C. D. Walcott.



# FIRST ANNUAL REPORT

OF THE

# UNITED STATES GEOLOGICAL SURVEY

TO THE

HON. CARL SCHURZ,
SECRETARY OF THE INTERIOR.

BY

CLARENCE KING,
DIRECTOR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1880.

Chas. D. Walcott.

# ANNUAL REPORT

OF THE

# UNITED STATES GEOLOGICAL SURVEY.

---

UNITED STATES GEOLOGICAL SURVEY,
OFFICE OF THE DIRECTOR,
*November* 1, 1880.

Hon. CARL SCHURZ,
*Secretary of the Interior, Washington, D. C.:*

SIR: I have the honor to present herewith the first annual report of the United States Geological Survey, covering the fiscal year ending June 30, 1880.

Congress having prescribed the mode of publishing the results of the survey, it is intended to confine these pages to a simple statement of the bureau organization, progress of field investigation, and results already attained.

The law creating the office of Director of the Geological Survey was enacted and approved March 3, 1879. On March 21, 1879, the President nominated me first Director of the Geological Survey, the Senate confirmed his action on April 3, 1879, and on May 24 I took the prescribed oath of office, and entered on my duties.

Congress expressed its determination to inaugurate the Geological Survey in a provision of law so brief, that I give it entire, in order to comprise in this report the history of the origin and organization of this bureau.

"GEOLOGICAL SURVEY.

"For the salary of the Director of the Geological Survey, which office is hereby established under the Interior Department, who shall be appointed by the President, by and with the advice and consent of the Senate, six thousand dollars: *Provided*, That this officer shall have the direction of the Geological Survey, and the classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain. And that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the Geological and Geographical Survey of the Territories, and the Geographical and Geological Survey of the Rocky Mountain Region, under the Department of the Interior, and the Geographical Surveys west of the one hundredth meridian, under the War Department, are hereby discontinued, to take effect on the thirtieth day of June, eighteen hundred and seventy-nine. And all collections of rocks, minerals, soils, fossils, and objects of natural history, archæology, and ethnology, made by the Coast and Interior Survey, the Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the National Museum.

"For the expenses of the Geological Survey, and the classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain, to be expended under the direction of the Secretary of the Interior, one hundred thousand dollars." Enacted and approved March 3, 1879.

Prior to the above enactment, and at irregular intervals since the early years of this century, the national government had made various attempts to acquire and diffuse information on the geological structure and mineral resources of the United States. Geologists were dispatched to report upon certain fields of mineral industry, and to nearly every military exploration or international boundary survey was attached some one more or less competent to delineate and describe the geological features of the land traversed. Instances of success in this line of expeditionary geological reconnaissance may be found in the reports of the Pacific Railroad and Colorado River surveys, executed under the Corps of Engineers of the Army, and those of the Mexican boundary surveys; while in the department of economical geology, Forster and Whitney's Lake Superior report stands almost alone.

Up to 1867, geology was made to act as a sort of camp-follower to expeditions whose main object was topographical reconnaissance. Charged with definite objects and missions, the leaders of these corps have tolerated geology rather as a hinderance than a benefit. In consequence, such subsidiary geological work amounts to little more than a slight sketch of the character and distribution of formations, valuable chiefly as indicating the field for future inquiry.

In the year 1867, however, Congress ordered the geological exploration of the fortieth parallel, a labor designed to render geological maps of the country about to be opened up by the Union and Central Pacific Railroads, then in process of construction. In this work, geology was the sole object. For the first time a government geologist found himself in independent command, able to direct the movements and guide the researches of a corps of competent professional assistants. At the same session of Congress, Dr. Hayden's "Geological and Geographical Survey of the Territories" was ordered, and a little later Maj. J. W. Powell's "Geological and Geographical Survey of the Rocky Mountain Region" was likewise placed in the field.

Eighteen hundred and sixty-seven, therefore, marks, in the history of national geological work, a turning point, when the science ceased to be dragged in the dust of rapid exploration and took a commanding position in the professional work of the country.

Congress, even then, hardly more than placed the Federal work on a par with that prosecuted by several of the wealthier States. During the years when the Federal geologists were following the hurried and often painful marches of the Western explorers, many States inaugurated and brought to successful issue State surveys whose results are of dignity and value.

Since 1867 the government work has been equal to the best State work, and in some important branches has taken the lead. The wisdom of the legislation which placed in the field those well-organized, well-equipped, and ably-manned corps is apparent in the improved and enlarged results obtained.

But there remained one more step necessary to give the highest efficiency and most harmonious balance to the national geological work.

It was the discontinuance of the several geological surveys under personal leadership, and the foundation of a permanent bureau charged with the investigation and elucidation of the geological structure and mineral resources and productions of the United States.

The legislation above cited, and upon which the existence of this bureau is based, leaves some room for doubt as to the precise intention of Congress, both regarding the functions of the organization and its field. Two special and distinct branches of duty are imposed upon the Director of the Geological Survey: 1. The classification of the public land; and, 2. The examination of the geological structure and mineral resources.

As regards the classification of public lands, the text of the law leaves an uncertainty whether this classification is intended to be a scientific exposition of the kinds of lands embraced in the national domain, such as arable, irrigable, timber, desert, mineral, coal, iron, showing the practical values and adaptabilities of the various classes or kinds of soil and surface, or whether, on the other hand, it was intended to furnish a basis of classification, upon which the government should part title to portions of the public domain.

At present the General Land Office possesses the machinery for the survey, classification, and sale of the public lands. In that bureau the field-notes and maps of the various deputy surveyors are intended to convey sufficiently accurate information for the general guidance of the officers who execute the sales. The law also provides a method of proof as to the character of lands, which forms an indispensable stage in the process of sale. Any transaction as to a piece of public lands may be challenged before the proper officers, and its character may be determined by competent proof. The present method of sale of the public lands depends, therefore, chiefly upon a rule of law rather than the classification of experts in advance of the procedure of sale.

Upon examination of the existing land system, I have assumed that Congress, in directing me to make a classification of the public lands, could not have intended to supersede the machinery of the Land Office, and substitute a classification to be executed by another bureau of government, without having distinctly provided for the necessary changes within the Land Office, and adjustment of relations between the two bureaus.

The Public Lands Commission, created by Congress in the same law which organized the Geological Survey, carefully examined into the question of classification and disposition of the public lands. In the deliberate opinion of that body, it has been adjudged impracticable for the Geological Survey, or any other branch of the Interior Department, to execute a classification in advance of sale, without seriously impeding the rapid settlement of the unoccupied lands.

I have therefore concluded that the intention of Congress was to begin a rigid scientific classification of the lands of the national domain, not for purposes of aiding the machinery of the General Land Office, by furnishing a basis of sale, but for the general information of the people of the country, and to produce a series of land maps which should show all those features upon which intelligent agriculturists, miners, engineers, and timbermen might hereafter base their operations, and which would obviously be of the highest value for all students of the political economy and resources of the United States. Studies of this sort, entirely aside from the administration of the Land Office, can be made of the highest practical value; and to this end a careful beginning has been made.

A second ambiguity in the language of the law which I am called upon to execute, will be found in the use of the term "national domain." All operations of this bureau are, by the language of the law, intended to cover the "national domain."

That term was supposed by the first framers of the law to cover the entire United States. On the other hand, it might be held to mean simply the region of the public lands. It was of the utmost importance, before beginning to plan for any field operations, to know whether "national domain" meant the lands owned by the nation, or the area within its outer boundaries.

With the small appropriation given to begin the vast work of this bureau, I considered it best to confine the operations to the region of the public land, concerning which field there could be no question as to my legal authority. In the case, therefore, of the uncertainties arising from the language of the law, I have chosen to take the conservative side, and have neither invaded the functions of the General Land Office, nor placed my field parties outside the area of the public lands.

Former national geological surveys have been conducted by means of annual campaigns in the far West. The corps, when driven from the field by the snows of late autumn, have returned to Washington, there to await the accidents of appropriation; and, if provided for by Congress, to take the field at the close of Congressional sessions.

By this means a large amount of valuable time has been lost in breaking up the Western camps and removing the corps to Washington and again returning to the field the following year. Moreover, a very large item of transportation cost has been annually incurred.

### GEOGRAPHICAL FIELD DIVISIONS.

I have entirely abandoned that plan, and have divided the region west of the 101st meridian into four geological districts. It will be seen by the map accompanying this report that these districts do not always coincide with political lines. On the contrary, they are outlined to embrace certain definite geological fields.

In passing westward the first division is that of the Rocky Mountains, which starts from the Mexican boundary on the Rio Grande, near its intersection with the 107th meridian. From that point the line follows the Texan boundary east to the 103d meridian, which it traces northward to the parallel of 37, and thence making a short jog eastward of a degree and a half of longitude, coincides with the eastern boundary of Colorado to the 41st parallel, and then continues along the meridian of the 102d to latitude 45. From that point a due west line is drawn to the 104th meridian, thence north along that line to the British boundary. The northern boundary of the district coincides with the British boundary to the meridian 116. From that point it follows the boundary line between Idaho and Montana southeasterly to its junction with the 111th meridian, and from that point south to the 41st parallel, thence east to the 109th meridian, and thence south to the Mexican boundary.

Embraced within these boundaries lie Colorado, New Mexico, Wyoming, and Montana, and a small part of Dakota; an area inclosing the whole great chain of the Rocky Mountains, whose geographical function is the dividing of the watershed of the Atlantic from that of the Pacific. This chain is made up of a great number of ranges and groups of mountains separated from each other by deep depressions, in which are either passes or inclosed lowlands known as parks. From the Mexican to the British boundary, the system is a geological unit, and should be studied as one, without reference to political lines.

One division of the survey corps, trained in any one part of this system, would have an immense advantage in deciphering the geological history of any other part. The same system of coal-fields, the same types of economical mineral deposits—gold, silver, and iron ore-bodies—extend from one end to the other of this vast mountain district. In charge of this field I have placed Mr. S. F. Emmons, geologist-in-charge, whose main office is fixed at Denver, Colo.

The Division of the Colorado embraces a remarkable plateau and cañon country unparalleled elsewhere in the world, which lies between the Rocky Mountains and the Great Basin. It is, in the main, a country drained by the great cañons of the Colorado River, and consists of elevated plateaus, above which arise isolated groups of mountains, and through which is traced a wonderful labyrinth of cañons from three to six thousand feet in depth.

This division has been for twelve or thirteen years the field of exploration of Maj. J. W. Powell, who has expended here over $300,000 in explorations and surveys, which are of the highest scientific value, and of which only the beginning has been published. His extensive work is inherited by the present bureau, and the Division of the Colorado is intended only as a temporary one until this work, already far advanced, can be brought to completion. The main portion of the division is most easily reached from Salt Lake City, and the headquarters of the division has been placed there in charge of Capt. C. E. Dutton, United States Ordnance Corps, geologist-in-charge.

The Division of the Great Basin is also a characteristic tract of country, differing essentially from the Rocky Mountains and the Colorado Plateau, which bound it on the east, and the country of the Sierra Nevada, Cascade, and Pacific coast ranges, which lie between it and the ocean on the west. It is for the most part a series of desert plains, interrupted by more or less parallel mountain chains. The chief peculiarity of three-quarters of the area is that its drainage never reaches the sea. Its geological characteristics, equally with its geographical ones, separate it from the surrounding country. It is a region to be studied by itself, and is of the highest importance from its abundant silver districts. Mr. G. K. Gilbert, geologist-in-charge, has been assigned to the direction of this division, with headquarters placed, for convenience of access, at Salt Lake; and it is designed that one office and one field laboratory will meet the requirements of this and the Colorado Division.

