedar, pine, and mahogany being used. The average cost of mining labor is from $3 to $4 per day. There is timber and a saw-mill in East Cañon. Water is brought 14,000 feet in asphalt pipes, at a cost of $5,000. The district contains 300 inhabitants. The country-roads are high-grade toll-roads.

OPHIR DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

This district was formerly included in the Rush district, which was discovered in 1864; Ophir district set off August 6, 1870, and has been worked continuously since that time. It is about

twenty-five miles via Lewiston and Fairfield to Lehi, the terminus of the Utah Southern Railroad, the nearest railroad-point. The mining-ledges lie along the west slope of the Oquirrh Range. The rocks dip toward all points of the compass from the town. Most of the lodes conform to the strata. The best-developed mines were not open to inspection. The ores are of great variety, but chiefly adapted to mill with water. The Pioneer Mill, Walker Brothers, has a capacity of from 25 to 30 tons. It is supplied with a Blake's crusher, 15 stamps, (750 pounds;) screens, 50 to the inch. The ore is dried over the smoke-flue.

Aikin furnace 5 per cent. of salt and a little lime is added; 6 Wheeler pans; 3 settlers; amalgam cold, strained; bullion 800 to 997, in silver; impurity chiefly copper; 80 to 95 per cent. is saved from pulp-assay. Walker Brothers work their own ore, and buy from others by Reno scale of prices. Salt from Bear River costs $18 per ton delivered; lime is made close at hand, at 50 cents per bushel; capacity of the furnace is 40 tons; engine, 80 horse-power; cylinder, 16 inches; stroke, 32 inches; fuel costs $4 per cord. There are three smelters, but none were in blast at the time of our visit, and it is currently held that there is not enough smelting-ore produced in the district to keep them supplied. Smith and Windiate offer for ore the Reno scale for the silver, plus 25 cents for each 1 per cent. of lead. Theirs is the only smelter visited. Mr. G. M. Gerrish is superintendent; 1 stack, (another building,) 28 by 30 inches, 13 feet from feed-floor to tuyeres; six 2-inch tuyeres; lining, quartzite; charge, 100 pounds carbonate ore, 20 pounds charcoal, 3 pounds limestone. The ore contains some hematite. Ores average $150 in silver and $10 to $20 in gold. When galena ore is used, a portion of it is roasted before adding to the stack. Roasting is done on open grates with draught from below; engine, 16 horse-power, runs blast; blast, cold; capacity 15 tons, 2 shifts; labor, $3.50 and $4; limestone, $1 per ton; charcoal, 22 cents per bushel; quartzite for lining, $7 per ton; keep stack in blast 25 days. The works when completed (2 stacks) will have cost $10,000. There are six arastras, and another building; of these, Mr. Benson has two, Mr. Lomax one, Mooney & Co. two, and Mr. Thompson one. The first named was visited. Mr. Benson has, besides the two arastras with quartzite mill-stones, a crusher and two Freiburg barrels, (4 feet long by 3½ diameter,) and is building an open furnace to roast his tailings for re-amalgamation. With this latter completed, he can work sulphides; but at present he uses only oxidized ores. Free ores yield him an average of 83 per cent., (maximum, 9 per cent.;) the presence of lead or antimony reduces the yield very greatly; cost of works, $3,000; capacity, 2 tons each 24 hours; water-power. The average cost of mining labor is $3 to $4 per diem. Timber and fuel are abundant in the district. The stream through the cañon runs the arastras. There are 1,000 inhabitants in the district. The country-roads are good westward.

CLIFTON DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

This district was organized in 1869. The nearest railroad-communication is Toano, eighty miles distant. The mining-ledges are scattered over the low broad summit of the range. The ores are chiefly smelting. None of the mines are now worked. There is a smelter, (J. F. Berry & Co.,) not now in operation; single stack; 3 tuyeres; it was in blast thirty-five days, and 225 tons of ore from the Gilberson mine produced 80 tons bullion, worth $200 per ton in silver. There is timber on the high part of the range, ten miles south. Fuel (piñon and cedar) is abundant. There are a few small springs. The district contains but two inhabitants. The country-roads are good.

NORTH STAR DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

This district was discovered March 8, 1871, and organized November 9, 1871, and worked continuously since that time. Nearest railroad-communication is via Fillmore to the Utah Southern Railroad, a distance of one hundred and ninety miles. The area covered by mineral croppings is about three miles east and west by six miles north and east. The mining-ledges lie along the summit and along both slopes. Trend is north and south. The general direction of lodes, &c., is northeast and southwest. The veins cross the country-rock at all angles. The richest veins are

in limestone. The ores are milling (both free and roasting) and smelting; assays show from $9 to $19 in gold in the silver-bearing ores in the "Lookout." It cannot be said that any mines are now worked, but a considerable number are "put up" for sale, being prospected generally by shaft or incline to a depth of 50 to 100 feet. There are no mills. Cost of mining the ore, $4 to $10 per ton; skilled mining labor, $4 per day; average cost of sinking a shaft on a main vein is from $15 to $20 per foot; barley costs 3 to 4 cents per pound, from Nephi, Beaver, &c. Abundant cedar and piñon. There is no water except at Shaunty Springs, (fills a 2-inch pipe;) water is hauled five miles to Shenandoah from Beaver River Valley, and sold at 3 cents per gallon. Population fluctuating, from 100 to 400. A "jerkey" connects daily with the Salt Lake and Pioche line of stages; country-roads are winding and steep. There are very few Indians in the vicinity.

STAR DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

These mines were discovered in June and the district organized in July, 1870, and worked at intervals since that time. The developments are scattered over an area three miles wide, (east and west, the width of the range,) and six to eight miles long. The ledges are chiefly on the east slope of the Picacho range. Strike of the country-rock is north and south to northeast and southwest. Lodes generally dip with the country-rock. The ores are chiefly smelting. The incline on the Saint Mary's mine follows the rim for 75 feet with a dip of 30° west; vein about 2 feet, all saved as ore, argentiferous galena; gangue, calcareous; walls definite; limestone of impure quality. The shafts or inclines on other mines are: Taylor, 75 feet; Jupiter, 80 feet; General Gates, 120 feet; Coyote, 80 feet; Tiger, 38 feet; Picacho, 75 feet; there are considerable drifts, also, on the Taylor and Jupiter mines. There are no mills. Cost of mining labor, $4 per diem. Wood for fuel is abundant. Water is hauled five miles to South Camp, the principal settlement. At Shaunty on the west side of the mountain there is a small spring. Population is fluctuating, 100 to 200. The country-roads are poor.

ROCKY DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

This district was discovered February 17, and organized March 27, 1872; work began May 1 following. It is situated on the Pioche and Salt Lake City road, called sixty miles from Fillmore. The mineral croppings cover an area of one-half mile square; the ledges are on the east face of the mountain. The general direction of lodes, &c., of the north group is east and west to southeast and northwest; south group, north and south; they dip with the country-rock; the ores are base, milling; assays show the presence of gold in silver-bearing veins, $12 being the highest. The principal mines now worked are the Rockafellow and Severance, shaft down 46 feet; Champion, shaft down 30 feet; and Homestead, shaft down 44 feet; no mill. Mining labor costs $4 per day, and the average cost of sinking a shaft on a main vein is from $10 to $18 per foot. Grain, farm produce, &c., comes from Beaver Valley; timber, eighteen miles; lumber, forty miles; and fuel, eight miles west; and water, (the Beaver River,) two and a half miles east. There are 15 inhabitants in the district. It is not a stage-station, but on the Pioche and Salt Lake stage-route. The country-roads are good. No Indians.

LINCOLN DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

The mines in this district were discovered in 1859, and included (with Granite district) in the Pioneer district in 1860; re-organized January 16, 1871, and worked until November, 1871. The developments are in an arc one mile by one-half mile, trending northwest, and including Grundy Spring. The mining-ledges are on the south face of Mineral Granite range, which trends north and south. General strike of strata and veins is west and south. Dip of both is easterly. The ores are chiefly of smelting grade; assays show the presence of gold in the silver-bearing ores; gold has also been found by panning. There are no mines worked at the present time. No mill. The

average cost of mining labor is $4 per diem; barley costs 2½ cents to 5 cents; hay, $20 to $25 per ton at Minersville. Timber distant, but piñon and cedar close at hand and abundant. There are several small springs of good water. The district is deserted. The range is a hunting-ground for several bands of Pah-Ute Indians.

GRANITE DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

The mines were discovered October 24, and district organized December 31, 1870, and worked at intervals since that time. The developments are within an arc 3,000 feet north and south by 500 feet east and west. The ledges are in the eastern base of the range, which trends north and south; the general direction of lodes, &c., is north and south; the chief lode trends north 20° east; ores of bismuth, cobalt, and molybdenum; iron and silver present; assays do not show the presence of gold; the Gentle Mary is the principal mine, but it is not worked at present; there is no mill; the average cost of mining the ore is $10 per ton; mining labor averages $4 per day; barley, 4 cents; hay, 1¼ to 1½ in Adamsville. Timber three miles up the mountain. Fuel is abundant and at hand. A fair spring close at hand. Number of inhabitants, 1. The country-roads are fair.

OHIO MINING-DISTRICT, UTAH.

[From notes furnished by Mr. Francis Klett.]

The mines in this district were discovered and district organized in April, 1868, and worked continuously since that time. The distance to the present terminus of the Utah Southern Railroad is one hundred and sixty miles. The area covered by mineral croppings is six square miles; trend of longer axis being east and west. The ledges are found on both sides of the cañon, and above the falls, generally running north and south, with general trend of mountains, foot-hills, and spurs running east and west. The general direction of lodes, deposits, and stratifications is north and south; lodes dip parallel with country-rock; dip to the west; country-rock runs very low and cannot be compared with vein-matter, although running as high as $30. The ores are sulphurates; few chlorides occurring. It is considered that the mill-process would be the most economical. The average yield per ton is $125. Gold occurs principally and in large quantities in the Morning Star lode; all other lodes show the presence of gold, from 25 to 40 per cent. The principal mines are the Daniel Webster, on southern slope of cañon; shaft 65 feet, very substantially built and timbered; 500 tons ore on dump; specimens collected here assay $2,920, including $397 for gold; country-rock works $36; Messrs. Hess & Hawley were offered $77,000 for two-thirds of this claim, being altogether 3,000 feet. Croppings can be traced for 2,600 feet. A tunnel of 50 feet has been run on this vein 225 feet above shaft.

Homestead, on south side of cañon, being northern extension of the Webster, about 800 feet above the sole of the cañon. Shaft 123 feet deep, beautifully built and timbered. Assays from this vein run as high as $2,800. There are at present thirteen men working at this shaft. One thousand tons of ore are on the dump. A cross-cut tunnel, running parallel with vein and now about 30 feet long, has been started in the cañon below. Croppings of this ledge can be traced for 500 feet.

Blue Cloud, on the southern side of the cañon, about three-fourths of a mile from Webster and Homestead to the west, 250 feet above the valley. Vein 4 feet, running north and south. Tunnel 31 feet long; little developed. Assays $250.

Springtown, one-fourth mile west of the former and on about the same level. Tunnel 82 feet long; ledge running north and south; 4 feet wide; picked ores assay from $600 to $800. Work, as a general rule, never less than $125; considerable copper and silver blend occurring; gold 25 per cent.

Belcher, about 100 yards west and 80 feet above Springtown; narrow vein in quartzite; tunnel 40 feet long; assays from $160 to $190; not much developed; direction of vein northeast and southwest.

Niagara, about one-fourth mile to the southwest of Belcher, and about 120 feet below; in the

neighborhood of a water-fall 80 feet high; the property of a Chicago company; John Pope, superintendent; not worked at present; vein 20 feet wide, running northeast and southwest; dip to the west; tunnel 90 feet long; average assays from $80 to $140, some running as high as $800; 42 per cent. gold.

Morning Star, supposed to be the same ledge as the former; about 400 feet above Niagara; granite formation. The nature of this ore is remarkably different, and runs very high in gold. This is one of the best veins in the district, but not worked at present on account of litigation with Pinto Silver-Mining Company of Chicago, Ill. Northern extension of Niagara, 200 feet below, shows a narrow vein of ore similar in character to that of the Niagara; little developed.

Saint Lawrence, on the north side of the cañon; vein 8 feet wide, running north and south; foot-wall, quartzite; hanging-wall, granite; assays from $80 to $160, and from 25 to 35 per cent. gold. In consequence of a break in the casing, there is water coming in the drift, (36 feet long,) and work had to be stopped.

Great Western, on the north side of cañon, 500 yards east of Saint Lawrence; vein 8 feet wide, running north and south; tunnel, 85 feet. This vein is well defined by two walls; clay casing; croppings, 1,000 feet; assays from $80 to $100; from 20 to 35 per cent. gold. There are, besides the foregoing mines, a number of others, such as the Illinois, Silver Chief, Golden Curry, &c.

Gold sand was discovered in Pine Gulch Creek in the early part of 1868, and washed by Captain Hess, Hawley & Co., at a considerable expense; proceeds did not amount to over $100, although the expense averaged several thousands. This led to the discovery of quartz-vein by Captain Hess. While washing gold it was discovered that a considerable amount of quicksilver was gained in the sluice-boxes; whether this is natural quicksilver occurring in the formation itself, or remnants of operations of a similar character in times gone by, could not be ascertained. Altogether the camp is a very promising one, and bids fair to excel the northern districts. The inhabitants are a very quiet, orderly set of people, and excel by far, in intelligence and conduct, the average population of mining-districts in general. There is one mill, 2-stamp battery; weight of stamps, 400 pounds; engine, 12-horse power, the property of the Pinto Silver-Mining Company and an entire failure; not worked. The cost of a 10-stamp mill, with Stedefeld furnace, is estimated at $22,000, which includes transportation of material, &c. The cost of mining the ore is from $6 to $8 per ton; mining labor, $4 per day; average amount of ore that can be extracted by one man in one day is five tons, and the average cost of sinking a shaft on a main vein is $40 per foot, including timber, &c.; expense of running a drift on a main vein is $18 per foot. Expenses will be decreased at such time as the Utah Southern Railroad passes within a reasonable distance from the district. Grain costs $2.50 per hundred; hay, $15 per ton. There are no facilities for raising farm-produce and stock. The present source of supply of these articles is Marysvale; an abundance of heavy pine, cedar, quaking-asp, mountain-mahogany, all over the mountains, and plenty of water for all purposes. Number of inhabitants, 100. One stage-line, three times per week, from Nephi. The country-roads are good. No Indians have been seen in this district for a number of years.

IRON-SPRING MINING-DISTRICT, UTAH.

[From notes furnished by Mr. Francis Klett.]

This district was organized in August, 1871, but not yet worked. It is located eight miles west of Cedar City. The area covered by mineral croppings is about 190 square acres. There are no developments, except dam to reservoir, and a few roads. Trend of longer axis is north and south, Mining-ledges run northwest and southeast; main range running east and west. The claims are situated in a gap opening southeast and northwest, in the northern portion of the Iron Mountains. Foot-hills and spurs trend north and south and northeast and southwest. The general direction of the ledges is northwest and southeast; the lodes dip and strike the country-rock perpendicular, and no relation is found to exist between the country-rock and the veins, except a slight iron coloring of the former. The ores are hematite and magnetic. The ores in this district have a much finer grain than those at Iron City, and seem to be richer by 10 to 15 per cent. The average yield is 75 per cent. Some of the ores have been worked by the Mormons about sixteen years ago, at Cedar City, with tolerably good success, considering the imperfect furnace erected there at that

time. The same working process as at Cedar City is proposed. There is no mill at present. The cost of a 10-stamp mill, with furnace, will be about $40,000. But this estimate, considering the abundance of material and facilities of transportation to furnace-site, is extremely high. The average cost for mining the ore is 50 cents per ton. Mining labor costs $3.50 per day, and the amount of ore that can be extracted by one man in one day is "unlimited." There will be apparently no necessity for tunnels or shafts for the next fifty years. Hay costs $20 per ton; grain, $1.50 per bushel. The soil is fertile, and it is an excellent locality for wintering stock. Parowan, Cedar, and Little Creeks supply excellent timber. Wood for fuel, such as cedar, mountain-mahogony, and scrub-oak, is abundant. Several springs yield a large quantity of water throughout the year. Six families, engaged in farming and stock-raising, comprise the population of the district. The country-roads are good. No Indians have been seen here for years. No coal has, so far, been discovered in the immediate neighborhood of the iron deposits, although it is supposed that by boring in certain localities large coal-beds could be opened. Coal from Iron City could be furnished at $5 per ton.