The Division of the Pacific embraces the whole of Washington Territory, that part of Oregon which lies west of the Blue Mountains, and all of California, except the desert region lying east of the Sierra Nevada and south of the thirty-eighth parallel, which, from its geological and physical characteristics, belongs, not to the series of Pacific coast mountains, but to the arid region of the Great Basin. The headquarters of the Pacific Division is placed at San Francisco; Mr. Arnold Hague, geologist-in-charge.

As soon as the work upon the cañons and plateaus of the Colorado is done it is intended to discontinue that division and to divide it on the line of the Colorado River between the Divisions of the Rocky Mountains and that of the Great Basin. Thus, after the space of four or five years, there will remain but three divisions west of the 102d meridian. The location and boundary of these divisions are clearly shown upon the map accompanying this report.

The Appropriation Committee of the House of Representatives were informed by me of the uncertainties as to the meaning of the term "national domain"; and they immediately caused to be offered House Resolution No. 116, extending the field of the geological survey over the whole United States. That resolution was promptly passed in the House, but is still pending in the Senate; but, in advance of the action of the Senate, I have laid down on the accompanying map the four divisions into which I would propose to district that part of the United States east of the 102d meridian.

Of the great Appalachian system of mountains, extending from New Brunswick to Alabama, I have made two divisions—one embracing Maryland, Delaware, Pennsylvania, New Jersey, New York, and the New England States; the other embracing West Virginia, Virginia, North and South Carolina, Georgia, Florida, Alabama, Tennessee, and Kentucky.

These two areas will include the whole Appalachian Mountain system in two parts of about equal geological importance; and, with the four divisions west of the 102d meridian, cover all the mountain country of the United States.

There remains, then, only the basin of the Mississippi, which, with all its enormous extent, is really one field and one geological problem. From its great size, however, I have thought best to divide it, as the lines upon the map will show, into two grand divisions; first, the Division of the North Mississippi, bounded west of the Mississippi on the south by a line including Missouri and Kansas, to the intersection of the 39th parallel with the 102d meridian. East of the Mississippi River the Ohio forms the dividing line between the Northern and Southern districts.

By placing each division under the charge of a geologist, whose personal experience and acquirements fit him to undertake the investigation of the chief problems of that division, and assigning to him a competent corps of assistants, a far better result will be obtained than by any plan of expeditionary operations, with parties moving from division to division. It is intended, on the contrary, to strictly confine each corps to its own division, and to keep it permanently at work there, except in case of certain technical economical investigations. In this respect the organization resembles that of the Army and the Coast and Geodetic Survey.

I have so arranged the initial work of the survey that special volumes on the most important geological subjects and mining industries in the four western divisions of the survey shall be brought to prompt publication. There can hardly be two opinions on the desirableness of immediately working out such problems in these great districts which in their past and present history offer examples of instructive geological structure and great bullion yield, and which have required of mining men special mechanical skill and large outlay of capital. Proper scientific reports on such typical districts become records of remarkable phenomena in the field of industrial geology and chronicles of distinguished success in the department of mining engineering. Among the great numbers of mining districts which merit rigid investigation I have chosen three, which more than others seemed to offer harvests of technical information, of which the mining population stands in immediate need. Leadville, the extraordinary district in Middle Colorado; Eureka, Nevada, which for fifteen years has been the most productive silver-lead district in America, and the incomparable Comstock Lode, are chosen as the first three districts to be illustrated by special monographs.

### OFFICIAL RECORDS, DISBURSEMENTS, AND MONEY RESPONSIBILITY.

The following report of the chief clerk at the Washington office will give full information as to the methods of preserving official records, and of transacting all business pertaining to disbursements and money accountability; also the records of the purchase, responsibility for, transfer, and final disposition of public property.

In general, the blanks for disbursements and money accountability are modeled on those of the Corps of Engineers of the Army, though certain modifications to meet the demands of the peculiar field service of the Geological Survey have been introduced.

UNITED STATES GEOLOGICAL SURVEY,
OFFICE OF THE DIRECTOR,
*Washington, D. C., September* 13, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, San Francisco, Cal.:*

SIR: I have the honor to submit a report of the operations of the office work during the fiscal year ending June 30, 1880, the duties of which are principally as follows:

Keeping a record of all communications sent or received, also of money and property responsibility of all disbursing officers connected with the bureau, and examining all accounts for the same, and making up and paying all accounts pertaining to the Washington office.

The average clerical force for the year is three.

During the fiscal year ending June 30, 1880—

954 letters have been received, briefed, and entered in book of "Letters Received," and indexed.

973 letters written, and indorsements made, which have been copied in the book of "Letters Sent," and indexed.

726 money accounts and 21 property returns have been received, examined, booked, and those pertaining to money accountability transmitted to the Treasury Department for settlement.

The following is the method, briefly stated, of keeping the records and transacting the clerical business of the office.

## RECORD DIVISION.

Book 1 is designated "Letters Received," into which a brief of all communications, necessary or proper to be recorded, are entered and numbered, beginning with the first, and ending with the last entry for a year.

Book 2 is designated "Letters Sent," into which all communications sent out of the office are copied. A continuous index is kept, giving the subject-matter of all communications sent and received, from day to day.

Book 3 is designated "Applications," into which all communications received from or relating to applicants for employment are entered.

Book 4, "Public Property Shipped," is designed to keep a complete record of all public property shipped, giving date, to whom sent and where, by what conveyance, for whom, contents, weight or measurement, rate, &c.

Book 5, "Public Property Received," is designed to keep a record of all public property received from time to time, which is similar in form to that of "Public Property Shipped."

## MONEY AND PROPERTY DIVISION.

Book 6, "Ledger of Disbursements," is designed to keep an open debit and credit account with each disbursing officer of the bureau, also of appropriations made from year to year.

Book 7, "Consolidated Account Current," is designed to show a recapitulation of amounts of public funds in hands of disbursing officers as per their last report, received since, expended or otherwise disposed of, and remaining on hand at end of each quarter.

Book 8, "Record of Vouchers Paid," is designed to show all accounts paid, giving date of purchase and payment, from whom purchased and by whom rendered, by whom paid, and where, articles or services.

Book 9, "Classification of Expenditures," designed to show the amounts paid under different heads.

Book 10, "Consolidated Return of Property," designed to show all public property belonging to the bureau, received, disposed of, and remaining on hand each quarter.

Book 11, "Record of Allotment," is designed to keep a record of amounts allotted each division of the survey for the fiscal year's work.

Book 12, "Record of Appropriation," is designed to keep a record of all appropriations made for the Geological Survey, giving date of approval of act, title of act, detailed object of appropriation.

Book 13, "Accounts of Disbursing Officers settled at the Treasury Department," designed to give name, address, or station, date of rendition of accounts, number of settlement, for what period, amount of differences and cause.

The following circular, issued from this office, will show the reports required to be rendered by, and the instructions given to, disbursing officers of the survey.

"CIRCULAR NO. 3.

"DEPARTMENT OF THE INTERIOR,
"UNITED STATES GEOLOGICAL SURVEY,
"OFFICE OF THE DIRECTOR,
"*Washington, D. C., April* 1, 1880.

"To facilitate and secure accuracy and promptness in the transaction of official business by disbursing officers of the United States Geological Survey, the following instructions and list of reports to be rendered are published for their information and guidance.

"WEEKLY.

"Statement of public funds on hand and where deposited.

"MONTHLY.

"Report of transportation requests issued over bonded roads, giving name of person transported, between what points, and cost of same.

"Report of persons and articles hired.

"QUARTERLY.

"Account current (in duplicate) with abstract of disbursements signed (in duplicate), with one set of vouchers, will be rendered to the director within twenty days after the expiration of the quarter to which they pertain.

"In making accounts, disbursing officers will be governed by the following rules:

"1. All accounts accruing during any quarter should be adjusted and paid during the current quarter.

"2. Accounts for expenditures of disbursing officers must bear dates, and all receipts upon vouchers must bear the date when they were paid.

"3. The receipts which are annexed to accounts should express the sums paid in words, legibly written out in full, and also by figures; and they should state the name of the person from whom the money is received (*i. e.*, the disbursing officer) and the date when paid.

"4. In all accounts for articles purchased, the date of each purchase, the name, quantities, and rate per unit of *each* article must be distinctly specified in the account. For instance:

"Feb. 29, 1880, 250 pounds of oats, at .02 cents per pound=$5.

"5. Subvouchers are desirable, and they should be appended to all vouchers when it is practicable to obtain them. When they cannot be obtained, a certificate to that effect should be added to the voucher.

"6. Subvouchers must be made out in ink, and no item should appear on a subvoucher for which payment has not been actually made to the person whose name it bears; and when signed by an employé they are inadmissible.

"7. When money is paid to a person unable to write his name, it should be written for him, and then he should make his mark, which should be witnessed by some person other than the disbursing officer.

"8. Receipts for payments should, whenever practicable, be signed by a principal, and not by an agent. When signed by an agent, he should sign his name in full; and the fact of his agency should be certified to by the disbursing officer.

"9. Disbursing officers should sign their accounts, and all other papers pertaining thereto, by the title under which they disburse, *i. e.*, "John Doe, disbursing agent," not "geologist."

"10. Disbursing officers have no authority to discount a United States Treasury draft or check.

"11. When transportation of funds by express or other public mode of conveyance becomes requisite, the necessary expenses are a proper charge against the government.

"12. When one is paid an annual salary, amounts due for fractional parts of the year or month should be taken from the salary tables used by the Treasury Department. Where salaries are monthly, amounts for fractional parts of a month should be computed according to the number of days the month may contain. The dates should be given, stating whether inclusive or not. For instance: A person employed from May 28 to June 12, inclusive, would have served 16 days, which, at $30 per month, would amount to $15.87. Thus:

"May 28 to 31, 4 days, at $\frac{30}{31}$ dollars=$3.87.
"June 1 to 12, 12 days, at $\frac{30}{30}$ dollars=12.00=$15.87.

"13. Actual traveling expenses usual and essential to the ordinary comfort of travelers will be allowed, which will embrace the following items of expenditures only, viz: Cost actually paid for fares upon railroads (other than those bonded, over which transportation requests will be issued by the Geological Director), stages, steamboats or other usual modes of conveyance, *i. e.*, street-car or omnibus or transfer-coach fare to and from depots and hotels; and, when there are no such conveyances, moderate and necessary hack hire, not exceeding legal rates, and baggage fees to porters; sleeping-car fare for one double berth for each person, or customary state-room and accommodations on boats. When delays at hotels are incident to, and necessary for, the performance of the duties for which the travel is ordered, charges for hotel expenses will be allowed, not exceeding $4 per day, and bills should always be obtained and filed as subvouchers to the account, giving the dates of arrival and departure and the rate per day. No charges will be allowed for hotel bills when the detention is unnecessary for the execution of the orders under which the journey is performed. Meals furnished on steamers or other means of conveyance which are included in the charge for fare will not, of course, be made an extra charge. Whenever special expenditures are made for meals they will be allowed, but for no other items of refreshment than the ordinary food provided for travelers. Travel must be covered by a specific order in the case, issued by authority of the Director previous to the commencement of the journey, or confirmed by him as soon thereafter as practicable. The items above authorized will appear in detail upon the voucher or memorandum attached thereto, together with subvouchers in all cases when practicable. No other items of whatever nature will be allowed.

"No account or pay-roll should be so made up as to involve payments from the appropriations for more than one fiscal year.

"Balances from the appropriations for one fiscal year cannot be applied to payment of indebtedness incurred during another fiscal year, unless it be in fulfillment of expenses incurred, or of contracts properly made, within that year.

"One copy of property return, with vouchers complete pertaining thereto.

"All articles to be itemized and classed under the following heads, alphabetically arranged:

"1. Fuel.

"2. Forage.

"3. Stationery, including drawing material.

"4. Office furniture.

"5. Camp and field equipage.

"6. Means of transportation.

"7. Subsistence.

"8. Instruments.

"9. Photographic instruments and material.

"10. Laboratory instruments and material.

"11. Miscellaneous stores, such as lumber, rope, nails, canvas, soap, candles, tools, and material for general repairs.

"No disbursing officer making a return of public property will drop from his return any articles as worn out or unserviceable until they have been condemned, after proper inspection, and ordered to be dropped or otherwise disposed of.

"A full report of all public property considered worn out or unserviceable will be made to the Director at the end of each quarter, if practicable, with such explanatory remarks as may seem to be required, after which orders as to the inspection or disposition of the same will be issued.

"Property intrusted to assistants and employés of the Survey will be carefully charged against them, and in case of loss the money value will be withheld unless said loss be unavoidable and satisfactorily explained. Affidavits and statements will be made up at the time of loss. Too great care of instruments and other property cannot be exercised by persons connected with the Survey.

"CLARENCE KING, *Director*."

A list of blank forms and vouchers adopted for use of this office, with corresponding Interior Department numbers, is herewith appended:

9001—Estimate of Funds.

9002—Reply to Estimate of Funds.

9003—Weekly Statement of Public Funds.
9004—Notice that Funds have been Remitted.
9008—Requisition for Funds.
9009—Voucher of Disbursements.
9010—Requisition for Printing and Binding.
9011—Requisition for Stationery.
9012—Inspection Reports.
9013—Account Current.
9014—Quarterly Returns of Property.
9016—Pay Roll.
9017—Invoice of Property.
9019—Receipts for Property.
9020—Abstracts of Disbursements.
9021—Affidavits as to Property.
9022—Estimate for Stamps.
9023—Return of Stamps.
9024—Notification of Receipt of Accounts.
9025—Abstracts of Weekly Statements.
9026—Acknowledgment of Receipt of Circulars.
9027—Acknowledgment of Receipt of Communications.
9028—Pay Voucher.
9029—Letter Transmitting Checks in Payment of Accounts.
9030—Letter inclosing Accounts for Signature.
Leave of Absence Blanks.
Letter containing Bureau Regulations relative to Appointments.
Report of Persons and Articles hired.
Orders for Journeys.
Transportation Requests over Bonded Railroads.
Orders for Supplies.

Very respectfully, your obedient servant,

JOHN D. McCHESNEY,
*Chief Disbursing Clerk.*

## APPOINTMENTS.

By the sanction of the honorable the Secretary of the Interior, appointments to the Geological Survey are divided into two classes: First. Members of the regular and permanent corps of the Survey, who are nominated by the Director and appointed by the Secretary, their appointments being made out and oath of office being filed in the Appointment Division of the Department of the Interior. Second. Temporary appointments, which the Director is authorized to make and revoke.

In organizing the Geological Corps, the greatest care has been taken in the selection of appointees. The following letter, which is returned to applicants for position, will convey an idea of the high character of requirements which is demanded of every member of the Survey:

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
OFFICE OF THE DIRECTOR,
*Washington D. C.*, 1880.

———, ———,
———, ———:

SIR: Your communication of ———, relating to a position for ——— upon the staff of the United States Geological Survey, has been received and placed upon file.

Your attention is respectfully called to the following Bureau Regulations concerning appointment:

"The Geological Survey is divided into two independent divisions. These are:

"1. General Geology. 2. Mining Geology.

"Applicants for appointment under the Division of General Geology will be required to furnish proper evidence of a good working knowledge of mathematics, physics, chemistry, geology, and mineralogy. Such evidence will consist of the degrees of universities, or the testimony of experts in the required branches, or the result of a written examination.

"Applicants for appointment under the Division of Mining Geology must furnish equivalent evidence of a working knowledge of mathematics, mechanics, mining geology, chemistry, metallurgy, and the mineralogy of economic mineral products."

You are requested to comply with the above requirements and present your scientific credentials.

Very respectfully,

CLARENCE KING, *Director*.

The following is the list of the *personnel* of the Survey, giving the position or character of duty, the dates of appointment, promotion, and resignation, and the annual salary:

*Personnel of the United States Geological Survey.*

| Number. | Name. | Position. | Salary. | | Date of appointment. | Remarks. |
|---|---|---|---|---|---|---|
| | | | Annual. | Monthly. | | |
| 1 | King, Clarence | Director | $6,000 00 | | May 24, 1879 | |
| 2 | Emmons, Sam'l F. | Geologist | 4,000 00 | | Aug. 15, 1879 | |
| 3 | Hague, Arnold | Geologist | 4,000 00 | | | Reported Apr. 9, 1880. |
| 4 | Gilbert, G K | Geologist | 4,000 00 | | July 10, 1879 | |
| 5 | Hayden, F. V | Geologist | 4,000 00 | | July 19, 1879 | |
| 6 | Pumpelly, Raphael | Geologist | 4,000 00 | | July 16, 1879 | |
| 7 | Becker, Geo. F | Geologist | 2,500 00 | | July 22, 1879 | |
| | | | 4,000 00 | | July 1, 1880 | Promoted July 1, 1880. |
| 8 | Wilson, A. D | Chief topographer | 3,000 00 | | July 10, 1879 | |
| 9 | Clark, Fred A | Topographer | 2,500 00 | | July 9, 1879 | |
| 10 | Lord, Eliot | Clerk | 1,800 00 | | July 9, 1879 | Resigned Sept. 30, 1879. |
| 11 | Bangs, Jas. E | Disbursing clerk | 1,800 00 | | July 9, 1879 | |
| | | | 2,000 00 | | July 1, 1880 | Promoted July 1, 1880. |
| 12 | Bodfish, Sumner H. | Topographer | 1,800 00 | | July 10, 1879 | |
| 13 | Foote, Arthur D | Assistant geologist. | 1,800 00 | | July 25, 1879 | Resigned Aug. 31, 1879. |
| 14 | Renshawe, Jno. H. | Topographer | 1,700 00 | | July 10, 1879 | Resignation request'd, not yet received. |
| 15 | Goode, Richard U. | Topographer | 1,200 00 | | July 12, 1879 | |
| 16 | Wright, Philo B | Topographer | 800 00 | | July 10, 1879 | Resigned June 30, 1880. |
| 17 | Smith, Chas. E | Clerk | 840 00 | | July 10, 1879 | Resigned Oct. 22, 1879. |
| 18 | Wilson, C. C | Clerk | 600 00 | | July 9, 1879 | |
| | | | 1,200 00 | | July 1, 1880 | Promoted July 1, 1880. |
| 19 | Wallace, H. S | Clerk | 600 00 | | July 10, 1879 | |
| | | | 900 00 | | July 1, 1880 | Promoted July 1, 1880. |
| 20 | Walcott, Chas. D | Assistant geologist. | 600 00 | | July 21, 1879 | |
| | | | 1,200 00 | | July 1, 1880 | Promoted July 1, 1880. |
| 21 | Meador, Leake S | Messenger | 480 00 | | July 9, 1879 | Resigned Jan. 31, 1880. |
| 22 | Mason, Anthony | Messenger | 2 25 | per diem | July 9, 1879 | |
| | | | 840 00 | | Feb. 1, 1880 | Promoted Feb. 1, 1880. |
| 23 | Blair, Andrew A | Geologist | 3,000 00 | | Sept. 10, 1879 | |
| 24 | Kimball, J. P | Geologist | 3,000 00 | | Sept. 10, 1879 | |
| 25 | McChesney, Jno. D | Chief disb'g clerk | 2,400 00 | | Jan. 1, 1880 | |
| 26 | Price, Gran | Watchman | 600 00 | | Feb. 1, 1880 | |
| 27 | Wheeler, Patrick | Watchman | 600 00 | | Feb. 1, 1880 | |
| 28 | Baldwin, Jeremiah | Messenger | 600 00 | | Jan. 16, 1880 | |
| 29 | Hanford, Chas. B | Watchman | 600 00 | | Feb. 1, 1880 | |
| 30 | Manners, Edw'd C. | Clerk | 1,000 00 | | Apr. 1, 1880 | |
| 31 | Reade, Francis R | Assistant geologist. | | $100 00 | Apr. 7, 1880 | Temporary appointment by Director. |
| 32 | Thompson, Gilbert | Topographer | 2,500 00 | | May 1, 1880 | |
| 33 | Leffingwell, Wm. H. | Ass't topographer | | 75 00 | May 1, 1880 | Temporary appointment by Director. Resigned Sept. 1, 1880. |

*Personnel of the United States Geological Survey*—Continued.

| Number. | Name. | Position. | Salary. | | Date of appointment. | Remarks. |
|---|---|---|---|---|---|---|
| | | | Annual. | Monthly. | | |
| 34 | Jacob, Ernst | Assistant geologist | $1, 200 00 | | July 1, 1880 | |
| 35 | Hillebrand, W. F | Chemist | 2, 000 00 | | July 1, 1880 | |
| 36 | Lakes, Arthur | Assistant geologist | | $100 00 | July 1, 1880 | Temporary appointment by Director. |
| 37 | Wilson, Geo. H | Ass't topographer | | 100 00 | June 23, 1880 | Temporary appointment by Director. |
| 38 | Iddings, Jos. P | Assistant geologist | | 75 00 | July 1, 1880 | Temporary appointment by Director. |
| 39 | O'Sullivan, T. H | Photographer | | 100 00 | July 16, 1880 | Temporary appointment by Director. |

## CASH STATEMENT.

The following cash statement, submitted by John D. McChesney, chief disbursing clerk, gives the quarterly and annual total disbursements expended by each disbursing officer, and the total for the bureau for the year.

To this statement is appended a classification of expenditures made from the appropriation for the fiscal year ending June 30.

The unexpended balance of $20,624.43 is reserved for the payment of the experts engaged in the collection of the statistics of the mineral productions in the Western States and Territories. It is an expense incurred to cover a period of the last fiscal year, and its results will be embodied in a volume upon the precious metals.