BEAVER LEAGUE DISTRICT, UTAH.

[From notes furnished by Mr. G. K. Gilbert.]

This district was re-organized September 2, 1872, and worked continuously since that time. It is located on the Pioche and Salt Lake road. The locations are scattered over the Beaver League range. There are no developments. The ores are chiefly base-roasting. The locations, Big Mountain and Hattie, were made just before our visit, and occasioned a "rush." There is no mill. There is wood for fuel, but no timber. A few very small springs furnish about enough water for 50 head of stock. Number of inhabitants, 20. No country-roads.

IRON PINTO MINING-DISTRICT, UTAH.

[From notes furnished by Mr. Francis Klett.]

This district was organized in June, 1868, and has been worked continuously, but not extensively, since that time. The nearest railroad-communication is the terminus of the Utah Southern Railroad. Almost the entire district is covered by mineral croppings. Developments few so far, with the exception of roads to and from the mines. The area of the district represents the shape of a parallelogram, with the trend of the longer axis from east to west. The ledges are running northwest and southeast, while the range itself runs east and west. Marked spurs, ridges, and foot-hills have a north and south trend; the iron ledges as well as the silver lodes are situated on the southern slope of the main range, while marble, coal, and zinc are found on the southern slope of the range. The general direction of lodes, deposits, and stratifications is northwest and southeast, with a dip of the ledges, in a few instances, to the north. In most instances the ledges run almost perpendicular. The silver-ores are all milling; average yield, $100 per ton; iron smelting-ore, average yield, 74.116 per cent. pure iron; zinc smelting-ore, average yield, 40 to 60 per cent. zinc, and 40 per cent. silver; copper smelting-ore, average yield, 50 per cent. copper; bituminous coal, good quality, free of slate; anthracite coal only discovered, not worked yet, but large bodies in the immediate vicinity. Assays show only traces of gold in the silver-bearing ores. The principal mines are silver. The East Ledge, shaft perpendicular, 12 feet; Monster, shaft perpendicular, 60 feet; Putnam, shaft perpendicular, 25 feet; Little Brig, shaft perpendicular, 6 feet; Mammoth, Washington, Humboldt, North Carolina, and others. Very little work has been done on the four last named. Iron mines are the Duncan Ledge, on southern slope; very large deposit of about three-fourths of a mile in diameter in a blue limestone formation; hematite-ores, with an excellent road from Iron City; distance about four miles northeast; ore contains 74 per cent. pure iron; about three-fourths of a mile northeast of this ledge a lode containing conglomerate ore of silver, iron, copper, and lead was discovered, (running east and west.) Assays show $30 silver per ton. This lode is not considered worth working for either of the metals contained therein. About 300 yards north from this ledge a small arsenic vein, three-fourths of an inch, has been found.

Blow Out.—Croppings three-fourths of a mile long and one-half mile wide, and 200 feet high; contains large crystals of quartz and amethysts; ores magnetic, and can be worked profitably by the rod or steel process. This deposit is in a red granite formation.

Chesapeake.—The largest deposit in the district and the most northeasterly location; is formed by a solid body of magnetic iron; 90 feet wide, three-fourths of a mile long, and 80 feet high; quartz crystals occurring in the ore.

Hanck's Lode.—Hematite ores.

Blow Out No. 4.—Black ore, slightly magnetic; deposit 200 feet wide across top of the mountain, extending to the low foot-hills 250 feet. Besides the above-named ledges, there are the Popp Metal and Blair ledges, and others of considerable extent. Very little work has been done so far on all these ledges, on account of there being such large quantities of ores on the surface. Zinc mines, Mountaineer, with a porphyr granite formation on north slope; ores calamine. These ores, it is said, are a puzzle to the assayers in Utah and Nevada. Some assays show 50 per cent. pure zinc and 300 silver per ton. The works were idle at the time of our visit, in consequence of experiments being made with the coal recently discovered, and opportunity was afforded to see the process employed in reducing the iron-ores.

The deposits in this mining-district have been known to the Mormons for the last sixteen years, and experiments for the reduction of the ores have been made continuously during that time. There are two furnaces, one blasting and one reverberating; also a foundry for iron castings. The estimate for a proper furnace is given at $25,000, including $6,500 for steam-engine. The average cost per ton for mining the ore, including transportation to Iron City, is, silver, $4; iron, $1.50; coal, $5; zinc, $5; copper, $5. Mining labor costs $3.50 per diem. The amount of iron-ore that can be extracted by one man per day is only limited by the amount he can handle. The average cost of sinking a shaft on a main vein is $20 per foot. There are no chances for a decrease in the expense of mining industry except by future railroad-communications. Hay costs $30 per ton; grain, $4 per hundred pounds. There are a few gardens, but Cedar, Harmony, and Pinto supply the market. Wood, such as cedar and pine, is abundant. Pine Valley supplies heavy timber. Water rather scarce. Number of inhabitants, 100. There is one stage-line, from Cedar to Clover Valley, weekly. The country-roads are good. There are Pah-Ute Indians in the vicinity, but the number is not known.

MOUNT NEBO DISTRICT, UTAH.

[From notes furnished by Mr. Francis Klett.]

These mines were discovered in the fall of 1870, and the district organized in the spring of 1872. It has been worked continuously since organization. The nearest railroad communication is American Fork, sixty-two miles distant. The area covered by mineral croppings is five square miles. The mining-ledges are on the western slope of Mount Nebo, in Bear Cañon, along foot-hills and across Bear Cañon. Trend north and south; spurs, ridges, and foot-hills west and east. The general direction of lodes, deposits, and stratifications is northeast and southwest. Dip a little west. The country-rock is limestone. The ores are smelting galena. It has not yet been worked, but assays from $17 to $260. There is no gold in the silver-bearing ores. The principal mines are the Mountain Queen, shaft 30 feet; Olive Branch, tunnel 120 feet; Hague Lode, Revolution, Atlantic, Aspinwall, Great Western, Monitor, Sultana, Olive Branch No. 2, Chicago Lode, Little Agnes, Saint Patrick, and Lily. The Olive Branch tunnel runs through four lodes—Hague, Revolution, Atlantic, and Olive Branch. The mines in this district are only in the first stage of development. Capital is sadly wanted, and consequently further developments can only take place in course of due time. The veins and ores look very promising. Mill-site and woodlands have not yet been located. There is very little water in the immediate vicinity of the mines, and wood can only be procured at a distance of about five to seven miles, from the high foot-hills of Mount Nebo. The average cost for mining the ore is $9 per ton. The average cost of mining labor is $3 per diem, and one man can extract one-third of a ton of ore per day. It costs $6 (average) per foot to run a drift on a main vein. There are no chances for a decrease in mining expenses. Grain is $1 per bushel; hay, $10 per ton. Salt and Willow Creeks (24 and 18 inches respectively)

furnish water. The district has a population of 1,800; one stage-line, Wells, Fargo & Co. There are good natural roads. There are 3,000 Utah Indians with 400 warriors in the vicinity. On the southern slope of Mount Nebo, and apparently within this district, are two large gypsum and one large salt (rock) deposits. The more prominent gypsum-bed covers an area of about four square miles, and the gypsum is very bright and pure. About four and a half miles east, in the same cañon, a deposit of rock-salt, said to be inexhaustible, has been discovered. The salt is imbedded in a conglomerate and red sandstone formation.

SCHELL CREEK DISTRICT, NEVADA.

[From notes furnished by Mr. G. K. Gilbert.]

This district was organized in 1870, but the developments are not yet sufficient to constitute mines. The locations are scattered over the top and both slopes of the range. They are grouped as Schellbourne, Centreville, Queen Spring, and Tehama. The ores are free and assays show the presence of gold in the silver-bearing ores. There are two mills: the Prospect (5 stamps) in Centreville, just set up and not yet roofed in; the Tehama Mining Company has contracted with Booth & Co. to erect a 20-stamp mill; Centreville Mill, Pennsylvania Mining and Milling Company, 5 stamps, 2 combination-pans, 2 settlers, cost $6,000 in San Francisco; complete it will have cost $15,000. The average cost of mining labor is $4 per day. Fir-timber on the mountain back of Centreville, and water is abundant in springs and creeks. Population of the district, 300. There is a daily stage to Humboldt Wells, and a tri-weekly to Hamilton. Supplies come from Humboldt Wells and Toano. The country-roads are good, and there is a toll-road over the mountains.

RUBY HILL DISTRICT, NEVADA.

[From notes furnished by Mr. G. K. Gilbert.]

This district was set off from Schell Creek district September 18, 1871. The principal developments are on top of the mountain within a mile of Ruby Hill. The ores are free. There are but few developments. The prospect-holes are from 20 to 40 feet deep. The Columbus has a tunnel 130 feet to strike the vein. The other mines are the Birch, Silver Reef, Cow and Calf, (first location,) and Monitor; a 5-stamp mill in Rubysville, (not visited.) Mining labor cost $4 per day. There is some timber on the mountains, and plenty of wood. The water-supply consists of small springs at Ruby Hill, and a small creek at Rubysville. The district has a population of 125, and a stage runs to Schellbourne daily. Supplies come from Humboldt and Toano via Schellbourne. The country-roads are high-grade toll-roads.

SILVER MOUNTAIN DISTRICT, NEVADA.

[From notes furnished by Mr. G. K. Gilbert.]

This district was organized March 8, 1870, but has been worked but very little as yet. The mining-ledges are found in a cañon of the east slope of the Schell Creek range. The ores are base, with lead characteristics; none have been milled. The district has 15 to 20 inhabitants, who have no regular means of communication with other points.

PIERMONT DISTRICT, NEVADA.

[From notes furnished by Mr. G. K. Gilbert.]

Discovered and organized in July, 1869. The area covered by mineral croppings is not great. The mining-ledges are in a cañon of the east slope of the Schell Creek range. General strike of the lodes, deposits, and stratifications is north and south. The ores are free, and assays show the presence of gold in the silver-bearing ores 1½ per cent. of value in bullion. The principal mine is the Piermont. This lode is said to be folded or to occupy a fold, and its two parts dip east and west at 45°; extreme depth, 150 feet; total shaft and incline, 550 feet; tunnels, 1,000 feet. One thou-

sand five hundred tons have been crushed; yield, $45 to $50. Twenty men are employed. The Piermont Mining and Milling Company has a 10-stamp mill; weight of stamps, 650 pounds. The ore is crushed with six small Wheeler pans; three settlers; bullion, 960–980 fine. Average cost of mining labor is $4 per diem. Population, 150; without stage or freight facilities. Fir and pine timber is abundant; also water in running streams. Country-roads are good.

BRISTOL DISTRICT, NEVADA.

[From notes furnished by Mr. E. E. Howell.]

The mines in this district have been worked continuously since its organization. The mining ledges are on the western slope of the Ely Mountains. The general trend of this range, like all others in the vicinity, is north and south. The country-rock is limestone, and has an average dip of 10° north-northwest. No well-defined veins have been discovered. The mineral deposits are found in "pockets" or coves, and have not been sufficiently explored to develop any permanent character. Mining labor is $4 per day. Wood and some timber for mining-purposes is obtained in the district. Timber for all other purposes is brought across Duck Valley from the Fortification range, a distance of thirty or thirty-five miles. Water is obtained by sinking wells in the valley. There are 15 to 25 inhabitants in the district. The stage-line from Pioche to Carlin, on the Central Pacific Railroad, passes up Duck Valley, about six miles from the center of the district. Country-roads are very good.

EAGLE (FORMERLY KERN) DISTRICT, NEVADA.

[From notes furnished by Mr. E. E. Howell.]

Discovered in April and organized in May, 1869, and has been worked since that time, with the exception of the winter of 1871–'72. The general trend of the mountain-range is north and south. The central portion of the district is granite, which forms the highest peaks and ridges, and is flanked on all sides by calcareous schists and silicious limestone. The mining-ledges are mostly confined to the granite, and the schists and limestone for 500 to 1,000 feet adjoining the granite. The strike of veins in the granite is northeast by southwest. In the limestone they run parallel to the line of separation between the granite and limestone. The ore in the granite is nearly a free-milling ore, and in the limestone it has more base, (galena and copper,) with the exception of one lode lately discovered, which is perfectly free. Twenty tons of ore have been milled, yielding from $100 to $700 per ton; average, $300 per ton; but this was very closely sorted. Assays show a trace of gold in the silver-bearing ores. The principal mines are the Lyons and Flemming, and the Sentinel. The former, a carbonate mine in the limestone, has been taken hold of by a company from San Francisco, who are making preparations to commence work immediately. The Sentinel is in the same condition in regard to work. It is in granite chloride ore, with some galena. A 40-feet shaft has been sunk; average width of vein, 3½ feet; strike, northeast by southwest; dip, southeast, 50°, which is unusually low. The average cost of mining labor is $4 per day. Hay costs $20 per ton; grain, $3.50 to $4 per hundred; beef, 12½ cents per pound. There is sufficient timber for mining-purposes in the district, and thirty miles north, toward Deep Creek, there is plenty of excellent timber. Population, 15 to 20. No stage or freight lines. The country-roads are very good. There are about 100 men, women, and children of the Goshute tribe of Indians in the vicinity.

SAN FRANCISCO DISTRICT.

[From notes furnished by Mr. Francis Klett.]

Discovered May 23 and organized June 1, 1872, and has been worked continuously since organization. The nearest railroad-communication is one hundred and seventy miles. The area covered by mineral croppings is supposed to be 30,000 acres; the mining-ledges run parallel with the mountain-range situated on divides between cañons. The general direction of lodes, deposits, and stratifications is north and south; dip to the west. The ores are sulphurets and bromides, and assays show the presence of gold in small quantities. The principal mines are Security ledge, Mc-

Glovin & Jarvis location, slope sunk 64 feet, cross-cut run 28 feet; Security ledge, Durkie & Washburne location, cross-cut 10 feet; Security ledge, Manning location, tunnel 10 feet, width of ledge 35 feet; Antler ledge, cross-cut 20 feet. The amount of work on other ledges is not known. The average cost of mining labor is $4 per diem, and one man can extract about 5 tons of ore per day. The average cost of running a drift on a main vein is $15 per foot. Hay costs $10 per ton; grain, 2½ cents per pound. The source of supply is Maryvale. There are about 3,000,000 feet of timber that will make lumber on the mountain-sides; water in Ten-Mile, Cottonwood, and City Creeks—about 300 inches in each. The population of the district is not known, and there are no regular freight or stage lines; nothing in the way of roads except mountain-trails. There are no Indians in the vicinity.

The limited time available for the preparation of this report renders it impracticable to give a preliminary rendering even of data gathered from the other districts visited this year, since the recorded information must be segregated from so large a number of note-books.

IRRIGATION.

So far as artesian wells relate to this subject, and the specification of certain localities where we might expect favorable results in prosecuting the search, G. K. Gilbert, geological assistant, alludes to the matter in his report hereto appended.

The scope of the present communication admits only of a few general statements in regard to this very important subject, and it is to be hoped that at an early day, when time for fuller consideration can be found, a more thorough and exhaustive treatment of the subject may be effected.

Irrigation, in its application to the various objects for which it may be employed, is of two distinct classes; namely, by canal, and by artesian processes. The former is more especially valuable to the agriculturist. In some cases it acts to improve agriculture in areas by nature arable; and in others, as would most frequently occur in its wide application to tracts in the western domain, it is called upon to create agriculture over arid areas. In the States and Territories of the Far West, the interests to be assisted are those of the agriculturist, the miner, the stock-raiser, and the present and future manufacturer.

By the construction of canals it would be proposed to utilize in an effective manner the supplies of water that are found above the surface, and by the artesian method to search for and to bring to the surface the supplies existing in underground currents and reservoirs. As a practical attempt to analyze the area west of the one hundredth meridian, so far as a difference of physical shape appears to indicate a large influence upon the water-supply above or under ground, we will divide this area into two parts: first, an aggregation of the several interior or inclosed basins without outlets, forming what has been termed the great interior basin; and, secondly, those basins whose waters have a known channel of escape to the ocean. Our divisions then are the interior and the exterior basins. Of the exterior basins on the Pacific Slope, the principal ones are the Columbia, with its tributaries, the Sacramento and its branches, and the Rio Colorado of the West, having as confluents the Green and Grand Rivers, joined near its mouth by the Gila, having a magnificent area of drainage; the latter, or the Colorado basin, is the largest. In this we have mountain-ridges, plateau and valley forms. The sources of the streams that rise at the summits of the water-sheds of the exterior basins approach more nearly the line of perpetual snow than do those of the interior basins.