*Cash statement for fiscal year ending June* 30, 1880.

| Name of disbursing officer. | Third quarter, 1879. | Fourth quarter, 1879. | First quarter, 1880. | Second quarter, 1880. | Total amount expended. | Balance on hand June 30, 1880, required to pay outstanding liabilities. |
|---|---|---|---|---|---|---|
| 1. George F. Becker | | $1, 000 48 | $1, 384 77 | $3, 848 95 | $6, 234 20 | $11, 265 80 |
| 2. James E. Bangs | $8, 243 50 | 8, 523 80 | 1, 261 60 | 2, 873 98 | 20, 902 88 | 97 12 |
| 3. Sumner H. Bodfish | 1, 954 03 | 4, 463 61 | | | 6, 417 64 | |
| 4. Samuel F. Emmons | 1, 984 62 | 2, 715 85 | 2, 705 53 | 3, 094 31 | 10, 500 31 | 7, 999 69 |
| 5. G. K. Gilbert | 25 60 | 2, 621 78 | 828 81 | 5, 389 64 | 8, 865 83 | 1, 134 17 |
| 6. John D. McChesney | | | 10, 044 69 | 14, 235 03 | 24, 279 72 | 120 28 |
| 7. Amount of accounts of bonded railroads charged to appropriation 1879–'80 | | | | | 2, 174 99 | |
| 8. Balance to credit of appropriation June 30, 1880 | | | | | | 7 37 |
| Total | 12, 207 75 | 19, 325, 52 | 16, 225 40 | 29, 441 91 | 79, 375 57 | 20, 624 43 |

| | |
|---|---|
| Appropriation for the fiscal year ending June 30, 1880, act approved March 3, 1879 | $100, 000 00 |
| Amount expended from appropriations for United States Geological Survey for the fiscal year ending June 30, 1880 | 79, 375 57 |
| Amount remaining unexpended June 30, 1880 (required to meet outstanding liabilities). | 20, 624 43 |

Respectfully submitted.

JOHN McCHESNEY,
*Chief Disbursing Clerk, U. S. G. S.*

*Classification of expenditures made from appropriation for United States Geological Survey for the fiscal year ending June* 30, 1880.

| No. | | Amount. |
|---|---|---|
| 1. | Fuel | $457 53 |
| 2. | Forage | 1,293 68 |
| 3. | Stationery | 1,705 73 |
| 4. | Drawing material | 81 42 |
| 5. | Office furniture | 5,430 85 |
| 6. | Rent of office | 733 33 |
| 7. | Repairs of office | 938 10 |
| 8. | Rent of telephones | 71 16 |
| 9. | Rent of post-office boxes | 42 00 |
| 10. | Gas | 57 09 |
| 11. | Ice | 16 78 |
| 12. | Services of assistants and employés | 46,846 98 |
| 13. | Telegrams | 569 83 |
| 14. | Transportation | 2,944 43 |
| 15. | Traveling expenses | 5,049 44 |
| 16. | Storage | 44 16 |
| 17. | Tollage | 10 50 |
| 18. | Instruments purchased | 1,948 88 |
| 19. | Instruments repaired | 715 15 |
| 20. | Camp and field equipage | 1,029 27 |
| 21. | Subsistence | 3,303 16 |
| 22. | Photographical material | 6 75 |
| 23. | Laboratory material | 2 25 |
| 24. | Job printing | 25 50 |
| 25. | Apprehension and delivery of lost public property | 25 00 |
| 26. | Freight | 718 86 |
| 27. | Pasturage | 409 25 |
| 28. | Horses | 153 00 |
| 29. | Mules | 1,760 00 |
| 30. | Miscellaneous | 812 66 |
| | | 77,202 74 |
| | Amount of accounts of bonded railroads for transportation of persons and property charged on books of Treasury Department against appropriation for Geological Survey for fiscal year ending June 30, 1880 | 2,174 99 |
| | | 79,377 73 |
| | Less amount of errors found in accounts for third and fourth quarters, 1879 | 2 16 |
| | Total | 79,375 57 |

## STAFF REPORTS.

The following reports from members of the Geological Survey who are in charge of special departments of work, convey brief accounts of the progress made and results obtained:

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF THE ROCKY MOUNTAINS,
*Denver, Colo., October* 10, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to submit the following report of operations in this division during the past year:

I qualified as geologist on the 15th of August, 1879, and, by your direction, at once assumed charge of this division, which embraces the State of Colorado and the Territories of New Mexico, Wyoming, Montana, and Dakota west of the one hundredth meridian.

Your instructions as contained in your letter of August 14, 1879, were as follows:

"1. You will devote the first years of the administration of your division exclusively to a study of the mineral wealth of the Rocky Mountains.

"2. Personally you will confine your investigations, till further orders, to the metallic minerals of Colorado, their geological connection, mode of occurrence and association. District by district you will acquaint yourself with the minutest features of lodes, with the legal aspect of mining, and you will prepare to furnish for the year 1880 such statistical tables as may be necessary to show, as far as practicable, gross and net product of each district and region, summing up in one general table the entire precious-metal product of Colorado.

"As far as possible you will check mine, mill, and furnace returns by the receipts of the various transportation companies, and, in general, trace the metals into actual market. In the case of base bullion, refining returns should be obtained, if the process is completed in America; if not, note to that effect should be made.

"3. You will prepare to execute, and, if possible, within two years complete, under your own personal supervision, monographs of the Leadville region, of the mining districts on the waters of Clear Creek and the Wet Mountain Valley group of districts. You will accompany your reports on these districts with topographical, geological, and mine maps, with full diagrams and sections illustrating all interesting points of lode structure. You will carefully describe all methods of mining and make full reports of all metallurgical processes, with plans and working drawings of all establishments which present peculiar interest.

"4. You will prepare to extend during the year 1880 precisely similar studies over all the mining districts of New Mexico, Colorado, Wyoming, Dakota, and Montana. In order to accomplish this, you will make requests upon this office for authority to employ the necessary corps of assistants and laborers; and there will later be allotted to you from the appropriation for the survey a sum against which you will make requisitions sufficiently large to cover the expenses of your operations.

"5. Mr. A. D. Wilson, chief topographer, will be ordered to report to you for duty in charge of the topographical survey of Leadville.

"6. You will report monthly to this office a general sketch of the progress of your operations."

In accordance with your instructions my first attention was directed to the report upon Leadville. The almost unexampled rapidity with which it had sprung from a comparatively unknown mining camp to a great mining center, whose annual production probably surpasses that of any other single district in the West, the Comstock always excepted; the unusual and peculiar character of its deposits, which were supposed to set at defiance all the known laws which govern the occurrence of mineral in other parts of the world, and to upset all geological theories; and above all, the flow of capital from the moneyed centers of the country, attracted by reports of the fabulous wealth of the mines, rendered it eminently proper that a thorough and exhaustive study should be made of its ore deposits, their geology and probable origin, &c., and moreover that the results obtained should be pushed to publication with the utmost rapidity consonant with scientific accuracy, that the public might at once be able to avail itself of practical benefit to be obtained therefrom. On the other hand, the position of Leadville is one which presents many difficulties in the way of geological research.

The city is situated on the foot of one of the western spurs of the Mosquito Range, at an altitude of 10,000 feet above sea level, while the mines are found between it and the crest of the range, from a few hundred to two and three thousand feet higher. As a consequence of this great altitude the season for field work and surface geological observations is extremely limited; over the greater part of the region barely four months in the year can be counted on as available for the advantageous prosecution of this work. Moreover, a great portion of surface, both of hill and valley, in the region of Leadville, is covered to depths often of several hundred feet with detrital material, a mixture of gravel and bowlders, originating in glacial moraines and more or less rearranged by subaerial agencies since the glacial period, thus effectually covering the underlying rocks and rendering extremely difficult the study of their structure and character. It is this feature of Leadville geology, which practically does away with the surface indications which guide the prospector and miner in other mineral districts, that has cast the glamour of mystery over these deposits. A very large number of the richest mines have been discovered quite accidentally by prospectors who dug through this gravel wherever they happened to find a piece of unoccupied ground, with a complete disregard of any previously-conceived reasons for finding ore in one place rather than in another.

The first requisite for studying satisfactorily the geology of a region, and more particularly of a mining region, where the determination must be carried out with accuracy to the minutest details, is to have it mapped with care and precision. And the peculiar character of the Leadville region, as described above, makes this still more indispensable. The preparation of the necessary maps, which, had circumstances permitted, should have been completed and printed before we commenced our geological work, was that which first occupied my attention. Mr. Wilson, with characteristic energy and promptness, accomplished in the few remaining available months of the summer and fall of 1879 the field work for a most detailed and exact map of the region containing the mines of Leadville. It was a work of no little difficulty, and involved a great deal of labor, the level lines by which he made his profiles having to be run through dense forests and over steep and almost inaccessible mountains, and could hardly have been accomplished but for his long experience and familiarity with mountain topography. The plotting of this map was done during the winter months, and field work was resumed as soon as the melting of the snow admitted of climbing the mountains. Some additional work was done upon the detailed map of Leadville, to accommodate the development of new mines, during the winter, nearer the crest of the range. A special map, on a still more enlarged scale, was made, as decided by you during the winter, of Fryer Hill; and a general map, on a less detailed scale, was constructed of the Mosquito Range for some ten miles north and south of Leadville, for the purpose of showing the general geology of the district around it. As this map did not include the mines of the Ten-mile district, a small, special map was also made of this region, whose limits, however, have been forcibly circumscribed by the unusually heavy and early snow, which put a definite stop to all field work on the 25th of September. We have now, therefore, in a more or less advanced stage of completion—

1. A detailed map of Leadville on a scale of 800 feet to the inch, with contour lines at vertical distances of 25 feet; which takes in a region between five and six miles square, and thus includes every mine of any importance, with perhaps one or two exceptions, within a radius of ten or fifteen miles of Leadville. On this map will be accurately located, not only the shafts of all producing mines, but those of most of the as yet not mineral bearing prospects, which have been used as points in determining the underground geology. This map will make two double atlas sheets.

2. A detailed map of Fryer Hill on a scale of 160 feet to the inch, with grade curves at a vertical interval of 10 feet, which will make a single atlas sheet.

3. A general map of the Park or Mosquito Range, from Quandary Peak on the north to Weston's Pass on the south, and from Leadville on the west to Fairplay on the east, or about sixteen miles by twenty. This map will be published on a scale of 2 inches to the mile, with grade curves at vertical intervals of 100 feet, and make one double atlas sheet.

4. A smaller map of the Ten-mile district, on the same scale, which will form the northern prolongation of the last-named map, and cover a district of about six miles by eight in extent.

An essential preliminary to the study of the geology of any particular district being a comprehensive view of the larger features of the geology of the whole region, I made use of every opportunity during the fall to trace the general geological connection of the other parts of Colorado with the Leadville district.

A trip from the Laramie Plains through the North and Middle Parks to Leadville gave a bird's-eye view, as it were, of the character of the second mountain uplift of the Rocky Mountain system, which forms the western border of the singular succession of depressions which have received the general name of parks. A second trip, made on the order of the Secretary of the Interior, to determine the mineral or non-mineral bearing character of the Pagosa Springs Reservation in Southern Colorado, furnished a glimpse at the great depression of the Saint Louis Park, and the remarkable volcanic ranges which form its western border. This work would have been greatly facilitated by the excellent map of the Hayden survey, whose geology in its general features would give much useful information, were it not for the want of any systematic discriptive text.

Unfortunately, the only descriptions are contained in the somewhat hastily written field notes, which were issued annually, often before the various regions covered had been properly compared and correlated, whereas the geology of the map itself has evidently been worked up at a later date, when many modifications in the conception of the authors had been adopted and the nomenclature of peaks had been essentially changed, so that it is now almost impossible to follow their descriptions on the map. During the winter months our investigations were necessarily confined to the underground working. Commencing with the larger mines on Fryer Hill, where, from the rapidity of the extraction of ore, many portions of the ore bodies would of necessity become inaccessible by the closing in of the surrounding rock, a systematic examination of all the deposits of Leadville was begun, which, carried on in my absence by my assistant, Mr. Jacob, was continued until the melting of the snow permitted the resumption of outside work. In this way the ore deposits were traced, step by step, and their position, form, and relation to the inclosing rocks accurately determined, so that by means of the notes and specimens obtained we shall be enabled to delineate upon our maps, not only their horizontal extent and shape, but by carefully-constructed cross-sections and profiles, so graphically to represent their position in the rock masses, that the probable position of the as yet undiscovered ore horizons can be foretold by whoever has occasion to consult our reports.

The question of the probable extent and permanence of the Leadville ore is naturally one of the greatest importance to the mine owners of the district, and indeed to the mining community at large; and owing to the extremely complicated character of the geology of that region, the most experienced and scientific mining engineers often find themselves completely at a loss to know in what direction to push their explorations for new masses of ore.

A very brief outline of its general geological structure will show the reason for this uncertainty. What is now the Mosquito Range was once a series of varying silicious and calcareo-magnesian beds of Carboniferous and Silurian age, resting on a floor of granite and gneiss, along the shore of a great Archæan island, now uplifted into the Sawatch Range.

During Mesozoic time, probably towards the close of the Jura, these sedimentary beds were traversed by immense and long-continued outflows of felsitic porphyries and diorite, which spread out between the strata, mostly as regularly interbedded masses. The great dynamic movements which formed the present Rocky Mountain Ranges, and which, from the best data the geological knowledge of the present day affords, are supposed to have taken place at the close of the Cretaceous period, exercised in this region an immense horizontal pressure against the unyielding granitic mass of the Sawatch, and gradually lifted up the Carboniferous and Silurian strata and their interbedded porphyries to the heights they now occupy along the crests of the Mosquito Range. The effect of the compression of these beds was first to bend them into long, sharp folds, whose longer axes had a general direction northwest and southeast, while the steepest side of the fold was naturally on the side of the greatest resistance, viz, the west. The pressure not yet being relieved, a further effect of the pushing force thus exercised was the production of great fractures or faults more or less parallel and frequently coincident with the axes of these folds, in which the uplift was almost invariably on the east. Thus the Mosquito Range presents, as it were, a series of steps, in which the beds east of these lines of fracture have been lifted relatively to their corresponding strata on the other side of the fault, from a hundred up to several thousand feet vertically, the greater fault, as might naturally be expected, occurring just west of the crest of the range more or less parallel with it. and showing a maximum movement of between two and three thousand feet.

For reasons which will be fully explained in our report, but which it were impracticable to condense into the brief limits required here, the spur lying between Iowa and Evans Gulch, upon which the mines of Leadville are situated, was more violently affected than any other by these dynamic disturbances, the result of which has been, as our map will fully show, that it is traversed in every direction by a perfect network of folds and faults. Probably no piece of ground of its size upon the continent can show such a complication of geological structure; and when we consider that since this folding and faulting took place, long ages of erosion have passed, the upper beds have gradually been worn away, great glaciers have slowly carved out the deep ravines which furrow the mountain sides, casting their *débris* of gravel and bowlders upon the intervening spurs, so as to practically hide the effects of all this previous action, it is not to be wondered at that mining men have been puzzled to know the right place to look for mineral, and that courts, in endeavoring to decide the rights of the many claimants to one piece of valuable ground, by the rules of a mining law which never contemplated such a class of deposits, should give decisions which, from a geological standpoint, are utterly without reason.

Some idea of the practical waste of labor and material consequent upon the want of a definite knowledge of the geological structure may be formed by the following figures: The number of approved mine claims in this district, of which the plats are on record in the surveyor-general's office, amounted, this summer, to something over 700. Supposing each of these had the full area allowed by law, they would cover, continuously, over ten square miles of ground, and this does not include the numberless prospect holes which have been commenced and abandoned without taking the necessary steps to secure a legal title to the ground. The hills for miles around Leadville are literally honeycombed with shafts and tunnels, probably the greater number of which are so situated that either it would be geologically impossible for them to reach the ore-bearing bed, or it would be found at such depths as, under the present conditions, to render it practically worthless when reached. These prospect holes have, however, been of the greatest value to us in our studies, furnishing, on such a large area, an actual knowledge of the relative position of the various rocks which form the earth's crust. They have been examined with great care, one by one, a labor of many months, and hundreds of specimens taken, illustrating the different characters of rocks thus exposed. It is my purpose, also, to use them as an illustration of the relative amount of productive and unproductive labor spent under the present system of mining, measurements being taken of each shaft and tunnel, which will form the basis of a calculation which shall show how much money has been put into the earth and how much taken out, in a given time. Throughout the region examined by us, a stratum of dark blue, often nearly black limestone, at the base of the Carboniferous formation, is the ore-bearing formation "par excellence."

This limestone is well characterized, both by its lithological peculiarities, and by the fossil remains found in it, and can therefore be traced with ease and certainty, once its characteristics are well understood. Other horizons there are in which ore is found; but, in general, far inferior in quality and extent to those occurring at the contact of this limestone and the porphyry, which almost everywhere overlies it. The porphyry, it is true, varies in character at different localities, and with it the character and richness of the ore; but wherever openings are made, although pay ore may not necessarily be found, evidences of mineralization are seen. By means of the field studies made this summer, we shall be enabled to lay down the outlines of all the different sedimentary and eruptive rocks occurring throughout the region, and construct accurate sections across the range, which will be published with the map, and present a graphic picture of the interior structure and the effects of the dynamic convulsions to which it has been subjected. With our map in hand, therefore, the miner will be able to trace out the ore-bearing horizons upon the surface, and in that district covered by the detailed map of Leadville, determine at any given point whether it still exists below him or has been carried away by erosion; and, if it is still there, what depth of shaft he will be obliged to sink before he can expect to reach it. In addition to the maps already mentioned, carefully compiled diagrams of the underground workings of the principal groups of mines of Leadville, those of Fryer Hill, Carbonate Hill, Iron Hill, and Bruce Hill are being prepared by competent engineers, on a scale of 80 feet to the inch, on which will be shown the outlines of the larger ore bodies thus far developed, both in horizontal projection and by profiles. These outlines will also be given upon the larger map of Leadville, so that the reader can see at a glance the distribution of the known bodies of ore, and draw his own conclusions as to the probability of their being formed in any particular portion of the district in which he is interested.

The present position of the ore bodies being thus defined, the question that next presents itself to the mind is: "Whence did they come?" The study of the origin of ore deposits is one upon which comparatively little systematic scientific work has been done; and which presents peculiar difficulties in its prosecution. Its results may not be of immediate practical value for any particular district, but for the advancement of the interests of mining in general they are of the utmost importance.

To this subject, therefore, considerable attention has been given, and preparations have been made to carry out the investigations thus commenced in a systematic manner, in all the mining districts, which will be reported upon in the future, in this division. It is my wish not to content myself with the simple expression of an opinion that the ore came from below or from above, but by patient research and investigation to prove definitely that it could or could not have proceeded from this or that source to which the results of our geological studies may have pointed. Chemical investigation being necessarily the essential part of such a study, it was important to secure competent chemical assistants, and to have a laboratory fitted with all the appliances requisite for the most accurate analysis of rocks and minerals. In the former respect I have been most fortunate in securing the services of Mr. W. F. Hillebrand and A. Guyard, gentlemen who have made a specialty of this branch of science, and fitted themselves under the best instructors that this country and Europe afford.

To get a suitable laboratory in this region, and with the means at my command, has, however, been a matter of much difficulty, and involving vexatious delays, as all the material had to be brought from the East, and the building itself constructed especially for the purpose. It is now, however, in complete working order, and exhaustive investigations, both of ore and country rock, are in progress, from which I hope to derive such practical results as will amply repay the labor and expense involved. Its value as an adjunct to the investigations of mining geology cannot be overestimated.

The rapid progress made during the past few years in microscopical petrography render a microscopical examination of its rocks an essential feature of the geological study of any district, and more especially of one so rich in varieties of eruptive rocks as this. Specimens of no less than 345 different crystalline and eruptive rocks were collected in the limited region examined during our short summer's field work.

In the month of July, Mr. C. W. Cross, who had just graduated with distinction at the University of Leipzig, where he had made a special study of this branch of geology, volunteered his services for this work, and is now engaged upon a systematic examination of thin sections of these rocks.

In obedience to your instructions, duplicate and triplicate specimens of all important rocks and ore have been gathered during the work. The specimens in our collections number already over two thousand. When they shall have been worked up and carefully determined and labeled, two sets will be sent to the National Museum at Washington, and one set preserved in the offices at Denver.

Each of these collections is to be systematically arranged, and as they accumulate, will, in time, form a representation in miniature of the geology of the whole country, which whoever desires may study without the expense and trouble of traveling over the mountainous regions from which they come. As time progresses I propose to make the collection at Denver a representative, not only of the ores of the precious metals and their inclosing rocks, but of all the useful material obtained from the earth, such as iron ore, coal, building stone, limestone, saline products, &c., whose value and fitness will have been previously determined by laboratory experiments. A special study has been made of the numerous smelting works of Leadville by Mr. A. Guyard, which will form an important chapter in the forthcoming report. This will include a critical examination of the processes employed, giving the composition of ore fluxes and fuel, the proportions of each in the average charge, the chemical combinations which take place at different zones in the furnace, the character and chemical composition of the products, together with some theoretical consideration of the thermic conditions under which the various chemical combinations occur.

Tables will be given showing the costs of various materials employed, the value and amount of products obtained, and the disposition of the bullion. Analysis and spectroscopic examinations will also be made of the matte, slag, and flue dust. Diagrams of all the apparatus employed, drawn to a scale, will illustrate the verbal descriptions. Should no unforseen obstacle prevent, the manuscript of this report, of the prominent features of which I have endeavored to give a brief outline above, will be ready, according to your instructions, in January or February of the coming year.

Owing to the late date at which the appropriations of the last Congress were made, and the inadequacy of the amount apportioned for the use of this survey, work upon reports similar to the above, contemplated in your letter of instructions, upon other important mining districts of this division, has not yet been commenced; but the organization of our work is now so far advanced in perfecting the necessary administrative machinery, or the securing and training of competent assistants, the procuring of the necessary chemical and microscopical apparatus, and in ascertaining the economical importance and general geological character of the districts to be examined, that, as soon as sufficient funds are furnished, they can be prepared with greater facility and rapidity than the work already accomplished.

Very respectfully, your obedient servant,

S. F. EMMONS,
*Geologist-in-charge.*

---

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF THE GREAT BASIN,
*Salt Lake City, Utah, October* 1, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to submit the following report on the geological field work in the division of the Great Basin, for the year ending June 30, 1880:

The field of operations lay in Northwestern Utah and adjacent parts of Nevada and Idaho. The field work was begun in the first week of October, 1879, and was stopped by stress of weather in the middle of January following. A single party only was engaged in it. Mr. Willard Johnson, of Washington, D. C., gave most acceptable assistance in the professional part of the work, and three men were employed for camp duty.

The subject for investigation was Lake Bonneville, the great ancient lake of Utah; and as the matter is of a somewhat special nature, a brief introduction will be necessary to show the bearings of the items of progress reported.