In turn, the amount of rain-fall per square mile in the great interior basin is very much less than that over the Colorado basin, and bears but a small ratio to that known to exist in the basin of the Columbia.

It is unfortunate that we have so little systematic data at typical points throughout these areas upon which to base a numerical calculation as to either relative or positive amounts of precipitation. A physical distinction of the most marked character is found in tracing the course of any stream in the interior basin from its mountain source or sources to its valley-sink. Most frequently, until the stream emerges from the mountains, the current is swift, and the average fall, the erosive agents of nature that are constantly acting upon the sedimentary strata and other rock-

masses of the Cordilleras, bring about a large annual amount of denudation, forming beds of loose *débris* underlaid by more finely comminuted particles after further pulverization from subsequent erosion and translation, generally present along the flanks of the mountains a series of permeable beds of considerable thickness. This is especially true where sandstone and quartzite-beds approach the flanks of the foot-hills or beds of any of the older lavas. These mountain-streams emerge from the rocky beds of the cañons, and very often immediately disappear, never to rise again. We may safely say that the majority of mountain-streams throughout the entire system of interior basins very seldom flow but a short distance beyond the mouths of the cañons of the lower foot-hills, and it has been noticed that the few half-mesa beds of *débris* seldom offer an attractive field to the agriculturist. However, where strata of clay or aluminous shale form the underlying beds of the foot-hills, we frequently find a substratum of marl or clay sufficiently near the surface to retain the water-supply above it; and although by percolation and evaporation, as the water spreads out after leaving the mountains, much of the supply is lost, still the streams that have any considerable area of drainage generally persevere in their course, and finally reach their resting-place in sinks of a lake-form. We have examples of this in the Great Salt and Utah Lakes in Utah, Humboldt and Walker Lakes in Nevada. From the peculiar shape of the elongated valleys in this interior basin, and because of the large amount of *débris* still in constant accumulation, the thickness of the beds of alluvial strata above the bed-rock of these basins is very great, and probably far in excess of that found in the exterior basins; comparing our profiles along water-courses of streams of the exterior and interior basins, we are met with this general fact, applicable to profiles along axial lines that follow the direction of the principal or larger streams, and note that the mountain part of the profiles in the first case is by far the most abrupt, while, on the other hand, that along the valley or detrital plain is more gentle. There will be notable local exceptions; as, for instance, in the thread of the Grand River, one of the main tributaries of the Colorado, an abrupt profile is found, until the stream has cleared the mountain cañons in the vicinity of its sources; but by a comparison of the profile from this point on to the point where the Colorado debouches into the Gulf of California, the marked distinction in profile is found to exist.

Provided there was a large rain-fall in the interior basins, the engineering features connected with the distribution of water on a large scale over different parts of the surface gathered from above or underground sources would be comparatively easy; but since so large a part of the amount precipitated is carried off by evaporation and absorption, the supply itself, as it will be irregularly distributed underground by percolation, affords, after all, but few localities where with certainty of success wells might be sunk. Indeed, after a general examination of the physical conditions surrounding many of these interior valleys, I am led to the belief that comparatively few points will be found where wells can be successfully sunk. I would not recommend the attempt at a large expense, unless preliminary topographical and geological profiles, the latter after a series of test-borings, had been made. Where agriculture, present or prospective, shall call for works of irrigation, the waters may be collected at the mouths of the cañons and judiciously distributed over portions of the adjacent valley-area.

The problem becomes, after it has been decided desirable and necessary, an engineering one, but the fact that the soil in these interior basins is capable of so large an amount of absorption will have for a long time great weight in the question as to whether or not the necessities of the case admit of the practical elucidation of the problem.

From the large amount of humidity gathered along the crests of the Rocky Mountains and other parts of the dividing ridge of the continent, from the thirty-fifth to the forty-ninth parallel, there seems to be but little doubt that a comprehensive canal-system would direct such a volume of water to accessible points now arid upon the plains, along the eastern flanks of these ridges, as to make it a matter of sufficient interest to have, in connection with the general topographical survey of that region, a series of special contours marked out, intersecting the axial lines of the basins at altitudes somewhat greater than the general contour of the country lying to the eastward. Large tracts in these sections would then, if irrigation ensue, become agricultural. Farther eastward, the sinking of the artesian wells ought to be successful if points are carefully selected, and vast grazing-fields become habitable for stock. I will here state that the objects to be gained by

irrigation in areas west of the Mississippi are materially different in their important features from those that have governed its use in Northern Italy and in Northern and Southern India. In these localities, where, prior to the introduction of irrigation, a numerous population existed that had gradually exhausted the arable value of the soil, the practical effect expected from irrigation was to improve the agricultural resources of the area already well watered by running streams and by direct humid precipitation. Although in parts of India, since its colonial occupation, the system has been so far developed as to stimulate agricultural industry over areas before that time arid and unreclaimed, still its larger uses have been as an improvement to, rather than a creation of, agriculture, while in our western regions, where the small amount of annual precipitation, comparatively smaller too in the seasons suitable for tillage, is insufficient for the wants of agriculture, it becomes necessary to provide by artificial means a sufficient amount of humidity over cultivated areas to produce the various crops. Hence the necessity of utilizing all the sources of water-supply in creating, after all, but a relatively small agricultural area.

However sanguine the inhabitants of the various western sections may be who desire to see growing up in their midst a chain of settlements occupied by industrious agriculturists, still it must be remembered that, with all the assistance that may be rendered by the General Government, States, and Territories, or by corporate and individual means, in their attempts to make use of the total water-supply provided by nature, that too much must not be expected in return for their enthusiastic attempts to reclaim its waste places. It has been the experience, in regard to irrigation in Italy and in India, that large works whose cost of time and money are great, have never been justified in areas where the streams are not fed from the regions of perpetual snow. As the areas of perennial snows are very few in our western mountains, this fact, connected with the history of the largest systems of irrigation that have ever been prosecuted, is most instructive. It must be conceded, however, that if a proper impetus be given to the development of this subject, large portions of our arid sections will in time become productive, and that the relations between evaporation and precipitation will be so far modified as to materially increase the amount of humid fall throughout the season. It is believed that this has been practically demonstrated in portions of Utah. I think some of the highest authorities who have examined into the subject in different parts of the world agree in this view.

In connection with this broad subject, should it at any time receive the earnest consideration of Congress and the country, it would be highly desirable that a system of meteorological observations be so conducted at typical points throughout the same basins that the meteorological values and the changes in their conditions might be determined, especially with regard to humidity-values; also that the soils of the various areas might be analyzed in relation to their mineral constituents at least so far as the determination of their absorbent powers, so that an approximate estimate could be determined as a standard for the amounts of water necessary to irrigate each acre.

In order to present a comprehensive estimate of the area of territory of which the General Government is still a possessor in the region west of the one hundredth meridian, where irrigation will at some time prevail, I submit herewith information obtained from the Commissioner of the General Land-Office, upon a request of the Secretary of War to the honorable Secretary of the Interior.

Statement showing estimated areas of land disposed of by the United States in certain States and Territories, accompanying letter from the Commissioner of the General Land-Office to the honorable Secretary of the Interior, dated December 2, 1873, in response to the Secretary's direction to report upon the matter of letter dated November 19, 1873, addressed by the honorable Secretary of War to the honorable Secretary of the Interior.

States and Territories.	Areas of States and Territories.		Cash sales entered under homestead acts and granted for military services.	Mineral lands sold.	Granted to railroads and wagon-roads. (See note 1.)	Approved swamp-lands, internal-improvement grants, and donations.	Valid Spanish and Mexican grants.	Granted for educational purposes. (See note 2.)	Indian reservations.	Military reservations.	Total.
	Sq. miles.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Arizona	113, 916	72, 906, 304	10, 008	55. 72	20, 200, 000	.....	.....	5, 112, 035	8, 000, 000	56, 846	33, 378, 945
California	188, 981	120, 947, 840	5, 668, 739	21, 773. 76	21, 000, 000	1, 692, 629	12, 000, 000	6, 765, 404	100, 000	16, 846	47, 265, 392
Colorado	104, 500	66, 880, 000	956, 620	1, 768. 38	3, 200, 000	.....	238, 769	5, 366, 451	10, 319, 000	64, 000	20, 146, 608
Dakota	150, 932	96, 595, 840	1, 007, 539	.....	10, 250, 000	.....	.....	3, 049, 693	30, 700, 000	800, 000	45, 807, 232
Idaho	86, 294	55, 228, 160	81, 537	.....	2, 350, 000	.....	.....	4, 050, 350	2, 178, 844	640	8, 661, 371
Kansas	81, 518	52, 043, 520	9, 943, 392	.....	8, 800 000	500, 000	.....	3, 375, 786	.....	8, 960	22, 628, 138
Montana	143, 776	92, 016, 640	168, 715	5, 812. 26	10, 500, 000	.....	.....	3, 715, 555	21, 680, 000	344, 400	36, 414, 482
Nebraska	75, 995	48, 636, 800	7, 356, 692	.....	7, 100, 000	500, 000	.....	4, 031, 508	9, 000, 000	40, 960	28, 029, 160
Nevada	112, 090	71, 737, 741	146, 260	1, 429. 42	5, 150, 000	500, 000	....	2, 937, 386	644, 000	14, 797	9, 393, 872
New Mexico	121, 201	77, 568, 640	48, 716	51. 87	14, 600, 000	.....	9, 000, 000	2, 534, 755	3, 767, 000	269, 840	30, 220, 363
Oregon	95, 274	60, 975, 360	1, 277, 204	1, 307. 06	11, 663, 600	2, 700, 000	.....	3, 016, 070	3, 473, 000	5, 000	22, 136, 181
Utah	84, 476	54, 065, 075	446, 327	489. 01	2, 400, 000	.....	.....	4, 355, 440	2, 039, 000	201, 280	9, 442, 536
Washington	69, 994	44, 796, 160	1, 223, 401	.....	16, 200, 000	.....	.....	2, 748, 124	881, 000	20, 000	21, 072, 525
Wyoming	97, 883	62, 645, 120	4, 843	.....	6, 000, 000	.....	.....	3, 068, 231	18, 200, 000	460, 000	27, 733, 074
Total	1, 526, 620	977, 043, 200	28, 339, 993	32, 687. 48	139, 413, 600	5, 892, 629	21, 238, 769	54, 126, 788	110, 981, 844	2, 303, 569	362, 329, 879

NOTE 1.—In Oregon, 1,863,600 acres were granted for wagon-roads.

NOTE 2.—By the act of July 2, 1862, and supplemental acts, Congress made a grant of land for the support of agricultural and mechanic colleges in the several States, to the extent of 30,000 acres for each Senator and Representative in Congress to which they are respectively entitled according to the apportionment of 1860, making the total quantity of 9,510,000 acres, with the prospect of the grant being extended as contemplated in the act of July 23, 1866, to the several Territories, on their being admitted as States, which, on the basis of two Senator, and one Representative in Congress for each, would make an addition thereto of 990,000 acres, and raise the aggregate quantity to 10,500,000 acres.

The exhibit presented relates to political divisions of the United States, all or the greater part of which lie west of the one hundredth meridian. The area west of this longitude line is 1,443,360 square miles, or 923,750,400 acres.

Upon the presumption that the tabulated statement includes all the classifications of land sold or otherwise disposed of by the Government within these several divisions, and applying a like percentage to the area disposed of in that area west of the one hundredth meridian, we deduce the probable fact that the General Government is still the possessor of (approximately) 582,602,880 acres.

From the experience of mapping large areas in portions of the West, I have approximately estimated the relation of the mountain to the valley area. This estimate has been more especially for Nevada, Utah, Arizona, New Mexico, and Colorado. Assuming the percentage found to exist, and deducing the amounts which are approximately at the present time arid, and all or part of which ought to become arable by means of irrigation, we find that although the data are approximate and subject to much modification, still that the probabilities are in favor of assigning at least 200,000,000 acres to this class.

In this entire portion to which an application of the system may be made, it needs but a single glance to determine that this question becomes a national one.

The objects to be gained by irrigation are many, and will from year to year be better understood. It is plain that the Government can afford to make large temporary sacrifices of parcels of this land, as it would in return reap the remuneration to ensue from the enhanced value of territory now entirely arid.

Should the general system of irrigation in all or part of the dom in w est of the Mississippi be determined upon, the subject will naturally receive full and earnest consideration at the hands of Congress when properly represented by the different States and Territories.

I have only to suggest that, provided a limited increase in the appropriation for the work under my charge should be made, the field-parties might be so organized that a branch of each could so far experiment in regard to the sinking of artesian wells as to gather a series of topographical and geological profiles; the latter to result from a series of test-borings, each of which might develop an instance of the presence of artesian water.

In connection with some of the present routes to and from military posts, and such others as may at times be opened, much good ought to result should the matter receive favorable consideration.

AGRICULTURE.

In portions of the territory examined during the season, this branch of industry is prosecuted by two separate and distinct classes of people, and naturally governed by different necessities:

First, the Mormons, who occupy the greater portion of the Salt Lake and Sevier basins that were covered by the survey. They are a people whose policy it has been to stimulate, by all available means, agricultural industry, introducing as an ally various mechanical and manufacturing pursuits, whenever skilled labor can be obtained.

Second, the Gentiles, who have generally made small settlements convenient to mining-districts, and established ranches along routes of interior communication, keeping here and there small herds of stock, and dependent upon local markets.

The Mormons are also quite a pastoral people, having herds of cattle and sheep. In all of the areas visited, irrigation is necessary for the production of crops. The Mormons have, to a considerable extent, tapped the local streams in the immediate vicinity of areas that they wish to irrigate. Other parties too, in different localities, have made use of the water from small streams and springs for the purpose of irrigation. No attempts have yet been made to introduce irrigation on a large scale, where, in order to take advantage of the topographical structure of the country, the problem of utilizing the water-supply from the mountain-systems becomes an engineering one. Hence, agriculture has been directed to the most arable parts of the generally narrow and elongated valleys found in this region. Of later years, mines have been discovered in Nevada and Utah, and the Mormons have increased the amount of their cereal and other crops, having found valuable markets in the several mining-camps; of these, Pioche, Nev., has been a notable instance; and in the streets of that little town Mormon wagons with products of the garden and farm may be seen that have been brought, perhaps, one hundred and fifty miles to reach a market.

The soils that are arable and easily irrigated, and those that border upon the arable parts, are the volcanic and sedimentary. Of the former, we have representative beds of the old lavas that protrude from the summits of the lower parts of the mountain-chains, and the flow of the *débris* from it, after it has been formed in place, often extending far into the valleys. The soils thus produced are loose and porous. The later of the basaltic and other lava forms, after disintegration and translations of the finely-comminuted particles, is a deep, rich, and strong soil; so, wherever such material predominates, it only needs the presence of water, as an active agent in the stimulation of soils, to the production of very large crops.

The sedimentary limestone and sandstone soils prevail in typical characters. The former produces a warm and durable soil; where the latter predominates, the area is generally a permanently arid waste. We have instances in Death Valley, California, and in valleys to the north of it, where the changing sand-dunes occupy large tracts. By estimating the area of the many trough-shaped valleys among the interior basins, and eliminating from it the area of sand-exposure, and that of a few half-mesa gravelly beds that protrude into them from the base of the foot-hills, we have a pretty general view of the amount of land arable, or that may be made such, in the State of Nevada, portions of Utah, California, and Arizona, so far as my experience reaches. Take from that the very small amount which is apparently arable, under rude methods of irrigation, and we have left that amount which, if artificially irrigated, might be made productive, thereby largely enhancing the value of our public domain. It is believed that in certain localities where underlying clay and marl beds more nearly approach the surface, by deep planting most of the grains and vegetables can be raised without artificial irrigation at the surface. This has been proven in Parahnagat Valley, Nevada. Indeed, the Moquis and Zuni Pueblo Indians of Arizona and

New Mexico raise crops of corn, squashes, and melons without irrigation; yet beyond a period of one month of summer, during which rain may fall intermittently during ten or twelve days, no irrigation, natural or artificial, is available. The secret of this is deep planting. Its application in the northern part of California has proved the fact that areas which it was considered necessary to irrigate, as long ago as the early settlement of that section, now produce steady crops without it. The effect of irrigation may be to increase or decrease the fertility of the land. This is due to the fact that certain mineral constituents are distributed by it, as matter held in mechanical suspension or chemical solution, and by increasing the amount of evaporation of the upturned soil, or driving off certain mineral ingredients that are in excess. In the valley of the Rio Grande it is probably due to the introduction of a series of alkaline constituents, while in parts of Nevada and Utah the soil is benefited by purging it of an excess of these. Especially in Salt Lake and Utah Valleys, as typical ones of Utah, could a much larger portion of territory be brought under subjection to agricultural industry. To be sure, there are no mountains facing these valleys whose crests reach above the line of perpetual snow; still, in secluded ravines, bodies of snow remain throughout the year, and the volumes of water collected through the different rock strata make a constant supply that issues from the mouths of many cañons only to silently flow and partially lose itself in the porous, alluvial, and volcanic material that flanks the mountains, only a limited portion thereof reaching the sink of the basin of the Great Salt Lake.

Economy considered, at the present time nothing more could be done than to tap a series of these streams that flow into the Salt Lake basin from the east at convenient relative heights, as they leave the cañons, and connect them by a main artery. The accumulated volume of water could be distributed over an area vastly in excess of that now rendered cultivable by minor means.

On the western side of the Great Salt Lake Valley, the Oquirrh range offers but a limited water-supply from its little streams; but it is believed that the project contemplated for directing the waters of Utah Lake on to the terraces west of the Jordan River is slowly being carried out. If advantage is taken of the natural features of the country, so as to direct a main canal-artery along these foot-hills of the Oquirrh range, having the same elevation as the surface of Utah Lake, an area of, say, from 80,000 to 100,000 acres, now entirely arid, may be brought under cultivation. The engineering problem is not impossible, but the expense may be too great.

In the Utah Valley, again, we have the Provo River, Thistle Creek, Spanish Fork, and several minor streams that have their courses distributed over the Wahsatch range, discharging a volume of water sufficiently great, if aggregated, to irrigate fully 100 per cent. more ground than is tilled at present, provided that an economic distribution is made. Many other instances could be cited where advantage could be taken of the present known sources of water-supply that could be utilized, so as to enhance the value of the public domain; but the expense attendant upon carrying out large enterprises of this character, in regions so remote and sparsely settled, may not, for some time, present sufficient attractions to induce capitalists to undertake them. Should, however, enlightened action on the part of the Government attempt to stimulate agricultural industry in our far western sections, it may then become a wise plan to afford substantial aid, in the way of grants of lands, to private parties and corporations whose capital should practically develop the fact of arability; guarding, of course, public interests, so far as the disposition of land to settlers in homesteads is concerned, and the public treasury; inasmuch as portions of the area brought under tribute would, at least as much as those lands known as double-minimum lands, afford an increased revenue from their sale.

ROUTES OF COMMUNICATION.

The examinations of the present year give data from which certain conclusions may be drawn regarding the *locus* of prominent lines of interior communication. This refers more especially to those lines that depart but little from a northern and southern direction.

The constantly accumulating series of profiles along lines of various azimuths create a record from which much may be drawn at such time in the future as the growing wants of interior communication call for the opening of new routes. West of the dividing ridge of the continent, between the parallels of 49° and 32° north latitude, most of the routes of interior communication must for-

ever remain upon the land. There are three streams whose navigability gives them more or less importance as commercial lines; namely, the Columbia, the Sacramento, and the Colorado Rivers. The limit of navigation of these streams for freight-carrying vessels has already been determined, and from it is deduced the conclusive fact that, except for their advantages as an assistance to local interior traffic and as the possible adjunct to transcontinental routes, the standard for their usefulness has been fixed; which usefulness is governed by the rates of increase of commerce from the ports at their mouths to and from the head of navigation in each case. So far, canals, as a method of transportation in the interior, have been scarcely attempted; should it become, however, a matter of interior policy that, for purposes of traffic, irrigation, for furnishing supplies, for mining purposes, &c., a system of canals should be constructed at economic points, in any portion of the interior, these canals can have only a local bearing. Assuming the status of interior communication, it becomes necessary to select lines of minimum gradients for rail or wagon roads after the general azimuths of direction that satisfy all the circumstances shall have been decided upon. In this, as in other seasons, we have encountered routes over which there are trails that would be impracticable for wagon-roads, and those over which wagon-roads might be built; also, wagon-roads already constructed. The latter, under franchise in Nevada, have often been improved and exist as toll-roads; such franchisements, however, have not been extended by the Territory of Utah; also railroads. These routes have been named in the ascending order of their character toward ease of communication. The wandering Indian cares little for the profile of his trail, but, generally, has selected his direction with a wonderful natural acuteness as the most direct one between two specified points that would avoid impassible obstacles. Independent of these trails, the hardy prospectors have made many in and out from the different mining-districts discovered.

The Mormons have built and maintained numerous wagon-roads, and the old overland stage-road crosses a part of our area. The Utah Southern Railroad has been graded as far as Provo, and rails laid as far as American Fork, from which point a narrow-gauge road, known as the American Fork Railway, has been driven, as one might say, up the American Fork Cañon to the smelting-works at Forest City, a distance of nineteen miles, having, as I was informed, a maximum grade of 296 feet per mile. This enterprise speaks well for the energy of the parties who are attempting to develop the mines of the West, although it may not at present be remunerative.

Routes of communication are used by the Government, more especially for the supply-departments of the Army, by the Indian Department, and as postal routes. Unlike the early days, when most of the military and Indian supplies were transported by Government teams, and the overland mails by the pony express, the policy of the Government has been to contract for the delivery of supplies, munitions of war, &c., and the movement of troops. Latterly, as the mineral and other resources in these sections have been opened up by civilization, private and corporate interests have built wagon and other roads that prior had been built of necessity by the Government through the labor of the troops or that hired from civil life. Many of the officers of the old Corps of Topographical Engineers were engaged in the construction of wagon-roads in various points of the interior, and up to the commencement of the war they were prosecuted with considerable vigor. Estimates were prepared for new and more convenient routes.

At the commencement of the war, they were withdrawn from their duties and joined our armies in the field. Since the war and up to the present time, no organized effort on the part of the Government has been made to continue the construction of these roads. Here and there, in the vicinity of military posts, the troops have been called upon for some little labor in local constructions. It would, in my opinion, be wise economy on the part of the Government to inaugurate anew the surveys and estimates for the construction of more accessible routes between the several military establishments of the interior, governed by necessities for their supply, possibility of the movement of troops in the change of stations or in operations against the Indians, or in placing of the military force with celerity at points where they may be called upon to sustain the civil law. If, for instance, it costs 2 cents per pound per hundred miles from, we will say, Santa Fé, to transport supplies by contract south or westward on existing roads for this year, and during this year a road shall have been improved 25 per cent. on a new route discovered and opened, improving travel by this amount; then, in subsequent years, if the contract were not 1½ cents per pound per hundred miles, it certainly would be less than 2 cents per pound per hundred miles. With very little trouble,

the approximate annual saving could be reckoned from data that might be collected. The fact of an economic return is applicable to all the routes used for or by the Government in the entire interior. It would seem that the subject is especially worthy of attention at the hands of those branches of the Government upon which devolve the necessary administration. It is proposed to aggregate, in connection with the survey, such data as will enable approximate estimates to be made in case the matter receives consideration. In this chapter I speak of the possibilities and propriety of a route connecting the forty-eighth parallel near the Salt Lake meridian by a southern line extending into the northern part of Arizona. By casual study of a map of our western country south of the Central Pacific Railroad, it will be seen that, west of Denver, on the east base of the Rocky Mountains, there are three separate and distinct mountain-systems passing to the southward, namely, those that have been known so long as the Rocky Mountain chain, the Wahsatch, and the Sierra Nevada. These ranges lose their typical character before reaching the thirty-fifth parallel, but between the fortieth and thirty-fifth, along these three lines, there are but few particular passes for east and west routes. The mountains that trend to the southward, following the general direction of the Wahsatch range, reach the immense plateau of the Colorado cañons, and the general line of junction is marked by a series of dislocation of strata and by extraordinary subsequent erosion, resulting in a structure whose contour offers but little guarantee for favorable profiles. The points must be few, if any, along the route of the Union Pacific Railroad west from the summit of the Rocky Mountains until we pass the Wahsatch chain, at which points in Northern New Mexico and Arizona can be found. The profiles along the line reaching from Salt Lake to the head of the Sevier, or to the lower part of Rush Lake Valley, are very gentle, and the wants of the Mormon communities, stimulated by the growing demands from mineral developments, will call for a railroad as far to the south as this latitude at no very distant day. It is proposed to explain how a route may be projected from the latter point to the vicinity of Prescott Ariz. As far as Saint George, Utah, this route is the one now used as a mail-route by stages from Salt Lake City. The only point offering a severe profile is from Kanara, the summit of the Rim, to the bottom of the descent into the basin of the Virgin River. This is not impracticable for a railroad. Passing south from Saint George, by an easy gradient we reach the head of the Grand Wash. The descent into this wash is abrupt but not great. By lengthening the line in the vicinity of this point, it may be entirely overcome. Following down the gradual wash, the Colorado River may be reached at two points, one at the mouth of the wash, another about three-fourths of a mile to the east of the crossing made by the expedition of 1871; thence to Tennakah Springs, which is reached by following a wash of easy grade leading directly to the south, which is situated about 1,250 feet below the summit of the mesa. From this point, the mesa could be reached only with considerable difficulty and expense. It can probably be skirted, however, by a contour-line of very little grade, and Truxton Springs reached, from which what is known as the Mogollon mesa might be gained, and a practicable route found via Devil's Cañon and Portal's Ranch, to Prescott.

Further reconnaissances might determine a passage down Partridge Creek, thence into Williamson's Valley; but the more favorable route would be from Truxton Springs, by the head of Aubrey Valley, north of Juniper Mountains; thence by a low divide into Williamson's Valley.

As the Colorado River is most accessible at the mouth of the Grand Wash, the route as described might be modified, should it be found by further search possible to reach the head of Hualapais Valley from that point. This is believed to be practicable, from information gathered from persons who have reached the summit of the low divide joining Hualapais Valley with the wash that leads to the river from the south, about three-fourths of a mile below the mouth of the Grand Wash. Reaching the head of the Hualapais Valley, one road might diverge to the mines in the Cerbat range, and another to those in the Hualapais range, as branches from the main route.

The total distance of the shortest of these routes from Salt Lake to Prescott is five hundred and eighty-five miles. The most direct route from Salt Lake City to the south, until latitude 37° 30′ is reached, is the present traveled stage-route to Nephi; thence entering the valley of the Sevier, Gunnison is reached, and following it to its head, whence by a low valley divide the Kanab Creek can be gained. At this point a series of flank movements to the east will be necessary, in order to reach the first practicable crossing of the Colorado at the mouth of Paria Creek. The profiles from whence the information might be derived as to the route from the head of Kanab

Creek to that point are not now at my command. Labors prosecuted in 1873 will have in view the gathering of facts in relation to this matter, and also of the opportunities of continuing a route to the south, to reach the vicinities of San Francisco Mountain and the head of Little Colorado River.

SITES FOR MILITARY POSTS.

The military establishments upon the western frontier and throughout the entire western interior are gradually assuming more permanent form. They also have been the advance-guard of civilization, and along and at the ends of the lines followed by immigration in determining the *locus* of this civilization; also at points from which operations can be successfully conducted against the several warlike Indian tribes. As fast as the Indian bands are subdued and brought under proper discipline upon reservations, these posts can more successfully co-operate with the different industries of their sections by acting as points from which parties may be at any time dispatched to protect the lives and property of settlers, and at which supplies drawn from the country are needed and from which much transportation is required. The generals commanding the different military departments usually direct the scouts and reconnaissances necessary to determine the point or points that most fully answer the requirements of changes of military posts, or for the establishment of new ones. It may not be outside of my province to suggest that, in connection with the opening of a route of communication to the southward, temporary camps be established not far from Saint George, Utah. The military forces have performed a great work in opening up routes of communication in the interior ever since its acquirement and occupation by troops and settlers.

They may still do a little more with honor and profit to the military service. The labors projected for the season of 1873 may prove the feasibility of a wagon-road from the head of the Sevier by the way of the crossing of the Colorado at some point near the mouth of the Paria; thence to a point not far from San Francisco Mountain in the valley of the Little Colorado, from which point, by branches, both Northern and Eastern Arizona could be reached.

I am led to believe, however, that the most practicable route for some time to come will be the one spoken of as leading from Saint George via the Grand Wash, Music Mountain, Aubry Valley. &c., to Prescott.

This subject receives attention under the heading "Routes of communication," and more special and detailed reports can be made, if called for, at any time from the data collected by the survey.

TIMBER-LANDS.

If the state of our geographical information permitted us to delineate upon a map of the areas of timber and no timber in the mountainous regions west of the one hundredth meridian, the small ratio of the former to the latter would astonish almost any one, whether acquainted with the subject or not. In the areas covered by our work, outside of pine, spruce, and fir, no amounts of timber of any importance are noted, with the exception of the Great Colorado plateau forests. These trees appear in the high mountains; pine generally ranging in altitude from 6,000 to about 8,500 feet between latitudes 40° and 36° north, extending above 9,000 feet in latitude south of 36° north. Spruce appears next in order of altitude, while fir keeps in many instances to tops of the highest mountain-ranges, and the points are few where these ridges reach a higher altitude than the limit of vegetation.

Our land-surveys have not reached many of the areas covered by the forests, hence the adventurous squatter has full possession, and consumes the property which he temporarily enjoys at will. The result very naturally appears as an improvident wastage of forest-products, with no return to the Government, and with the danger, at an early day, of the most damaging decimation of the forests containing trees of the kinds above mentioned. It would seem wise that the Government, through some of its branches, should take cognizance of this matter, and, by legal enactment or otherwise, stay the fearful cutting of timber, which, in connection with the many mining-towns, agricultural settlements, and military posts, will fast bring about the disappearance of forest-products that in time must have an effect upon the local climates.

Unfortunately the small areas that are under cultivation bring about no opposite to this state of affairs by the creation of other areas of increased exportation.

The subject of arboriculture has received the attention of thinking men who are interested in the vast plain regions west of the Mississippi River, and the results from investigations in this direction may receive their application in various localities in the mountains to the west of them.

Governments in older countries have found it necessary to frame laws to stimulate the working of waste places to make them fertile, and to assist in keeping fertile places from going to waste.

Although the magnificent proportions of the interior of the United States and the limited ratio of the population to the square mile to that found upon other continents would not seem to indicate a necessity of a near approach to frugality in this generation, yet as the wise experience of others often suggests actions that may properly be taken, so it would seem advisable to institute some method of obtaining statistics bearing upon this question by some bureau of the Government.

INDIANS.

The several Indian bands encountered along the routes of our march were the Uintah and the White River Utes, the Pahvans, the Pah-Utes, the Seovietz, (called Sheaviortz by Powell,) Hualapais, and the Apache Mohaves. Of these, the Pahvans, Pah-Utes, and Hualapais may be called friendly; the Utes and Seovietz, semi-friendly. The Uintah and the White River Utes, who had been considered friendly and who generally remained upon their reservations, were a disturbing element to the Mormon settlers along the valleys adjoining the Wahsatch, and east of the Sam Pitch. The Apache Mohaves were at this date hostile, although a vigorous campaign was being prosecuted against them under General Crook. We encountered a deputation of the Uintah and White River bands, with several of the principal chiefs, at Provo. They desired to know our mission; on learning which they seemed fully satisfied. They explained that their trip away from their reservation was one they desired to make annually, to visit the graves of their fathers, to gather berries, &c.; and that they would soon return to their reservations. Subsequently, further depredations having been committed in the Sam Pitch Valley, an expedition was fitted out by Lieut. Col. H. A. Morrow, Thirteenth Infantry, from Camp Douglas, Utah, for the purpose of enforcing the demand made by the Indian superintendent for their speedy return to their respective reservations. It is needless to add that this expedition had the desired effect, and probably prevented considerable further difficulty between the settlers and the Indians. I was favorably impressed with the generally intelligent and peaceful appearance of these Indians, of their comfortable costumes, and of their mounts; and it was noted that many of them were armed.