The Great Salt Lake Desert and a congeries of valleys connected with it were filled with water at a period so recent that the vestiges of the flood are little impaired at the present time. The sea cliffs that were carved by the dash of the ancient waves are sea cliffs still, though they stand a thousand feet above the present level of Great Salt Lake. The bars and beaches of sand and gravel that were built by the ancient currents are furrowed here and there by the rains that have since fallen on them, but they are furrowed only, and not destroyed; and the imagination is not strained to fill the gaps and restore their full contours. The fine silt that settled quietly in the deeper waters still forms the floors of the valleys. To the geologist, accustomed to speak familiarly of millions of years, it was the veriest yesterday when all these things were wrought; nor can any one who stands on the quartzite shingle of one of the old beaches, and contemplates the rounded pebbles, gleaming with the self-same polish they received when the surf laid over them, fail to be impressed by the freshness of the record.

There is a topography of the land and a topography of the water. The forms of the land are sculptured by the beating of rain and by the flow of rills, and creeks, and rivers, and they have peculiar characters accordant with their origin. The forms of the beds of lakes and oceans, and especially the forms of shores, are sculptured by the sway of waves and currents, and are distinguished by characters equally peculiar. All the hills and mountains above the shore line of Lake Bonneville bear witness of the play of subaerial agents, while below that line the slopes betray their subaqueous shaping. There is a trenchant line between them, and their peculiarities are beautifully contrasted. A careful inspection, however, shows that the subaqueous characters are superimposed on subaerial characters. The forms belonging to the dry land are continued down past the shore line, and the sculpture of the lake has been superficially impressed on them without entirely obliterating them. It is thus made evident that before the epoch of the lake, the land it covered was dry, just as it is now. The lake had a beginning as well as an end. It came, it lingered long enough to make an unmistakable record, and then it departed as it came.

The immediate cause of this appearance and disappearance is not at all mysterious. Both events were due to changes of climate. The lakes of the basin are now shrunken because the climate is arid. The evaporation from the surface of the land nearly balances the rainfall, and the small surplus of water gathers in the lowest depressions, forming salt lakes, from which it is finally all dissipated. The climate of the Bonneville epoch was relatively humid. There was a great surplus of unevaporated water. The basin was filled to overflowing, and sent a large river to the ocean.

The history of Lake Bonneville is therefore the history of the ancient climate of Utah, and is thereby closely linked to the material interests of the Territory. The secular cycles of climate whereby the water level was raised and lowered a thousand feet, and the water surface increased and diminished, as compared to the present surface, a thousand per cent., finds its modern counterpart in oscillations whereby the level of Great Salt Lake has recently varied through a range of 12 feet and its area through a range of 15 per cent. Whatever we can learn as to the character and cause of the greater change will contribute directly to an understanding of the lesser, and the public domain presents no more important problem to the survey. In a dozen States and Territories agriculture is restricted by the insufficiency of the water supply, and in half of them it is only here and there that a spot can be found to repay cultivation. The supply of water for a few years shows a flattering increase, and then for a like period discourages by its decrease. It is a matter of the utmost importance to determine what, on the whole, is the tendency of the climate. Is it growing moist or dry? And are there any means by which precipitation can be increased? Upon the solution of these problems will ultimately depend the population of a great district, and if the logic of events can be anticipated and the conditions of the future foretold or modified, the immigration that has begun can be duly stimulated or discouraged, and the investment of the great capital which appears to be demanded for works of irrigation can be wisely directed or wisely limited. It is partly by the study of causes and effects in meteorology, and partly by the empirical study of the history of storms, that the scientific weather prediction of the day has been achieved. It may fairly be hoped that a critical investigation of the secular oscillations of climate in the past will help to solve the problem of secular change which is of such vital importance to the agriculture of an arid domain.

The preceding account of Lake Bonneville is not novel, but is a brief sketch of the results already published by the geologists of the official corps which have preceded the present. The material they put forth was for the most part acquired in an incidental way, and not by systematic search. It was the fortune of the writer, after penning his first impressions of Lake Bonneville, to renew and extend his acquaintance by means of a journey which carried him about the northern shore. The journey, which was made under the auspices of the Powell survey, had for its immediate object the cognate subject of the irrigable lands of the Salt Lake basin; and it afforded a considerable store of new facts with regard to the ancient lake. It was the purpose of last winter's field work to so complement this unpublished material that a monograph of the lake could be written. The event proved that the magnitude of the subject had been underrated; and while the investigation gave satisfactory answers to most of the pending questions of fact, it developed a host of new suggestions and new problems that seemed imperatively to demand further examinations in the field. So long as observation was indirect and cursory—at a distance as it were—the history of the lake appeared simple; but so soon as it was closely scrutinized and made a subject of special and direct study, it was found to be highly complicated—so complex, indeed, that its complete elucidation is not to be hoped for.

One of the questions proposed for solution by the field examination was a question of outlet. It had been announced by some observers that the point of outlet was at the north end of Cache Valley, at a place known as Red Rock Gap; but it was asserted by another that that point was merely the site of a strait joining to the main body of the old lake a smaller body which occupied Marsh Valley, Idaho, and which discharged the surplus water of the whole from its northern extremity. A careful study of the localities showed the former view to be the correct one. There are no shore lines in Marsh Valley, and there has been no recent barrier at its northern end. A map of the actual locality of outlet was made, and the vertical relation of the channel of outflow to the shore lines was established by means of the spirit level.

A second subject of investigation was found in the deltas of streams that were tributary to the lake. Just as the Mississippi is now throwing its detritus into the Gulf of Mexico, and slowly extending the shore of Louisiana, so in this ancient time the Bear, the Weber, the Sevier, and a multitude of smaller streams brought their tribute of gravel and sand to Lake Bonneville, and built additions to its shores. As the water slowly fell from its highest stage, new deltas were built at lower levels, and now that it has almost completely dried away, the deltas are exposed as systems of terraces grouped about the cañon mouths where the rivers issue from the mountains. These terraces are everywhere conspicuous features of the topography, and some of them are of notable magnitude. A part of Salt Lake City stands on deltas of City Creek. The cemetery at Ogden occupies an old delta of Ogden River, the Mormon temple at Logan overlooks Cache Valley from a delta of Logan River. The "Sand Ridge" between Ogden and Keysville, now celebrated for its unirrigated farms, is the delta of Weber River; and the Union Pacific Railroad runs from Uintah to Ogden in a valley the Weber has recently excavated through the same deposit.

The successive deltas of each group record the successive water stages of the shrinking lake; and their study, which was begun but not completed, will contribute to the history of the changes of climate by which the lake surface was made to rise and fall.

A more delicate measure of the periods during which the water lingered at its various stages is found in the phenomena of bars. Wherever a current which has followed a lake shore for some distance is forced by the configuration of the bottom to turn toward deeper water, a bar is thrown out in the direction taken by the current, and this bar is increased in length and size so long as the conditions of its formation are maintained. Upon the sloping sides of the Bonneville basin there are many places where the conditions of bar formation remained practically the same, while the water level underwent considerable change, and the dimensions of the bars built at different horizons afford valuable time ratios. The study of these records was begun and carried far enough to demonstrate its importance to the investigation, but its full and satisfactory prosecution was reluctantly deferred for lack of time.

A fourth desideratum was the detailed and discriminative determination of the lake sediments. It was already known that they consisted of marls and clays and sands, but no considerable section had been measured, and no constant order of sequence had been observed. It was ascertained last winter that the marls invariably overlie the clays and form a relatively thin deposit. At one locality a beach gravel was found immediately beneath them, and in such relation as to demonstrate that a very low stage of water had intervened between two high stages. This is a capital discovery, proving, as it does, that the humid epoch was interrupted by an interval of dryness. If it be true, as argued by Mr. King and the writer, that the Bonneville epoch was synchronous with the glacial epoch, then it may also be true that the subdivision of the glacial epoch into two subepochs, with an interval of warmth, finds here a manifestation. However that may be, the discovery confirms in a most gratifying manner an independent conclusion of Mr. King's. Reasoning entirely from mineralogical facts and the necessary conditions of chemical reaction, that geologist was led to conclude that Lake La Hontan, the contemporary and neighbor of Lake Bonneville, was first flooded, for a long period, without overflow, and then, after an interval of desiccation, was refilled for a shorter period, during which there was a discharge. The history of Lake Bonneville is based purely on stratigraphic and topographic data, and is identical in every determined particular. The basin was flooded for a long period, represented by ninety feet of clay; there was then a desiccation, shown by intercalated shore deposits; and there was finally a second flood stage, represented by fifteen feet of marl. The fact of overflow is proved by the discovery of the channel of discharge, and it has been shown that the second epoch of flooding was accompanied by overflow. Whether the first epoch was similarly characterized has not been ascertained, but it is a significant fact that the deposits thrown down during these two epochs have a marked difference of composition. If a relation can be established between the clay and marl as indicative of continence and overflow respectively, the parallel will be absolutely complete.

The series of local orographic movements by faulting, which had previously been shown to have followed as well as preceded the Bonneville epoch, were found to have continued also during the epoch. A shore deposit was found at one place to have been faulted and afterward covered by other shore deposits. The observation is trivial in itself, but it adds its mite to the cumulative proof of the continuity of geological processes.

The relation of the epoch to another class of phenomena is illustrated by an extinct volcano observed in the Sevier Desert. The crater was a ruin before the lake water washed its base, and it has produced no subsequent eruption; but the cooling of the central mass is not yet complete, and its warmth gives rise to a group of feeble fumeroles.

Attention was given also to the recent changes of the salt lakes, which survive the desiccation. As a consequence of the juxtaposition of two dry years, Great Salt Lake has fallen about three feet, and Sevier Lake, which in 1872 was nearly thirty miles long, has disappeared. The bed of the latter exhibits everywhere a saline mud, and in a central area this is covered by a crust of chloride of sodium and sulphate of soda several inches in thickness. During a fortnight of extreme cold at the close of the year 1879, ice was formed on the surface of Great Salt Lake, and at the same time there was a precipitation of sulphate of soda from the brine. The ice coat was thin, and its formation is not to be regarded as the cause of the precipitation. It was merely a concurrent effect of the fall of temperature, which diminished the power of the water to hold the salt in solution. The precipitate was redissolved in the course of a few weeks.

For the double purpose of study and illustration a number of local maps were made by Mr. Johnson. His instrument was the plane table, and his method that of intersection. In a final report occasion will be taken to advocate the use of the plane table for work of this class, and to describe a special method of handling, which in our experience has proved economical of time.

In pursuance of the instructions of the Director of the survey that the coming field season shall be devoted to the continuation of the same investigations, a selection has been made of the lines of observation which seem most important. Active preparations are in progress for the prosecution of the following work:

1. A new and probably final map of Lake Bonneville will be prepared. The topographic base will be compiled in chief part from official data now in existence, but a small amount of territory will need to be delineated in the field. Two-thirds of the outline of the lake has already been ascertained with precision, and the remainder will be traced during the summer.

2. The history of the rise and fall of the water will be studied in detail, and in a quantitative way. Contour maps will be made of some of the best series of deltas and bars, and the spirit level will be freely used in determining their relations.

3. The relations of the lake phenomena to recent orographic displacements will be investigated. The absolute height of the highest beaches will be determined by level at enough points to show the character and amount of its distortion by the rise and fall of the country on which it is carved.

4. An effort will be made to determine the relation of the lake phenomena to the glacial phenomena of the Wasatch Mountains. Accord-

ing to Mr. Emmons, at least one glacier, that of Little Cottonwood Cañon, pushed its foot as low as the shore of the lake, and the conjunction of its moraines with the lake formations may confirm or controvert the theory that the Bonneville epoch is identical with the glacial.