The Pahvans have been more or less peaceful Indians for a long time, although receiving few if any gifts from the Government; and, so far as I know, are only to be charged with one massacre, that of Captain Gunnison and his party, in 1853, which, as has been fully explained in former official reports, was more the result of accident than of design. They are a half-domestic, half-nomadic people, cultivating fields of wheat and corn, squashes, melons, &c., being provident of their supplies, and quite well-to-do.

The Pah-Utes are an offshoot from the great Ute Nation, and in small bands inhabit the interior mountain-valleys, about the heads of the Sevier River, Santa Clara Creek, parts of the valleys of the Virgin and the Muddy, and range, as will appear from our 1869 and 1871 reports, considerably to the westward. They speak a similar language or dialect, having few differences among their different bands, but materially changed from that spoken by the Utes proper. There are several bands of Utes that have occupied the range in Grass Valley and other creek-valleys about Fish Lake and in the San Rafael, that have not yet accepted the offers of the Government, and have thus far been on no reservation. The settlers on the Upper Sevier, until as late as 1868, have had frequent difficulties with these Indians, and it was necessary at one time for the former to withdraw. Of later years, there has been a better feeling existing, and these Indians could, doubtless, be consolidated with the Uintah and White River Utes, on a reservation in that vicinity. The Seovietz are a small nomadic tribe, who live by hunting, upon roots, mice, &c., along parts of the valley of the Colorado, in the Grand Wash, and numerous cañons and narrow valleys that lead into it. Here and there they plant small fields of corn, wheat, squashes, and melons, but the amount raised furnishes only a small share of their subsistence. South of the Colorado, about New Creek and Diamond Creek, they are quite successful in hunting, but to the north they live a squalid and miserable existence. At the date of our crossing the Colorado, a party of volunteers and Pah-Utes, about seventy in number, had just been collected to go on a scout with General Crook against the Apaches.

After reaching Camp Beale Springs, they were joined by a detail of Hualapais scouts, and proceeding to Prescott they from thence took an active part in the campaign, which now stands upon the records as a success, and one which resulted finally in quelling the warlike spirit of the Apaches; and from it we may expect most valuable results to ensue, after these several Apache bands shall have been gathered upon reservations and properly treated by the Government.

The Apache Mohaves were upon the war-path; and although straggling bands had been seen in the Hualapais Mountains, none were met by members of our party. More fortunate than in 1871, no member of the expedition was killed by Indians.

Being at times in hostile sections, it has always been necessary to keep vigilant guard over our camps and marches; thus making each one of the detached parties a separate expedition, and crippling, to a considerable extent, the effectiveness of the professional *personnel* of the party, but which could not be avoided.

In the tribes above mentioned, we have noted the usual want of industry of the males, the usual begging spirit, treacherous feeling of revenge, accompanied by a quick perception as to right and wrong, and habitual cowardly obedience to their superiors, as common to the Indian character. Unlike the Navajoes, these tribes make the females of the race "hewers of wood and drawers of water," obliging them to perform all the menial service. These tribes are all sun-worshipers; they have no respect for anything terrestrial, except that which is instilled into them through the medium of fear. It is my firm and consistent belief that the Government will not be able to stop the fast disappearance of the remnants of the aboriginal tribes now on our frontier, except by taking advantage of the fact that the Indian must be ruled through fear, and that he may be educated through labor. So far as I know, nothing has been done to necessitate industry on the part of the Indians of these mountain-sections, and those upon reservations are led to consider it as the bounden duty of the Government to feed and supply them without any return.

A small percentage of the cost of annuities paid to practical agriculturists to go among them and teach them how to labor in accordance with the modern forms, and supply them with proper implements and seeds, explaining to them the objects and values of the different crops that can be raised, or encouraging them in the purchase of stock, horses, and herds, inciting them to live in in better habitations, and we would see after one generation a most remarkable change. But few of the elements of civilization should be applied to the full-grown Indian, because under them he will languish and die. The process above mentioned acting as a matter of education could be successfully applied to the younger members and with very hopeful results. All efforts that are likely to be made available on the part of the Government to Christianize any of the Indians within the area covered by the survey under my charge will probably prove a total failure. The experiment, however, will perhaps be worth the cost, if the application of it is made through the hands of faithful persons.

The whites of this section are in the main a hazardous, impetuous people, reaching conclusions in their own peculiar way, not always characterized by the "vexatious delays of the law." They are there to open up and settle the country, or wrest from nature her hidden wealth. In pursuit of these objects, they do not stop to consider the so-called original rights of the Indian, but look upon him as something in their pathway. The rapidly increasing wants of population demand that a less portion of valuable domain be dedicated to the use of the unproductive savage, and that a sufficient amount of territory only shall be devoted to provide for the actual wants of a race that must continue to recede before aggressive and expanding enterprises, which in turn bring wealth to the nation, and correspondingly enhance the prospects of peaceful relations.

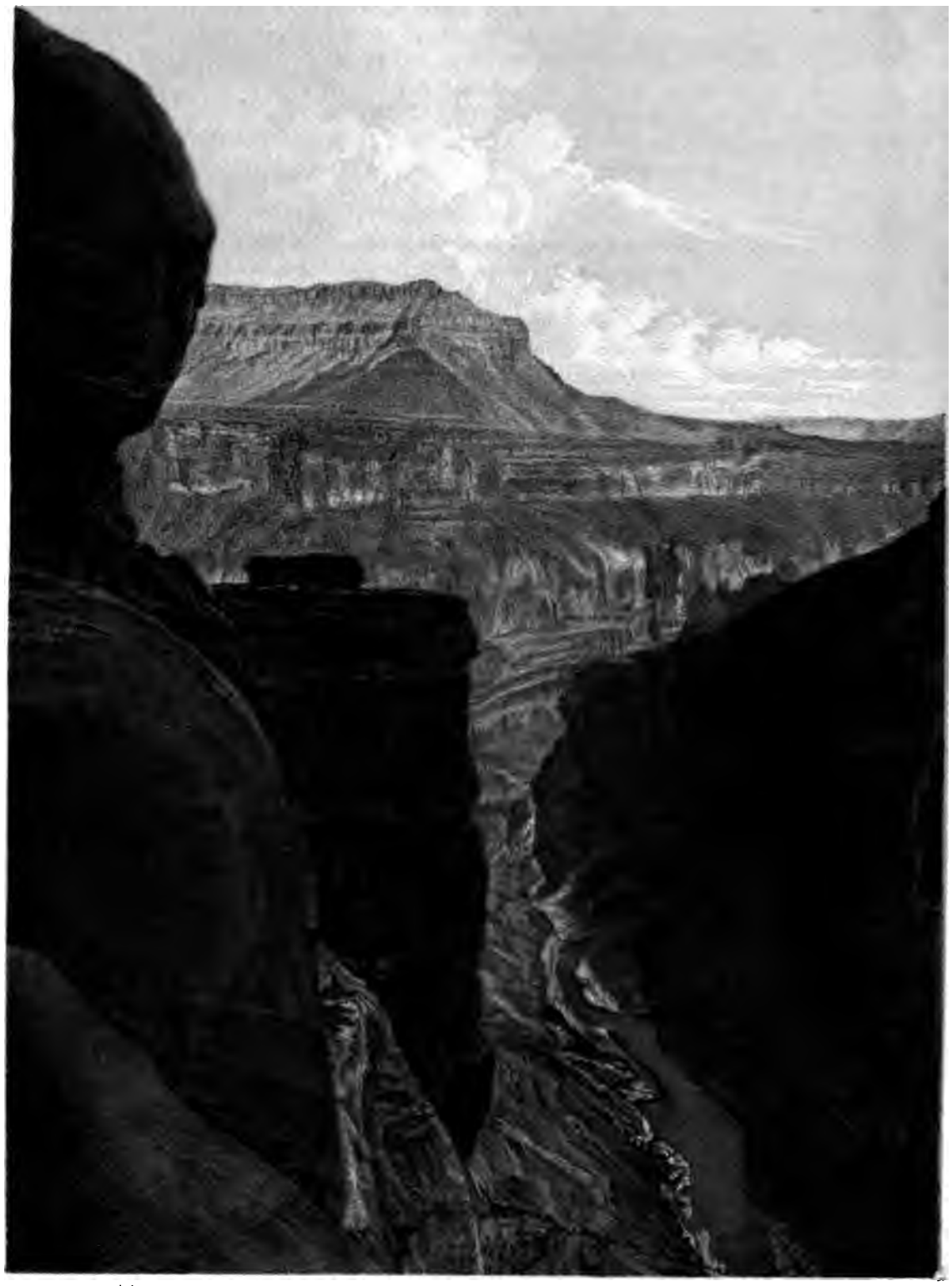
COLORADO CAÑONS.

Two parties during the season have visited at special points the lower of the main grand cañons of the Colorado River.

These points command all the crossings of the river known to exist from the foot of the cañon as El Vado de los Padres. The results, affording some of the most striking topographical details that are known in the world, can be but partially delineated upon a map, no matter what its scale may be.

Photography assists us somewhat in gathering ideas of local forms, but fails entirely to impress one with the grandeur of the shapes and details of coloring expressed in nature.

Plates 4 and 5 are characteristic sections across the cañon.



Lieut Geo M Wheeler Corps of Engrs Commdg

GRAND CAÑON OF THE COLORADO-MOUTH OF KANAB WASH, LOOKINC EAST.

Expedition of 1872. Lieut. Geo. M. Wheeler Corps of Engrs Comdg

LOOKING SOUTH INTO THE GRAND CAÑON-COLORADO RIVER

SHEAVWITZ CROSSING

CHAPTER III.

SUGGESTIONS REGARDING THE SURVEY-ORGANIZATION—SUMMARY OF RESULTS—SCHEME FOR PUBLICATION OF RESULTS—EXPLANATION OF THE SKELETON-MAP.

SUGGESTIONS REGARDING THE SURVEY-ORGANIZATION.

It is considered proper at this time to make certain suggestions, resulting from an experience of five years, regarding the organization for the survey under my charge, so far as relates to the working-parties in the field and office.

These suggestions contemplate the arrangement of the unit of force for the topographical and allied field parties; the detail of force for the astronomical parties; the force of draughtsmen required; and the clerical force.

The unit of force necessary for exhaustive examinations in the several departments of the survey in any given area should consist of three field-parties, with, at least, one officer in executive charge; one to be known as the triangulation-party, the others as parties for collecting topographical, meteorological, geological, and other data.

These parties will carry on their operations in lines nearly parallel, and make a thorough trigonometric connection over the entire district surveyed.

Herewith is submitted a memorandum showing the proposed *personnel* for these parties, as follows:

MAIN FIELD-PARTY NO. 1, OR TRIANGULATION-PARTY.

One officer of engineers, executive and astronomical duty;
One officer of the line, assisting;
One chief assistant;
One subassistant;
One chief geologist;
One assistant geologist and mineralogist;
One naturalist;
One collector;
One photographer;
One artist;
One odometer and meteorological recorder; and
Eight engineer-soldiers.

MAIN FIELD-PARTY NO. 2.

One officer of engineers, executive and astronomical duty;
One officer of the line, assisting;
One chief topographer;
One assistant topographer and meteorologist;
One geologist;
One collector;
One odometer-recorder; and
Eight engineer-soldiers.

MAIN FIELD-PARTY NO. 3.

One officer of engineers, executive and astronomical duty;
One officer of the line, assisting;
One chief topographer;

One assistant topographer and meteorologist;
One geologist;
One collector;
One odometer-recorder; and
Eight engineer-soldiers.

The plan that I would propose for the main astronomical work is to have three distinct parties: one to occupy the central and connecting station at Ogden, Utah, to be in charge of an engineer-officer; a second to occupy points accessible by railroad-communication within the area west of the one hundredth meridian; and a third party, more lightly equipped, for duty away from railroad connections, yet at points where the telegraph-line has penetrated.

The following is the *personnel* proposed for these three parties.

MAIN ASTRONOMICAL PARTY NO. 1, AT OBSERVATORY AT OGDEN, UTAH.

One officer of engineers, in executive charge;
One astronomical observer and computer;
One mechanician, telegraph operator, and assistant meteorologist;
One engineer-sergeant; and
Two engineer-privates.

MAIN ASTRONOMICAL PARTY NO. 2, RAILROAD-LINES.

One astronomical observer and computer, in charge;
One assistant observer and recorder;
One engineer-sergeant; and
One engineer-private.

MAIN ASTRONOMICAL PARTY NO. 3, STAGE-ROUTES.

One astronomical observer and computer, in charge; and
One engineer-private.

A constant drafting force of at least three persons should be employed, for the purpose of final construction and elaborate execution of the finished maps.

The clerical force should be, one money-clerk, one property and purchasing clerk, and at least one copying and record clerk.

The distribution of this force, so far as its office and field duties are concerned, should be so directed as to secure the necessary time in the office for the complete compilation from the notes and records of the results annually accumulated by the survey.

It will be seen that each of the field-parties has two executive persons in connection with it: one an engineer-officer; another an officer to be selected from some other branch of the military service.

It has been found that, where an executive officer is called upon to carry on field astronomical observations, the duties of his position become too arduous; hence he should have assistance, so that the executive and astronomical duties may be divided up between the two persons.

For assisting astronomical parties and to protect the public property and animals of the working field-force, I have thought it wise to suggest that a special detail, to consist of two sergeants, three corporals, and twenty-five enlisted men of the engineer-battalion, be stationed near the observatory-site at Ogden, Utah; said station to be in charge of an engineer-officer selected for that purpose.

At this point could be established an interior depot of supplies, which is quite necessary for the economic interests of the service, and as a matter of convenience to the survey.

Below is a tabulated statement, showing the *personnel* in the different parties:

	Officers, engineer.	Officers, line.	Astronomers.	Recorders.	Topographers.	Assis't topographers and meteorologists.	Geologists.	Natural history.	Odometer-recorders.	Soldiers.	General.					
											Photographer and artist.	Mechanician.	Money-clerk.	Property-clerk.	Copy-clerk.	Draughtsmen.
Field-party No. 1	1	1	0	0	2	0	2	2	1	8	2	0	1	1	1	3
Field-party No. 2	1	1	0	0	1	1	1	1	1	8	0	0	0	0	0	0
Field-party No. 3	1	1	0	0	1	1	1	1	1	8	0	0	0	0	0	0
Astronomical-party No. 1	1	0	1	0	0	0	0	0	0	3	0	1	0	0	0	0
Astronomical-party No. 2	0	0	1	1	0	0	0	0	0	2	0	0	0	0	0	0
Astronomical-party No. 3	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Total	4	3	3	1	4	2	4	*4	3	30	2	1	1	1	1	3

* Three medical.

EXECUTIVE.

One officer, in charge;
Three clerks;
Four engineer-officers; and
Three line officers.

ASTRONOMICAL.

(Including meteorological observations.)

Three observers;
One mechanician and assistant meteorologist;
One recorder, civilian; and
Six engineer soldiers.

TOPOGRAPHICAL.

(Including meteorological observations.)

Four topographers;
Two assistant topographers and meteorologists; and
Three odometer-recorders.

GEOLOGICAL.

One chief geologist;
Two geologists; and
One mineralogist and assistant geologist.

NATURAL HISTORY.

One naturalist; and
Three collectors.

GENERAL.

One photographer; and
One artist.

OFFICE.

Three draughtsmen.

ESCORT.

Twenty-four engineer-soldiers.

In order to fully utilize the data gained in the departments of geology and natural history, and to facilitate its proper collation and presentation, it becomes necessary to have some person to assume the executive and professional charge of each.

The salaries that have heretofore been allowed to assistants in these departments have not seemed to justify the officer in charge in continuously requiring services other than professional.

Should the above suggestions meet with favorable consideration, the following slight changes and requirements become necessary:

1st. Establishment of an interior depot of supplies at Ogden, Utah, and subdepots at other places, if necessary;

2d. The detail of 1 engineer-officer, 2 sergeants, 3 corporals, and 25 privates from the engineer-battalion, to take station at Ogden, Utah;

3d. The assistance of officers, to be selected from other branches of the service;

4th. The services of a chief geological assistant; and

5th. The services of a chief natural-history assistant.

It is considered necessary, as an essential element, that the number, size, and constitution of the several parties shall be determined, following which a larger number of persons of a high order of professional talent will be attracted to the work, in view of its expected permanency.

I think it will be apparent that, by increasing the number of units of moving field-parties, the survey can be prosecuted over proportionately increased areas, at any time, in obedience to a call from an Executive Department of the Government or Congress, provided a *pro-rata* appropriation or allotment should be made.

SUMMARY OF RESULTS IN CONNECTION WITH EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN.

The inception of this work dates from the early spring of 1869, while the officer in charge was engaged at the headquarters of Brig. Gen. E. O. C. Ord, commanding the Department of California. It comprises so far the expedition in Southeastern Nevada of that year, and the expedition of 1871, south of the Central Pacific Railroad, in parts of Nevada, Utah, California, and Arizona, and also the expedition of the present season in Utah, Nevada, and Arizona.

The scope of the survey since 1871 has contemplated examinations in the departments of astronomy, topography, meteorology, geology, and natural history. Among the most important results for the use of the Government are the topographical maps that, in finished form, appear as a part of the atlas, in ninety-five sheets, projected for the entire area west of the one hundredth meridian. There is also to be a geological atlas of the same territory, as shown by the skeleton-map. The area covered by the survey at the close of the field-season of 1872 is a little more than 155,000 square miles, or an area as large as the New England and Middle States combined. The cost per square mile has been very small; so far it has been kept within the amount justified, at an expense which is amply repaid by the map-results. The official *personnel* have charge of the executive and field astronomical work, while civilian assistants perform the majority of the duties required in the other departments, assisted, as they have always been to a greater or less degree, by soldiers specially detailed and those acting as escorts to the several parties. A map of the reconnaissance of 1869 and also a preliminary report was published at the headquarters of the Department of California; a final report of that year goes forward to the present Congress, in answer to call of that body of January 9, 1873. A preliminary report and map of the operations of 1871 appeared in the spring of 1872. The progress-report for the year 1872 is herewith.

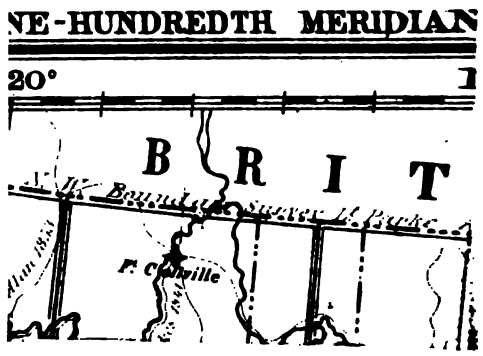
A variety of office-publications have been necessary as aids to the compilation of the immense mass of topographical and other material gathered by the survey.

SCHEME FOR PUBLICATION OF RESULTS.

The annual report submitted to the Chief of Engineers, June 30, 1873, presents the scheme proposed for the publications pertaining to the survey thus far, as follows:

It is proposed to group the material at disposal into the following form:

1st. Six quarto volumes.


NE-HUNDREDTH MERIDIAN
20°
B R I T
Ft. Colville

2d. One topographical and one geological atlas, 19 inches by 24 inches.

Volume 1 is to include the general report concerning the expedition of 1871 and 1872, describing the country traversed, facts relating to its industries, the condition of present and extinct aboriginal tribes, &c. The text-matter will aggregate about 250 pages, and 12 plates in illustration.

Volume 2 will comprise the systematic report upon the longitude and latitude campaigns of 1871 and 1872, in their due order of sequence, and, if sufficiently delayed before going to press, can receive in addition the results from the field-season of 1873, including the establishment of the observatory and the more matured plan for a comprehensive system of astronomical determinations in the area west of the one hundredth meridian. This volume will not exceed 250 pages, with but few additional plates.

Volume 3. This volume will embrace the collected data from a very large number of hourly stations, and from meteorological records connected with altitude-work, illustrated by various tables and plates. The text-matter will not exceed 50 pages. The tables and plates will complete a volume of moderate thickness.

Volume 4 will contain the finished report of the geological work for the years 1871 and 1872. The sections will appear in immediate connection with the text. The size of this volume will not differ greatly from 225 pages, increased by a few geological plates.

Volume 5. This volume, known to be the one upon "paleontology," will contain a report and numerous plates of the new vertebrate and invertebrate fossils for the years 1871, 1872, and 1873. The pages of text-matter will not exceed 100, and the plates for illustrating new subjects, probably not more than 50 or 60.

Volume 6. This last volume of the series will render the matured results for the years 1871, 1872, and 1873 in the different branches of natural history, the manuscript-matter of which will call for at least 200 pages of quarto text, and several plates.

Many photographic negatives of subjects that are of interest geologically, for special publication or for illustration of the appropriate volumes, have become the property of the survey.

It is proposed hereafter to include in the annual report for each fiscal year the results up to that date in the astronomical, topographical, and meteorological departments, while the reports relating to the geology and natural history will appear, from time to time, in a separate or special form.

The long field-seasons, the continued detail incident upon the organization, and the uncertain tenure of the survey as an annual work, have all acted heretofore as a hinderance to an earlier accomplishment of the above result.

During the present winter the first edition of the Topographical Atlas will be published; also a general topographical sheet of the entire area west of the Mississippi; a sheet illustrating certain characteristics of the basin-forms west of the one hundredth meridian; also several sheets in contours of 1,000 feet, referred to sea-level, will be prepared as fast as topographical atlas-sheets are brought out.

By the assistance of a very large office-force, the results of the survey up to the close of the field-season of 1873 will be rapidly pushed forward to elaborate completion, and the greater share of the labors therein concluded by the 30th of June, 1874.

It will be noticed by statements made in the annual report that it is proposed to so regulate the size of field and office forces that the more important results of the field-season will be published within the year.

EXPLANATION OF THE SKELETON-MAP.

This map has been projected with a view to illustrate graphically the scheme proposed for a series of atlas-maps, on a scale of one inch to eight miles, of the area of our possessions west of the one hundredth meridian; and also for the delineation of the routes pursued by the several exploration-parties sent out by the Government since the commencement of the present century, so far as the records of the Engineer Department show the same. The material required for its construction has been kindly furnished from the records of the Engineer Department. Although its compilation was exceedingly hasty, most of the information which it contains has been accurately transferred.

The routes laid down are only those resulting from the expeditions where maps have been rendered to the Bureau of Engineers for publication or for use in the compilation of their general topographical maps, and cannot be expected to embrace the large number of military expeditions of various characters that have been directed from the headquarters of the several geographical and military departments of the interior.

This map has been extremely valuable for a variety of office-uses in connection with the compilation of our finished maps, and will form the basis of a series of topographical and other maps of this scale, proposed for publication from time to time.

APPENDIX A.

PRELIMINARY ASTRONOMICAL REPORT BY JOHN H. CLARK, ASTRONOMICAL ASSISTANT.

UNITED STATES ENGINEER OFFICE,
EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., February 1, 1873.

SIR: Herewith submitted is a brief report of the astronomical determinations made by me in 1872, as a member of your expedition. The stations fixed in latitude and longitude in the order of their dates are Beaver, Utah Territory, Cheyenne, Fort Fred Steele, and Laramie City, Wyoming Territory. It is proposed to give, at this time, only a general idea of the amount and character of the work done, together with the approximate results. These latter are such as were made out and used in the field-operations, and may be considerably changed by a complete reduction of all the observations.

BEAVER.

This station was in the main plaza of the town, and was occupied in August and a part of September. The observations were made with the Würdemann meridian-instrument No. 16, 26 inches focal length, aperture 1¾ inches, mounted on a block of wood 7 feet long, firmly planted in the ground. For latitude the work extended through eight nights, embracing some 130 pairs of stars selected mainly from the British Association Catalogue.

The longitude was obtained by the exchange of arbitrary signals over the telegraphic wires with Mr. Brigham Young's observatory at Salt Lake City. These exchanges consisted of 42 signals (21 each way) each night, and were repeated five times. For clock-error, all the stars attainable from dark till an hour and a half past the time of signal-exchanges, which was 9½ o'clock, Salt Lake time, were observed. The approximate results are, latitude, 38° 16¼′; longitude, 3^m 0^s west of the Salt Lake observatory.

CHEYENNE.

The observatory here was erected in lot 11, block 413, and connected with Salt Lake by a loop into a wire of the Western Union line.

The observations were made during the month of October with the Würdemann meridian-instrument No. 26, which was substantially mounted on a huge block of wood. This is a transit and zenith telescope combined, known as the meridian-instrument of the United States Coast Survey; its focal length is 30 inches; its object-glass, 2⅝ inches in diameter. The longitude was obtained by chronometric signals, which were received and sent by the instrumentality of the chronograph devised by Professor Harkness and manufactured by Messrs. Alvan Clark & Sons, of Cambridge, Mass. The chronograph was also used to record the observations for time. These automatic signals were exchanged six evenings; besides, there was one evening of ordinary signals. For latitude there was a list from the British Association Catalogue of about 40 pairs, most of which were measured from six to eight times, and will give some 175 results. The approximate latitude is 41° 07¾′; longitude, 28^m 20^s east of Salt Lake observatory.

FORT FRED STEELE.

For the determinations at Fort Steele, as also at the subsequent station, Laramie City, the instruments used were the same as those employed at Cheyenne, and they were mounted in the same manner. The observatory here was very favorably situated in respect to the jar and smoke of the trains; there was a deep ravine between it and the track, and, being on the west side, it was to the windward.

The connection with the Salt Lake observatory was made by the Atlantic and Pacific line; and despite the unfavorable weather (it being November) and the constant occupation of the line with its own business, I succeeded during the month in getting six exchanges for longitude and a full series (about 175 pairs) for latitude. The approximate results are, latitude, 41° 46¾′; longitude, 19ᵐ 47ˢ east of Salt Lake.

LARAMIE CITY.

Laramie was occupied in December, and connected with Salt Lake by the Western Union line. The observatory was necessarily put rather close to the track, and on the east side, but, fortunately for the observations, there was but one train passing in the earlier part of the night. By the 23d of December, when our field-operations were brought to a close, I had got in work enough on the latitude for some 150 results; on the longitude three satisfactory nights, both as to signals and time. The approximate latitude is 41° 18¾′; the longitude, 25ᵐ 12ˢ east of Salt Lake. At Beaver I had the assistance of Mr. W. W. Maryatt, astronomical assistant; at the other stations that of Mr. F. R. Simonton, meteorological observer.

While at Beaver a succession of storms, (which commenced about the middle of August,) preceded by heavy winds, came up from the south, bringing sometimes torrents of rain, and interfering much with my astronomical operations. By the time any given storm had left weather fit for observations at Beaver, it had reached Salt Lake and interrupted my friend and coadjutor Mr. E. P Austin, so that out of twenty-one nights there were only ten that could be used in common for time and signal exchanges. When operating on the line of the Union Pacific Railroad, this condition of things was reversed. The storms did not now come from the south, but from the west and north, and in the place of rain, were clouds of drifting dust and snow. The movement and direction of these latter was so regular that I was well assured (when the weather-report came from Salt Lake, "cloudy, no chance") that I would be obliged to send back a similar report the next night.

In the time of the operations at Cheyenne there was but little interruption from bad weather, either there or at Salt Lake; the ratio of cloudy and clear nights at both places being about 1 to 5

Fort Steele, however, more than made up this disparity; in fact, almost reversed the ratio. In a stay of thirty days there, scarcely a week of nights were available for astronomical purposes in connection with Salt Lake. The experiences at Laramie City were almost an exact counterpart of those at Fort Steele. Both places at that time of year were subjected to too much cold and to too many wind and dust storms for any human brain and muscle to effect its best work in astronomy.

It is said our weather-experience in Salt Lake Valley this last season was an exceptional case. However that may be, I am satisfied that cloudy and stormy weather would interfere but little during the summer and fall months with the work of observatories connected for longitude along the Union Pacific Railroad, or any other line ranging east and west.

Yours, respectfully,

JOHN H. CLARK.

Lieut. GEORGE M. WHEELER,
Corps of Engineers, U. S. A., Commanding.

APPENDIX B.

PRELIMINARY ASTRONOMICAL REPORT, BY WILLIAM W. MARYATT, ASTRONOMICAL ASSISTANT.

UNITED STATES ENGINEER OFFICE,
EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., February 18, 1873.

SIR: In compliance with your instructions, I have the honor to submit the following brief preliminary report of my observations for latitudes and longitudes during the field-season of 1872:

Observations were conducted by me at the following—

STATIONS.

1. Pioche, Nev., from September 15 to October 12.
2. Gunnison, Utah, from October 21 to November 25.
3. Green River, Wyo., from December 10 to December 23.

INSTRUMENTS.

The instruments employed were—

1. A combined meridian-instrument, of the United States Coast Survey pattern, (Wm. Würdemann, No. 16,) having a telescope of $1\frac{3}{4}$ inches aperture and a focal length of 26 inches. This instrument was used at Pioche and Gunnison.

2. A Würdemann combined meridian-instrument, No. 27, of a $1\frac{3}{4}$-inch aperture and a 26-inch focus, used at Green River.

3. A break-circuit chronometer, by T. S. & J. D. Negus, No. 1491, regulated to sidereal time.

4. A recording-apparatus, consisting of a Morse register, with necessary appendages and other telegraphic instruments.

OBSERVATORIES.

For the careful protection of the instruments, a temporary observatory was constructed at each station. In selecting sites for these observatories, the chief advantages sought were proximity to the telegraph-line with which connection was to be made for exchanging signals, stability of the instruments, and, so far as practicable, an unobstructed horizon in the direction of the meridian. The combined instrument used was carefully mounted in each instance upon a solid block of wood or stone firmly planted several feet in the earth.

OBSERVATIONS.

These consisted in observations for time, with telegraphic exchanges of signals for difference in longitude, observations for latitude, and instrumental c onstants. Twelve successful nights' work, six on the longitude and six on the latitude, were gi ven to each station, except at Green River where, owing to the limited extent of time allowed, and the unpropitious state of the weather, the work remains yet to be completed.

OBSERVATIONS FOR TIME.

For a time-determination, complete transits of at least three time and two circumpolar stars were observed, by eye and ear, in each position of the transit-axis, that is, with illumination east and west. As a time-star, any star was taken whose right ascension is well determined and whose declination lies between 35° south and 50° north.

Preference w as given to almanac stars, as their right ascensions are tabulated; and other stars were introduced into the working-list from the Pulkowa catalogue of 539 zero-stars, for the German Astronomical Society's Resurvey of the "Northern Heavens," only where gaps were required to be filled in the almanac-list.

On evenings when exchanges of signals were effected, observations for two independent determinations were made, one series preceding and the other immediately following the exchange.

TELEGRAPHIC SIGNALS.

Telegraphic signals for difference in longitude were exchanged with President Brigham Young's observatory in Temple Square, Salt Lake City, with which the requisite connections were made at the first two stations by the Deseret Telegraph-Line, (A. M. Musser, superintendent,) and at the last by a wire of the Atlantic and Pacific line, (J. J. Dicky, superintendent.)

The Salt Lake observatory was in charge of Mr. Edward P. Austin, principal astronomical observer to the expedition.

The exchanges consisted, first, in receiving, during an interval of five minutes, in addition to

the Salt Lake and local chronometer breaks, a series of thirty-one arbitrary breaks made by the Salt Lake observer at consecutive intervals of about ten seconds each; and, secondly, in returning a similar series of signals made by means of a break-circuit key, the registering-apparatus being employed to record the transmission each way.

For the full satisfaction of each observer, means of the middle seven of the thirty-one arbitrary signals received and sent, together with the approximate chronometer correction, were exchanged with the Salt Lake observer on each night, subsequent to an exchange of signals, or as soon thereafter as practicable.

OBSERVATIONS FOR LATITUDE.

Observations for latitude were conducted by the zenith-telescope method upon pairs of stars selected for the most part from the British Association Catalogue. Four hundred micrometric measurements, or observations for two hundred independent results, were made at each finished station.

PROBABLE CHARACTER OF RESULTS.

No very precise statement of the probable errors dependent upon all, or even a considerable number of the observations, can be given at the present stage of the reductions.