5. The relation of the lake to the volcanism of the district will receive attention. It is already known that many basaltic outbursts occurred within the area of the lake beds before their deposition, and at least one *coulée* has spread out upon them after they were dried. An endeavor will be made to ascertain whether there were also subaqueous eruptions. If the ocean plays its reputed role in the production of volcanoes, then surely the volcanism of this arid region should not have ignored its only opportunity for association with a body of water.

6. Material will be gathered for the illustration of the types of topography to which lakes give rise, and especially for their comparison with certain types of land sculpture with which they have sometimes been confused.

It is believed that the material will be ready for discussion at the close of the field season.

Very respectfully, your obedient servant,

G. K. GILBERT,
*Geologist-in-charge.*

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF THE COLORADO,
*Mount Trumbull, Ariz., September* 3, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: On the organization of the Geological Bureau, the unfinished work of the Geographical and Geological Survey of the Rocky Mountain Region was turned over to it. This work consisted of a survey, both topographical and geological, of a territory in Southern Utah and Northern Arizona, about 70,000 square miles in extent. To complete the reports on this region, two detailed maps of special districts in Northern Arizona were necessary. One embraced the Uinkaret Mountains, an extensive group of volcanic peaks and cones; the other a portion of the Grand Cañon of the Colorado, and a great number of cañons subsidiary thereto.

For the purpose of making the topographical surveys necessary in these two districts, a party was organized, and July 16, 1879, placed under the direction of Mr. S. H. Bodfish, which, on taking the field, was divided into two branches—one being placed under the direction of Mr. John H. Renshawe, the other under the immediate direction of Mr. Bodfish himself.

Mr. Renshawe made the survey of the Uinkaret district, Mr. Bodfish of the Grand Cañon district.

The Uinkaret district is an area of 1,475 square miles; the Grand Cañon district of 1,900 square miles. The surveys were somewhat elaborate, embracing all the details necessary to the construction of grade-curve maps on a scale of one inch to the mile—the curves representing levels of 50 feet. The Uinkaret district being a region of volcanic peaks and cones, with intervals covered with beds of lava and scoriæ, presented many serious difficulties to the explorer. Again, the region was one of excessive aridity, no living stream being found, and but one living spring was known in the area. Scattered supplies of water were found at great intervals in water pockets.

The Grand Cañon district is a labyrinth of deep gorges; through its center flows the Colorado, more than 6,000 feet below the general level of the country, and the tributary cañons are profoundly carved, resulting in a district of deep gorges and towering cliffs. This survey was successfully completed.

With these topographical parties a geological party was organized, under Mr. Charles C. Walcott, who was instructed to make a stratigraphic section from the summit of the Pink Cliffs, at the source of the Kanab, along its course through cañons to its junction with the Colorado. This section embraces a nearly unbroken series of geological formations, from the Eocene Tertiary to the base of the Carboniferous, with unconformable Devonian and Silurian rocks below. It was the purpose of this work to establish a detailed section as a standard of comparison for various subordinate sections previously made in the adjacent country. This work was successfully accomplished. A good section was made, and valuable suites of fossils collected in the several formations represented in the section.

During the past winter, Mr. Bodfish and assistants were engaged in the construction of the maps, materials for which had been collected during the field season. At the close of the fiscal year these maps were completed. At the same time Mr. Walcott had completed his report on the geology of the Kanab, with graphic sections and schedules of the fossils collected.

Assigned to the charge of this district at the beginning of the present field season, I proceeded via Salt Lake City to Kanab, a Mormon village, situated upon the southern boundary of Utah Territory, and divided the party into three divisions; one under Mr. Bodfish, one in charge of Mr. Goode, and a third under my personal direction. Each party was equipped with the necessary instruments, camp equipage, and animals, and supplied with a small corps of laborers.

Mr. Bodfish at once proceeded to the Kaibab Plateau, for the purposes of continuing the topographical work essential to the completion of the special map of that plateau, and of the Grand Cañon, and also to establish monuments and make the observations required to connect the salient points of the plateaus with the primary triangulation of this survey. This latter work is of high importance, and has long been one of the most difficult geodetic problems in the western surveys. The great expanse of the Kaibab Plateau, its great altitude, the flatness of its surface, densely clothed with timber, and the utter absence of even one eminent point upon it from which other primary points are visible, have combined to render the connection of the topography of the plateau with the general survey a very difficult matter. Several points on the terminal escarpment of the plateau, and upon the brink of the Grand Cañon, have at last been found, and monuments built thereon, which it is believed will fully connect the western and southern portions of the plateau with the geodetic work already done. Mr. Goode and myself accompanied Mr. Bodfish, the former for the purpose of becoming familiar with this ground and these monuments, which he has been instructed to observe and connect with the main triangulation from the San Francisco Mountains, a matter of no small difficulty.

One object in visiting myself the Kaibab Plateau was to inspect and ascertain the character of the work performed by Mr. Bodfish during the past year. I am very glad to be able to report that it is exceedingly successful, and that Mr. Bodfish is, in my opinion, entitled to high praise and warm congratulation for the exceedingly able and accurate manner in which he has performed one of the most difficult pieces of detail topography which can be encountered in the West. He will continue his work this season in the southern and southeastern portions of the plateau front, in those localities which are of greatest interest and moment to the geologist. Another feature of this most sublime and interesting plateau, which he will endeavor to complete this season, is the surface topography, embracing its surface drainage. I find that this topography is a remnant, and a large remnant, of an ancient drainage system, identified with the earlier evolution of the Grand Cañon, and I am fain to believe that its careful study and analysis will not only throw much light upon the geological history of this great chasm, but will be an important factor in the work of unraveling the history of the great denudation and erosion of the Plateau country.

Mr. R. U. Goode was sent, August 15, upon his dismal journey across the Colorado River, to the San Francisco Mountains, for the purpose of accomplishing the work of secondary and some primary triangulation in that district. I have instructed him to make observations from the San Francisco Peak, from Mounts Kendrick and Floyd, upon the new monuments built upon the Kaibab; also to prospect the southern slopes and mesas of that district for a suitable locality for the future measurement of a base line, and to devise a series of triangles which may be used for the contraction of the triangulation upon its extremities.

The geological work planned out for myself consists of the study of the Uinkaret Plateau, lying about fifty miles west of the Kaibab, and such accessory features of the adjoining plateaus as may suggest themselves. On the 18th of August I left Kanab for Mount Trumbull, a considerable mass which dominates the Uinkaret, and have established here a camp, as the base of operations. On my way I met, at the Pipe Spring, Mr. W. H. Holmes, who joined me to assist in the work. It is an exceedingly instructive and interesting field, and in many respects it is highly dramatic. Its surface geology is chiefly a widespread field of basalt, mostly of very modern origin, covering a platform of Carboniferous and Permian strata. More than one hundred, perhaps nearly two hundred, well-preserved craters are seen, most of them hardly touched by the ravage of time, and a few of them so fresh and black that it seems as if two or three centuries would be an extravagant estimate of their age. A considerable number of these cones are perched upon the very brink of the Grand Cañon, and have sent many *coulées* of basalt cascading down the upper walls and into the vast inner gorge.

In the magnificent Toroweap Valley, on the eastern side of the plateau, five of these grand basaltic passages, each representing numerous *coulées*, are seen pouring over a wall a thousand to fifteen hundred feet in height and spreading out over the valley below. In the Queantoweap Valley, on the western side, the same phenomenon is repeated on a similar scale. The black basalt, with the brilliant pale gray promontories of the Carboniferous jetting out between the flood, forms a striking picture.

Most instructive is the relation of the basalt to the great faults across which it has passed, and also to the Grand Cañon itself, in respect to the relative ages of these events.

Into the progress hitherto made in the study of these relations it would now be premature to enter, but I may venture to remark that it foreshadows the ascertainment of greater recency and rapidity in the cutting of the inner gorge of the Grand Cañon, and also of the great outer chasm, than would have otherwise been credited. That a very large portion of the throws of the Hurricane and Toroweap faults has been accomplished in a very recent period, is proven at once.

The lithology of the region is not rich. Nothing but highly augitic olivinitic basalt has thus far been discovered, and of this there is very little variety—too little almost to merit distinctive and critical description—at least so far as cursory microscopic investigation has indicated. There is considerable range in the epochs of eruption, but none appear to be very ancient. A distinction may perhaps be drawn in the mode of occurrence between the older and some of the newer basalts. The more ancient appear to spread out in broad fields and to occupy the more elevated situations, forming the basaltic plateaus so well known in the Auvergne and Vivarrais, and upon the Rhine. They overlie the greater part of the Permian series, which here has great expansion and thickness, and thus form the dominating masses of Mounts Trumbull and Logan, and a basaltic plateau to the south of Logan. The newer basalts, for the most part, spread out in thin sheets, diverging from beautifully preserved and symmetrical craters, built of lapilli and peperino, and occupy lower platforms. Lithologically there is no apparent difference between the older and newer basalt—not even in the slightest.

Much interest attaches to the study of the Permian series, not only in the Uinkaret but in the adjoining plateaus. This series bids fair to assume a greater importance than has hitherto been accorded to it. Much of the area which has hitherto been supposed to be surfaced exclusively with upper Carboniferous strata, has, in reality, a thin covering of the lowest members of the Permian. The latter lies in patches covering the gently rising knolls, while the upper Carboniferous occupies the shallows which intervene. In many places, however, the Permian is present in great force, from half to three-fourths of its entire column being preserved. An attempt will be made during the season to gain a more complete knowledge of the vertical extent and character of this important formation.

Mr. Holmes is proving to be a most invaluable coadjutor in this work, not only by the exercise of this great artistic ability in depicting the grand scenery of this locality and its very striking geological features, but equally so by his great skill and discernment in the analysis of the geological problems. His work will be of the greatest value and interest.

I have the honor to add that the health of the parties is excellent, and that great harmony and zeal are displayed by all engaged in the work.

Very respectfully, sir, your obedient servant,

C. E. DUTTON,
*Captain of Ordnance in Charge.*

Among the investigations in practical geology undertaken by the survey, one of the most important is the study of the geology and ore-deposits of the district of Eureka, Nev.

In order to delineate the complicated structure of the region, it was necessary that the geological field-work should be preceded by the construction of a thorough topographical map.

Accordingly, Mr. Frederick A. Clark, topographer in charge, was placed in the field with a small party, with directions to execute a grade-curve survey of twenty miles square, including the principal mining localities of the region, using a scale of 1 : 10,000, with fifty feet vertical interval between contours.

His survey having progressed sufficiently to afford advanced sheets, Mr. Arnold Hague was placed in the field, in charge of the Eureka district work. His letter, with the subjoined note of Topographer Clark, follows herewith.

EUREKA, *September* 30, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to present the following preliminary report upon the field-work of the United States Geological Survey, during the present season, in the Eureka district in the State of Nevada:

In accordance with your instructions, I took the field, accompanied by two geological assistants, Mr. C. D. Walcott and Mr. Joseph P. Iddings, and immediately began preparations by establishing our first camp in New York Cañon, near the eastern base of Prospect Peak, and in the immediate neighborhood of the mines which occur along the limestone belt to the southward of Ruby Hill.