The field-results, however, were sufficiently accordant to warrant very satisfactory results in the end. From these and the preliminary office-reductions, the probable error of a single determination of longitude cannot exceed 0.03 seconds of time; and that of a single pair observed for latitude is somewhat less than 1.50 seconds of arc.

These values will be sensibly diminished upon final computation.

Very respectfully, sir, your obedient servant,

WM. W. MARYATT,
Astronomical Observer.

First Lieut. GEORGE M. WHEELER, *Corps of Engineers,*
In charge of Explorations and Surveys West of the One Hundredth Meridian.

APPENDIX C.

REPORT BY FIRST LIEUT. W. L. MARSHALL CONCERNING THE SEXTANT ASTRONOMICAL OBSERVATIONS.

WASHINGTON, D. C., *March* 11, 1873.

SIR: I have the honor to report that, in addition to the observations at the main astronomical stations established by you within the area surveyed during the past field-season, sextant-observations were made by Lieutenant Hoxie and myself at seventy-two of our camps.

TIME AND LATITUDE.

The method employed was to take, when practicable, equal altitudes of the sun for local time, and circum-meridian altitudes of the same body and altitudes of Polaris for latitude.

When the camps were for a single night, east and west stars were observed for time, and Polaris and, when practicable, south stars for latitude.

At all rendezvous-camps, and particularly at main astronomical stations, the observations were multiplied.

By comparing the results at the latter points with those obtained by the use of more perfect instruments, the limit of probable error at the sextant-stations may be found.

LONGITUDE.

Throughout the season, M. S. box-chronometer No. 1501 by Myers, and pocket-chronometer No. 1497 by Frodsham, were carried by Lieutenant Hoxie, and M. S. box-chronometers No. 1521

by Myers, and 288 by Hutton, with my party, except when in the Wahsatch Mountains, when pocket-chronometers were used.

Careful comparisons with each other almost daily, and occasional comparisons with the chronometer in use at the Salt Lake main observatory, were made to serve as checks upon their rates. It is found, however, that, owing to the rough character of much of the country traversed and the imperfect facilities for carefully transporting them, they changed their rates so frequently that not much dependence can be placed upon the results as far as longitude is concerned.

At Deep Creek, Utah Territory, near the northwestern limit, at Fillmore and Beaver, near the center, and at Toquerville and Kanab, Utah Territory, and Pipe Springs, Arizona, in the southern portion of the area surveyed, telegraphic exchanges with Salt Lake for difference of longitude were effected.

At the first two stations mentioned, the local chronometer-error was obtained from observations upon east and west stars. At Beaver, Toquerville, and Kanab, Utah Territory, and at Pipe Springs, Arizona, from 20 to 40 sets of equal altitudes of the sun were taken on consecutive days for rate and local time, and the exchanges effected near the intervening midnights.

Respectfully submitted.

W. L. MARSHALL,
First Lieutenant of Engineers.

Lieut. GEORGE M. WHEELER,
Corps of Engineers.

APPENDIX D.

PRELIMINARY GEOLOGICAL REPORT BY G. K. GILBERT, CHIEF GEOLOGICAL ASSISTANT, EXPEDITION OF 1872.

UNITED STATES ENGINEER OFFICE,
EXPLORATIONS AND SURVEYS WEST OF ONE HUNDREDTH MERIDIAN,
Washington, D. C., February 1, 1873.

DEAR SIR: In the preliminary report for 1871, I presented a scheme for the final arrangement of the material at hand; but the work was so far from completion when interrupted by the field-season of last year, that it now appears desirable to modify the plan so far as to combine the material for the two years in a single final report. There seems, however, no reason to change the general plan of arrangement. On many accounts, the work of the past season has been more satisfactory than that of the preceding. The combination of slow-moving supply-trains, following main lines of travel with light-loaded parties deploying to the right and left, afforded the geologists many welcome options and facilities; and parallel routes were, in most cases, sufficiently near to afford some knowledge of the geological features of intervening tracts, and permit the description of areas rather than lines.

In regard to its physical characters, the area of survey may be divided into two nearly equal provinces: in the northwestern, which is part of the Cordillera system, narrow mountain ridges, chiefly composed of crushed and altered Paleozoic strata, alternate with somewhat broader valleys, half filled with the waste of the mountains; in the southeastern, which belongs to the plateau region of the Upper Colorado, the rock-system, ranging from the Tertiary to the Devonian, is comparatively undisturbed, and denudation has left its harder beds in a succession of steps. A set of parallel faults across these steps cuts them into a system of limited tables, which are so thoroughly drained by tributaries of the Colorado and Sevier Rivers that the valley-deposits interfere little with geolcgical examinations, while deep cañons afford frequent natural sections. In the former province granitoid rocks are of frequent occurrence, and in both are considerable areas occupied by lavas. Metalliferous veins are almost entirely confined to the former; but the latter contains coal inexhaustible in quantity and widely distributed.

From the great diversity of material afforded by this field, I have selected for brief mention here a few facts of somewhat general interest.

GLACIERS.

Our knowledge of the ancient glacial system of the Cordilleras has been extended by the discovery of several new localities. About White's Peak, in the Schell Creek range, Nevada, are the terminal moraines of five or six glaciers that descended to 8,000 feet altitude in latitude 39° 15′. At about the same altitude, and in latitude 39°, are moraines and an alpine lake upon the flanks of Wheeler's Peak, of the Snake range, Nevada. Old Baldy Peak, (north latitude 38° 18′,) near Beaver, Utah, overlooks two terminal moraines, one of which contains a lakelet at an altitude of about 9,000 feet. Mr. Howell thinks it probable that Fish Lake, Utah, (north latitude 38° 30′,) was produced in the same way.

No traces were seen of a general glaciation, such as the Northern States experienced, and the cumulative negative evidence is of such weight that I do not hesitate to express the opinion that the glaciers in this region were confined to the higher mountain-ridges.

ANCIENT FRESH-WATER LAKE.

The water-level of Great Salt Lake, varying with the ratio of evaporation to precipitation, has exhibited considerable change during the few years its shore has been inhabited. Former levels are marked by a series of shore-lines carved on the adjacent mountain-slopes to a height of more than 900 feet, and so conspicuous that they attract the attention of every observant traveler. When the waters rose to the uppermost beach, they spread westward across the Great Salt Lake Desert into Nevada, and southward so as to include the Sevier Desert and Sevier Lake. Beyond this an arm stretched, via the lower Beaver Valley and Escalante's Valley, nearly to the southern line of Utah. Northward the extent was comparatively slight, and at the east the Wahsatch range then as now constituted the barrier. The lake was diversified by numerous rocky islands and promontories, and its water was fresh. A rough estimate places its area at 18,000 square miles, eleven times that of the present lake, and a trifle less than that of Lake Huron; the average depth was about 450 feet, and the volume of water was nearly four hundred times greater than now. Along the portion of the shore we examined (the southern half) we found no outlet, but there is strong circumstantial evidence that one exists, and I am told by Prof. O. C. Marsh that he found it at the north leading to the Snake River, and so to the Columbia. Barometric observations at numerous and remote points of the beach tend to show that it is not now perfectly horizontal, but has been slightly flexed. The necessary computations are not yet sufficiently advanced to demonstrate the amount of change, but the maximum is approximately 300 feet.

The deposits from this great lake are wide-spread, but not thick. The most conspicuous is a white marl filled with fresh-water shells. This is found not only underlying gravel of recent subaerial deposition, the wash from the mountains, but also *overlying* a precisely similar gravel—a sequence of deposits admitting of no other interpretation than that the epoch of high water was preceded by a period like the present, and instead of being a stage in the gradual desiccation of the continent, marked a transient and not remote episode in a climate that has been for a long period a dry one. A group of basaltic lava cones in the vicinity of Fillmore, Utah, bear testimony to the recency of the lake epoch. They are scattered, with their associated lava-fields, over a plain 200 feet lower than the highest water-mark, and their state of preservation shows that they are of slight antiquity. The majority of them were covered by the lake; but a few have been formed since the subsidence, and these are so fresh as to be absolutely devoid of vegetation.

These features of the flooding of Great Salt Lake Valley, namely, that it marked a temporary climatal extreme, and that its occurrence was, geologically speaking, very recent, lead me to regard it as contemporary with the general glaciation of the northern portion of the continent, and with the formation of the numerous local glaciers of western mountain-systems, and to consider it, in common with them, a phenomenon of the Glacial epoch. While the general climatal change that caused or accompanied that epoch (depression of temperature, carrying with it decrease of evaporation, if not increase of precipitation) may be adduced as the cause of the inundation of Utah, there is no reason to suppose that the relative humidities of the various portions of the continent were greatly changed; and this consideration will aid in accounting for the curious fact that the

ice on our eastern seaboard stretched unbroken past the fortieth parallel, while under the same latitude in the Cordilleras no glaciers formed below 9,000 feet.* The climatal change that in the humid east admitted a continental glacier, sufficed in the same latitude at the arid west only to fill the water-courses and cap with perennial snow and ice the highest mountain-peaks. If we suppose that the glacier which overran the Northern States had its source within the arctic zone, we bring another consideration to the aid of the one already adduced; for the comparative resistance of the elevated rugose mountain-region and the eastern lowlands would determine the motion of the ice toward the latter area. The southern margin of the glacier might thus be as far removed in climate from the conditions of ice-accumulation as are the fertile Swiss valleys in which the greater Alpine glaciers terminate.

MOUNTAIN-BUILDING.

Our routes in 1871 and 1872 were of such nature as to enable us to accumulate a great number of cross-sections of mountain-ridges of the Cordilleras in parts of Nevada, Arizona, California, and Utah. The study of these led to some speculations in regard to the origin of mountain-ridges, very nearly identical with the views recently advanced by Prof. Joseph Le Conte, (American Journal of Science, November and December, 1872.) Without entering upon these, or attempting to present the material upon which they depend, I will briefly note a single conclusion in regard to the structure of the Cordilleras of the West that seems pertinent to the discussions of general orology now in progress.

The sections accumulated by our geological observers admit of the following classifications:

1. Faulted monoclinals occur, in which the strata on one side of the fault have been lifted, while

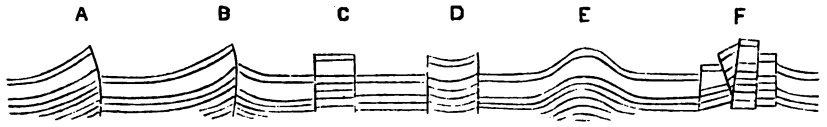


FIG. 1. Diagram of generalized mountain-sections, discounting denudation.

those on the opposite side either do not appear, (*a*,) or (less frequently) have been elevated a less amount, (*b*.) Two-thirds of the mountain-ridges can be referred to this class.

2. Other ridges are uplifts limited by parallel faults, (*c*,) and to these may be assigned a few instances of isolated synclinals, (*d*,) occurring under circumstances that preclude the idea that they are remnants omitted by denudation.

3. True anticlinals (*e*) are very rare except as local, subsidiary features, but many ranges are built of faulted and dislocated rock-masses, (*f*,) with an imperfect, anticlinal arrangement.

Not only is it impossible to formulate these features, by the aid of any hypothetical denudation, in such a system of undulations and foldings, as the Messrs. Rogers have so thoroughly demonstrated in Pennsylvania and Virginia, but the structure of the western Cordillera system stands in strong contrast to that of the Appalachians. In the latter, corrugation has been produced commonly by folding, exceptionally by faulting; in the former, commonly by faulting, exceptionally by flexure. In the latter, few eruptive rocks occur; in the former, volcanic phenomena abound, and are intimately associated with ridges of upheaval. The regular alternations of curved anticlinals and synclinals of the Appalachians demand the assumption of great horizontal diminution of the space covered by the disturbed strata, and suggest lateral pressure as the immediate force concerned; while in the Cordilleras, the displacement of comparatively rigid bodies of strata by vertical or nearly vertical faults involves little horizontal diminution, and suggests the application of vertical pressure from below. For these reasons, and others that will be adduced in the final report, I regard the forces that have upheaved the Cordilleras as distinctively deep-seated, producing, in a portion of the earth's crust below the immediate surface, inequalities, perhaps undulations, in adjusting to which, under gravity, the upper portion of the crust has assumed the forms we see.

* The possibility of the formation of glaciers and their magnitude at any point depend on precipitation no less than temperature.

COAL.

Two coal-horizons were distinguished, the upper occurring in fresh-water beds of the age of the Lignites of the Upper Missouri,* the other low down in the Cretaceous series. A bed of the former is worked in a small way at Wales, San Pete County, Utah, and affords a coal of such superior quality, as compared with competing grades, that its limited quantity is especially to be regretted. The vein nets but three feet, and cannot be worked in depth without pumping. The coal is highly bituminous, cakes in burning, and is readily converted into coke. Its only visible impurity is carbonate of lime, and the usual visible traces of sulphur, for which careful search was made, are entirely absent. Equally remarkable and exceptional is the fact that it is roofed and floored by limestone, and the two or three thin coal-seams associated with it are similarly encased, no one of them resting upon the well-nigh universal under-clay. Fresh-water shells abound through the section, occurring even in the coal, and complete the parallelism of the series to the alternation of calcareous and carbonaceous deposits (marl and peat) to be found in modern land-locked marshes.

The Cretaceous coal-series includes a number of veins, one to three of which are of workable thickness wherever I crossed the horizon. Few openings have been made, and little is known of the quality, but the quantity is certainly very great. The coal-lands form, with little interruption, a belt one hundred miles long, traversing Southern Utah (Iron and Kane Coun ties) in a generally east and west direction, and should receive a far more thorough examination than we were able to make. The distribution and character of coal should have great weight in determining which of several alternative routes shall be followed by a railroad running south from Salt Lake City, and will greatly affect the future development of Southwestern Utah. It was with regret that I left a field that, while it affords much matter for scientific study, is at once so intimately associated with important and more immediate material interests.

ARTESIAN WELLS.

The importance of this subject to the inhabitants of the Great Basin will excuse a few words as to the conditions of success. Artesian water (*i. e.*, deep-seated water-veins, with head to overflow) might be expected in our field in two classes of localities; the water-bearing beds being in the one case undisturbed and comparatively recent basin-deposits, and in the other indurated strata, more or less inclined. For localities of the first class, one essential condition is that an impervious (*i. e.*, fine-grained) bed, (*a*, Fig. 2,) overlying a porous bed, shall have its margins sufficiently elevated to afford the requisite head.

Since all the deposits of a valley are apt to be coarse in close proximity to a mountain-range,

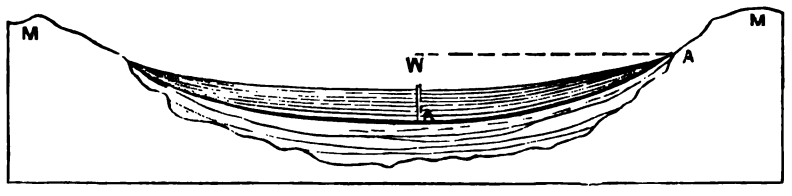


FIG. 2. Ideal section of valley between mountain ridges, *m m*; *a*, impervious bed; *w*, well.

this is not likely to be fulfilled in a *narrow* valley among the Cordilleras, but may in a broad one. I can think of no place where I should be more confident of artesian water than on the Great Salt Lake Desert—say on the *jornada* between Granite Rock and Redding Spring—but *pure* water could not be expected from the bottom of a basin so perfectly land-locked. Some point on the Amargosa Desert, or in Ralston's Valley or Big Smoky Valley, Nevada, would be more likely to afford it.

To pierce the indurated rocks, a locality should be selected where those of the adjacent range dip toward the valley with such inclination and uniformity as to promise continuity below the

* Identified by a comparison of fossils by Mr. F. B. Meek.

valley-deposits, and where, too, the rocks comprise a proper succession of permeable and impermeable strata.

FIG. 3. Ideal mountain-section: *a*, impervious strata; *b*, water-bearing strata; *w*, well.

Such localities are very numerous, but are usually so well watered that there is no demand for artesian wells. Exception may be made of the western base of the Fish Creek range, Utah, near its northern extremity; of the eastern base of the same range, near Sevier Lake; of the eastern base of the Beaver Creek range, Utah; of the western base of the Cedar range, Utah; and of the western base of the Pahranagat range, under Quartz Mountain, Nevada. The most favorable of these stations are the two last mentioned, but none of them give unequivocal promise of success

ACKNOWLEDGMENTS.

My own work has been supplemented throughout the season by that of the assistant geologist Mr. E. E. Howell, and the data presented above are in part from his notes. I am specially indebted to Messrs. Gilbert Thompson and Francis Klett, of the Topographical Corps, for valuable notes and collections from points not visited by the geologists, and I gratefully acknowledge the cheerful co-operation and assistance of all the officers and other gentlemen of the party.

Our thanks are tendered to Prof. J. E. Clayton, of Schellbourne, Nev., and to Mr. John Harris, of Glendale, Utah, for valuable fossils.

Very respectfully, your obedient servant,

G. K. GILBERT,
Chief Geological Assistant.

GEORGE M. WHEELER,
First Lieutenant United States Engineers, in charge.

APPENDIX E.

REPORT UPON NATURAL-HISTORY COLLECTIONS, BY ACTING ASSISTANT SURGEON H. C. YARROW, SURGEON AND NATURALIST.

UNITED STATES ENGINEER OFFICE,
EXPLORATIONS AND SURVEYS WEST OF ONE HUNDREDTH MERIDIAN,
Washington, D. C., January 8, 1873.

SIR: In accordance with verbal instructions received from you, I have the honor to submit the following preliminary report of the work and collections made in natural history during the months of July, August, September, October, November, and December, 1872, in Utah, Nevada, and Arizona, by the expedition under your command. Our labors in natural history may be said to have commenced from the time of our arrival at Salt Lake City, Utah; for, during the unavoidable delay incident upon organizing so large an expedition, nearly every moment was occupied in studying and collecting specimens in the vicinity of Salt Lake City and Provo, Utah, and I am glad to be able to state that our researches were richly rewarded. The Great Salt Lake was visited, and its waters carefully examined for forms of animal life; but with the exception of *Artemia fertilis*, a curious crustacean, described by Prof. A. E. Verrill, of Yale College, some time since, nothing was found. From certain newspaper and popular reports, we had been led to believe there existed in the lake a representative of the genus *Anguilla*, (eels;) but after a close and careful examination of the bottom of the lake for upward of sixty miles, no such fish could be seen; in short, no fish

whatever were perceived, and it is believed none at present exist in its waters. Dead fish are frequently found floating upon the surface of the water, but they are of the river-forms, and no doubt have entered the lake accidentally, losing their lives thereby. Numbers of the *Artemia* were captured and forwarded to Professors Baird, of the Smithsonian Institution, and Verrill, of Yale College, for examination, with the hope that additional species of the same family might be discovered. These interesting forms were also found in Sevier Lake, Utah; and in the final report more space will be devoted to their discussion. On the shores of the lake were noticed large masses of the *Exuviæ* of a certain dipterous insect (*Chironomus?*) mentioned by Capt. H. Stansbury, United States Topographical Engineers, in his report of the expedition to Great Salt Lake in 1849 and 1850, and vast swarms of the mature flies were seen hovering over the surface of the water for miles. It may be mentioned in this connection that from the teeming abundance of these insects and crustaceans in the lake, affording a great supply of food, there seems no reason to doubt but at an early period salmon, alewives, and shad may be introduced and thrive in Salt Lake, the fresh-water streams emptying therein furnishing a good spawning and running ground for these fish. The water of the ocean is said to contain about 12 per cent. of salt, that of the Mediterranean Sea 15 per cent., while the water of Salt Lake contains about 25 per cent. May we not (if accepting the theory of evolution) expect to find that at no distant period fish may become so habituated to the endosmotic action of a saline solution only twice as strong as ordinary sea-water as to thrive in the waters of Salt Lake? From an economic point of view, the experiment of introducing the spawn of the fish already named is of vast importance, and will probably be tried under the supervision of Professor Baird, United States Commissioner of Fish and Fisheries, who is thoroughly cosmopolitan in his desire to cheapen and furnish fish-food for the people. At Provo, Utah, a small city situated some fifty miles south of Salt Lake City, my assistant, Mr. Henshaw, and myself remained eight or ten days collecting specimens in the immediate vicinity of the town and Utah Lake, a beautiful body of water four or five miles from Provo, abounding with fish.* As might be expected from the character of the country in this neighborhood, there being plenty of trees and water, representatives of the feathered tribes were numerous, and the waters of the lake and rivers emptying therein were crowded with ichthyological life, while the fields and marshes afforded many specimens of reptiles and insects. The habits of the food-fishes of the locality were carefully studied, with a view to their economical importance, and a valuable array of facts was obtained from those who derived their principal subsistence from these waters. The knowledge acquired in this way will be made the subject of a special paper to the Commission of Fisheries. I may here state that ten years ago, when Provo was in its infancy, with the exception of some few water-birds found near the lake, very few, if any, birds were seen near the settlement; but as the arborescent foliage has increased, the number of birds has correspondingly multiplied, until no less than ——— species from this locality are numbered in our collection. At this point one hundred and fifty birds' skins were secured, besides a large collection of fish, reptiles, and insects. Although rather late in the season to collect birds' nests and eggs, yet quite a number of valuable specimens were obtained, among which may be mentioned the nests and eggs of the black-chinned hummingbird, (*Trochilus Alexandri*, Bourc. and Muls.;) particularly valuable, as few museums possess examples of this interesting nest. The collection of coleoptera at this point was large and interesting, and it is believed several new species may be found therein. A large number of botanical specimens were also secured, and will probably prove valuable in increasing our knowledge of the somewhat limited flora of Utah. It is an interesting fact, and worthy of mention, that in Provo is the only locality in all Utah in which the common garden or angle worm is found. They are not native, but were introduced by Doctor Roberts, of this city, and have increased to such an extent as to completely honey-comb the soil of all the gardens of the vicinity, and in this way greatly assist in irrigation. To the same public-spirited gentleman, the settlers are indebted for the introduction of the common eastern quail, (*Ortyx. Virgianus.*, Bonap.,) which is constantly increasing to such a degree as to bid fair in a few years to overrun the entire western country. After leaving Provo and pro-

* At this place our attention was called to a fish numerous in winter, called by the Mormons "mountain-herring;" upon investigation, much to our surprise, this was found to be a species of whitefish, (*Coregonus Williamsoni*,) a native of the fauna of Puget Sound. From the basin of the Great Salt Lake it has never been chronicled before, and this interesting fact is mentioned as showing one of the many valuable items of geographical distribution established by the expedition. It was also found in the Sevier, near Panquitch.

ceeding toward the Nevada line, owing to the extreme barrenness of the country the birds gradually decreased in number until days would pass without meeting a single individual; but as an offset to the paucity of specimens in this respect, many interesting fish were obtained from nearly all the streams and springs we passed; these were nearly all cyprinoids, and it may be mentioned, as a matter of interest, that some of these fish were found in alkaline water at a temperature of from 80° to 120°, and so strongly impregnated with sulphuretted hydrogen-gas as to be unfit for potable purposes. While passing through the barren country on our way to the Nevada line, our attention was called to the singular mimicry of color in the reptiles and insects; even the few birds seem partaking more or less of the color of the earth and sage-brush in different localities. The peculiar noise made by the rattlesnake was several times mistaken for a similar noise made by the larger grasshoppers; and whether, according to Professor Aughey, this rattling was intended as a sexual call or for the purpose of intimidating its victims, we were not able to discover. Certain it is, according to our experience, that these snakes frequently rattle without any apparent cause of provocation. In Spring Valley, Nevada, a valley in which lakes and small creeks abound, no fish are found, while in Snake Valley, only a few miles to the eastward, great numbers of fish are taken and furnish a major part of the food of the Snake Indians who reside there. The conditions of life being apparently the same in both valleys, it is curious to note this want of occurrence. Constant watchfulness was observed in journeying through this locality, and many valuable specimens secured. After leaving Nevada and approaching the settlements, the birds again increased in number, and we found this invariably to occur, and we may thus establish as a law this proposition: the larger the settlements and the more the land is cultivated, the greater the number of birds. At Fillmore and Beaver valuable collections were made, and at Meadow Creek we were fortunate enough to secure several crania of Ute Indians, among which was that of Wah-ker, a celebrated chief, who for a long time was a scourge to the people of New Mexico, California, and Utah. At Panquitch, southwest of Beaver, some time was spent investigating the icthyology of the Sevier River and that of the lake of the same name. Many valuable fish and shells were here obtained. After passing the rim of the Great Salt Lake Basin, we found the fauna and flora very different from what we had heretofore seen, and our eyes were delighted with the almost tropical vegetation which surrounded us in favorable localities, while our ears were pleasantly greeted with the sweet songs of myriads of small birds. At Toquerville, our rendezvous-camp, my esteemed assistant, Mr. Henshaw, joined the main party, from a trip to the eastward of the Salt Lake road, bringing with him a large and valuable collection. It is greatly to be regretted that in the passage of a difficult Indian trail leading from Shonesburgh to Toquerville, a collection of mineral waters and a number of bottles containing insects were lost. This was particularly unfortunate in connection with the fact that most of our lepidoptera had been destroyed by fire in the Sevier. At Toquerville valuable results were obtained in collecting mammals, birds, fish, &c., the country for miles around being thoroughly explored and laid under contribution. At this point, by your order, Mr. Henshaw and myself detached from the main party and started for Salt Lake City, making a detour to the southward, and taking *en route* all the most favorable localities for collecting; and, with your approbation, we were permitted to remain for a certain period in every possible spot where our work could be of advantage to the expedition. At Washington we remained some time, constantly engaged in our researches, and were here rewarded by finding the swamp-sparrow, (*Milospiza palustris*, Baird,) whose previous geographical range was from the Atlantic Eastern States to the Missouri, and Abert's Towhee, (*Pipeto Abertii*, Baird,) an individual heretofore found only in New Mexico, Arizona, and California. We secured this bird also at Saint George, and about ten miles northward from that city we were fortunate enough to capture a fine cactus-wren, (*Campy torhynchus brunneicapillus*, Gray,) a species found in California, New Mexico, and Arizona, but never before in Utah. Passing up the valley of the Santa Clara River, we were overtaken by a severe hail-storm, which effectually drove away all the migratory birds, and for days no specimens were seen except a few jays and ravens. At Beaver we had a few days pleasant weather; but after this, during the entire trip to Provo, we had such severe cold, that had specimens been abundant, we should have failed to collect them. At this latter point, our work again commenced, and we made a fine collection of birds and fish. We here procured a valuable

series of hawks, which were unusually abundant, and many skins of water-fowls. Trout were being captured in large numbers in the river and lake, and some were procured. As we had found in the spring, this point was by far the richest locality visited for ornithological specimens, and we ended our field-work at this point. I would mention that in the final report, (according to your directions,) the collections of 1871 will be described and consolidated with those of 1872; the various specimens having been forwarded, through the Smithsonian Institution, to scientific gentlemen well known as specialists in their several lines of research. The names of Cope, Gill, Edwards, Thomas, Ulke, Tryon, Uhler, and Watson are a sufficient guarantee that the work will be properly performed. It is impossible to give at this time the exact number of specimens collected, yet an approximative idea may be obtained from the statement that, in addition to a number of mammals, the bird-skins alone number over six hundred, embracing probably not less than one hundred and ninety species. The fish and reptiles will probably number nearly four hundred, and the insects, shells, and plants many more. When we take into consideration the fact of our rapid travel from point to point, and the many disadvantages we were obliged to labor under, such as leaky cans, loss of alcohol and other material, and breakage, I think we may assume that in natural history much has been accomplished. In regard to the arrangement of the final report, it is intended to devote certain chapters to lists and descriptions, whenever necessary, of the various specimens collected, with notes as to habits, localities, and geographical distributions; the synonomy will be made as complete as possible, and a general summary of facts will be given.

In concluding, I desire to return my sincere thanks to yourself for the great interest you have always manifested in my special department, and for the many facilities you have afforded me, without which our collection could not have obtained its present magnitude; and to my able and energetic assistant, Mr. H. W. Henshaw, my acknowledgments are also due for his invaluable services, and to other members of the party who have kindly collected specimens, thereby helping to increase the aggregate of general results.

Very respectfully, your obedient servant,

H. C. YARROW,

Acting Assistant Surgeon, U. S. A., Surgeon and Naturalist Expedition of 1872.

Lieut. G. M. WHEELER,

Corps of Engineers, in charge of Explorations west of One Hundredth Meridian.

APPENDIX F.

PRELIMINARY ETHNOLOGICAL REPORT BY M. S. SEVERANCE.

UNITED STATES ENGINEER OFFICE,
EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., March 19, 1873.

SIR: I have the honor to make the following succinct preliminary report on ethnological work accomplished during the season of 1872, in accordance with verbal instructions issued by yourself in the field.

The extent of the work in the department of ethnology was necessarily abridged to a considerable degree by the rapidity of the marches consequent on the traversing of large areas of country, and the small amount of time that could be devoted in any one place to the consideration of a special local topic. Another element hostile to much work in this line was the unfriendly attitude in which the Ute and other tribes of the Territory of Utah stood to the General Government during the months in which the expedition held its line of march through their country; which naturally rendered intimate intercourse not only profitless but dangerous, and shut the door upon a source of information concerning a tribe of comparative obscurity and interesting history. An endeavor was made, however, as far as possible, to overcome these obstacles; and the collection of data relating to the present and past inhabitants of the country passed over will be found to be not inconsiderable.

At Provo, Utah, several careful excavations were made in a number of mounds scattered over the plain on which the town stands, and a mass of miscellaneous objects secured; stone-mills and pestles, arrow-heads, bits of pottery of various patterns, numerous bones of animals, several domestic implements fashioned from bone and other materials, and the almost perfect skeleton of a man.

Several articles of ethnologic value were also presented to the expedition by Mormon farmers, who had obtained them from mounds and elsewhere; conspicuous among which is a water-pitcher of beautiful fashion, slightly imperfect.

At Paragonah, Utah, a congregation of mounds four or five hundred in number, and covering an area of at least fifty acres, was examined superficially, under the guidance of a Mormon who has partially leveled the largest and most central of the group. As the expedition did not camp at a convenient distance from Paragonah, there was no opportunity afforded to continue the Mormon's excavations nor to begin anew. In this connection, it may not be improper to state that if the Government were ever disposed to prosecute a thorough and scientific inquiry as to the origin, nature, and probable use of the mounds of Utah, in their relation to the general subject of ancient mounds, no more suitable field than the mounds of Paragonah could be wished, scattered as they are over a level stretch of untilled country, and in such numbers that a large amount of work might be done in a limited time. The complete leveling of several of these mounds, including the central and apparently focal one, in which traces of rude adobe-work and wooden beams have been found, might reasonably be expected to furnish much valuable information in regard, at least, to their construction and uses, if not their age.

At Beaver, Utah, another interesting and compact collection of mounds was examined and probed to a slight degree, yielding the same general curiosities as the mounds of Provo, but pottery of quite distinct marking, though of similar material and form. A couple of Indian rock graves were also opened at this place, on a side-hill east of the town, and three skeletons and a large number of burial-trinkets secured.

At other points in Utah, as well as at Camp Beale Springs and elsewhere in Arizona, Indians in greater or less numbers were met; but beyond the securing of a small amount of philological material, there was little ethnologic work effected on account of the rapidity of the expedition's movements.

Notwithstanding the unfriendly temper in which the Utes and some of their outlying bands were found at the time when we passed through them, I was fortunate enough to secure a three-hours' talk with Anterro, an old war-chief of the Utes, at a Mormon cattle-ranch near Spanish Fork, and drew much interesting information from him regarding the customs and beliefs of his tribe. At various times favorable opportunities were found to obtain additions to the Ute vocabulary, already tolerably well understood, and arrangements are in train for obtaining still more copious information on their dialect and history from a soldier attached to the escort of 1872, who has spent several months among them in daily intercourse. Arrangements have also been made for obtaining vocabularies and other interesting matter concerning the Hualapais and Mohaves from officers in Arizona. Much good might be annually effected, if the spare time of frontier officers here and elsewhere were devoted to ethnologic and philologic research among the fast disappearing people around them.

To yourself and the officers under your command, and particularly to Dr. H. C. Yarrow, surgeon and naturalist, I am indebted for valuable aid in prosecuting the work briefly mentioned in the above skeleton-report.

I am, sir, your very obedient servant,

MARK SIBLEY SEVERANCE.

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