On my arrival in Eureka I found the map of the geological survey, which was to serve as the basis of our work, far less advanced than I had hoped; but the topographical party, under Mr. F. A. Clark, was then well organized, field-work was progressing rapidly, and will be completed, unless the weather proves exceptionally bad, by the 20th of December.

The topographical map, which is on a scale of 1: 10,000, with 50-feet contours, will furnish ample detail to lay down the geological formations with great accuracy, and enable us to express the geological structure of this complicated mountain region, with its lines of faulting, which form one of its most characteristic features.

The area of the map (twenty miles square) not only permits accurately locating every mine in the district, but is sufficiently large to furnish a fine geological section across the Palæozoic rocks of Central Nevada, from the Primordial to the Coal Measures—a section that will serve as a standard for future reference.

The area covered by the map lies partly in the county of Eureka, and partly in the county of White Pine. It embraces a broad, isolated mountain region, nearly everywhere surrounded by the characteristic Quaternary plains of Nevada. To the north, two parallel longitudinal ranges, the Piñon and the Diamond, border the Diamond Valley. Where they terminate to the southward, the valley is shut in, and the two ranges connected by the Eureka Mountains under consideration. To the southward a group of low hills connects, in a somewhat similar manner, these mountains with the Fish Creek Range.

Topographically, the area covered by the map possesses a singularly broken expanse of mountains. Long, sharp ridges, with serrated outlines, and bold, prominent peaks, broad table-topped masses of horizontal strata, are strikingly contrasted with rough, irregular outbreaks of erupted masses.

Deep cañons, rough, steep mountain slopes, abrupt walls, shallow basins, and valleys everywhere mark the region. Indeed, it is doubtful if any area in Nevada of equal extent presents a more varied topographical character, and nowhere within the limits of the State is the dependence of the topographical upon the geological structure of the country more clearly defined than here.

The altitude of the Quaternary valleys is about 6,000 feet above sea level, while prominent peaks rise from 3,000 to 4,600 feet above these desert plains. Diamond Peak, in the extreme northeast corner of the map, has an altitude of 10,640 feet above sea-level, and Prospect Peak, in the center of the map, reaches an altitude of 9,600 feet.

As already mentioned, our first camp was made in New York Cañon, and work commenced on Prospect Mountain ridge—the most important part of the country. Owing to the occurrence of the "Richmond" and the "Eureka Consolidated" mines on Ruby Hill, and the belt of mines found on both sides of the range, Prospect Mountain ridge forms the most important uplift in the region. At the same time it embraces the oldest formations known in the district.

The entire formation, from the massive broad quartzites found on the western slopes of Prospect Peak across the overlying limestones, argillaceous and calcareous shales, down to the most easterly outlying limestone ridge, is of Primordial age. On the geological map we will, I think, be able to indicate the outlines and width of all belts of limestone and shale, showing at the same time their mutual relations. In this way we hope to show, not only the exact geological limits of the remarkable bodies of oxidized ores of Ruby Hill, but to show their relations to similar ore bodies occurring on both the east and west slopes of Prospect Mountain. This class of ore deposits in the Eureka district is confined within certain, somewhat narrow, geological limits. In addition to the structural evidences of the beds, paleontology affords clear proof of the age of these formations. We have succeeded in finding Primordial fossils throughout the entire series, from the lowest limestone stratum immediately overlying the lower quartzite of Prospect Peak to the top of the series found east of the Hamburg mine.

Directly east of Prospect Peak, along the outlying ridges of the mountain, occurs a fault along the strike of the mountain uplift.

East of this fault line are brought up well-defined Coal Measure formations, everywhere carrying paleontological evidence of the age of the horizons.

They may be traced from the entrance to New York Cañon, and the hills forming the base of Brown Mountain, behind the Richmond mill, southward to Fish Creek Valley, where they are concealed by Quaternary formations.

In places they are broken through and partially concealed by erupted masses of trachyte and rhyolite.

In general these beds are formed of light-colored limestones, more or less arenaceous, and in places passing into beds of sandstone or quartzite. From these beds we also have large collections of fossils. The strata are perfectly conformable, and belong to the Lower Coal Measure group. They carry no mineral deposits of any special value.

The Carboniferous formation extends eastward across the Pinto Toll road, forming the lower hills and ridges of the mountain mass beyond. Passing eastward, these hills fall away gradually toward a narrow cañon or gorge, whose eastern side rises in striking contrast in abrupt precipitous walls.

Along this cañon runs another great north and south fault line, bringing up still to the eastward a broad, massive body of Devonian rocks, extending from Brown Mountain southward to Fish Creek Valley. In general, it may be said to lie parallel with the Primordial and Carboniferous uplifts.

Its structure is that of a broad, gently inclined synclinal fold, the beds dipping eastward, then lying horizontal or inclined to the north with a low angle, and finally rising with a westward dip. The mass presents some fine examples of minor faulting, and the entire block is furrowed by deep, narrow cañons, showing magnificent sections of strata. There are represented here from 1,500 to 2,000 feet of rock. To the northeast of this Devonian block, the Palæozoic rocks are hidden by broad sheets of basalt, which serve to connect it, however, topographically with the uplift of the Diamond Range. Newark Mountains, situated in the northeast corner of the map, may be considered as forming the southern end of the Diamond Range. It forms a monoclinal ridge, dipping to the westward, and presents a magnificent escarpment to the eastward, rising 2,500 feet above the valley.

Probably nothing in our summer's work will have so much interest for geologists as the discovery of so great a thickness of Devonian strata, which is shown to exist here in Central Nevada.

It is estimated that there occurs here at Newark Mountain 4,500 feet of Devonian beds, and the evidence seems quite conclusive that the Devonian hills lying to the eastward of the Pinto Toll road underlie the beds of Newark Mountain. If this is correct, we have a thickness of between 6,000 and 7,000 feet of strata.

At Newark Mountain, from the base to the summit, there occur at intervals beds carrying *brachiopods* of characteristic Devonian types.

Above the limestone of Newark Mountain occur several hundred feet of black fissile shales, crumbling easily on exposure. In places they are more or less arenaceous, and pass into thin beds of sandstone, which finally become a dark compact quartzite, again overlaid by black shales. The interesting feature of these shale beds is, that they are the exact equivalent of the black shales of White Pine—a formation that heretofore has never been recognized except at the latter locality.

Here, at Eureka, Mr. Walcott has found several species of fossils identical with those obtained from the Hamilton black shales at White Pine.

The Devonian limestones and shales pass under the eastern base of Diamond Peak, and are lost in the plain, but are overlaid by a heavy body of quartzite, which has been referred to the Ogden quartzite of the Wahsatch section.

Conformably overlying the quartzite, and forming the top of Diamond Peak, occurs the Lower Coal Measure limestone, rich in characteristic well-known forms. Above the limestone comes a large development of conglomerate, of unknown thickness, as it is by no means certain that the upper beds are reached. From its geological position, it has been referred to the Weber quartzite, while its lithological habit bears close resemblance to similar beds in Central and Northern Nevada, and regarded by the "Geological Exploration of the Fortieth Parallel" as belonging to the same horizon.

Throughout the entire series of beds there is very little true quartzite.

Compact, reddish-brown conglomerate, filled with steel-gray, black and red nodules of cherty material, cemented with a fine ferruginous sand, is the most striking lithological feature. Interstratified in this conglomerate is a belt of gray limestone about 300 feet in thickness.

To the west of Prospect Peak ridge the geology is not sufficiently well known, as yet, to speak definitely of the formations. We have just begun work in that portion of the district.

Enough is known, however, to say that the formation consists largely of Devonian limestone—both the older and newer rocks occupying a very subordinate position.

The region is characterized by heavy faultings and displacements complicating the structure, but rarely bringing up the lower beds.

The extreme western group of hills forms a broad mass of Devonian limestone, without, however, exposing a heavy thickness of strata. The beds incline from the central mass, with gentle dips, in all directions presenting roughly a dome-shaped body.

One of the most interesting geological features of this portion of the district is found at Lone Mountain, where the Silurian and Devonian strata occur, perfectly conformable, without any breaks, with both structural and paleontological evidence of their true position. We here have 4,000 feet of conformable beds with organic remains throughout the series. The Devonian beds are easily correlated with the beds to the eastward.

Already we have large paleontological collections from the Silurian, Devonian, and Carboniferous rocks, and every day important and valuable additions are made, filling up the known gaps, and more closely defining the different horizons.

From the Devonian Rocks our collection is already very extensive. Nearly all the genera and species brought in by the "Geological Exploration of the Fortieth Parallel," from White Pine, Piñon Range, and one or two other localities, have been recognized as occurring here.

The Tertiary volcanic rocks of the district cover large areas and present some interesting features. They have been carefully mapped, and their relations to the Palæozoic uplifts studied.

A matter of great interest, geologically, and of considerable importance in mining and economic questions, is the connection between the great lines of faulting and points of greatest weakness in the sedimentary beds, with the lines of volcanic outbursts. These points, I think, will be fully brought out when the geological map of the district is published.

Trachytes, rhyolites, rhyolitic tufas, basalts, represent the varieties of Tertiary volcanic rocks as yet discovered in the district. These, however, are all well displayed, and Mr. Iddings has made large collections from the different outbursts, showing every variety of rock. In addition to the cabinet specimens obtained, thin fragments, or "chips," are collected from each locality for the purpose of preparing microscopic sections of the rock, without afterwards injuring the larger specimens.

All investigations of the sequence of volcanic rocks fully confirm the order laid down in the work of the "Geological Exploration of the Fortieth Parallel." The order is always the same—trachytes, rhyolites, basalts.

Perhaps the most interesting part of the volcanic geology is the abundant evidence of the position of the tufa beds.

These tufas cover much the largest area of any of the erupted masses. They are not only widely distributed, but extend in a nearly continuous line from the entrance of Eureka Cañon, across the "Pinto Divide," the Pinto Basin, and southward to Fish Creek Valley, where their limits are concealed by the Quaternary plain. Wherever observed in connection with trachytes, the tufas are always seen resting upon the uneven surfaces of the former rock, and presenting no products of alteration along the lines of contact.

Rhyolites and basalts, on the contrary, are observed cutting and capping the tufa with exceedingly interesting contact products—pearlites and glassy rocks produced by rapid cooling.

It is my intention to furnish, with the final report, two complete geological sections, drawn to a natural scale, across the map from west to east—one across the center of the map, through Prospect Peak, the other in the neighborhood of Ruby Hill and the trachytic mass of Brown Mountain. In addition to the above, there may be several short sections, illustrating special points in the geological structure of the district.

In reading this report I trust you will bear in mind that it represents less than three months of geological field work, and on none of the questions treated can our work be said to be completed. Large areas of the country have not, as yet, even been visited.

Very respectfully, your obedient servant,

ARNOLD HAGUE,
*Geologist-in-charge.*

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF THE GREAT BASIN,
*Eureka, Nev., September* 14, 1880.

Hon. CLARENCE KING,
*Director, United States Geological Survey, Washington, D. C.:*

SIR: I have the honor, in accordance with order of the director, to submit the following report upon the Eureka topographical survey, to June 30, 1880.

Ordered to the charge of this work upon July 17, 1879, I arrived at Eureka, Nev., on August 5. A rapid examination of the country, with view of including twenty square miles in the survey, showed that it would be difficult to find a section more complete in the requisites for a handsome map; there being some 3,000 feet range of elevation, great variety of form, and character strongly marked.

Delayed in making outfit, camp was pitched on August 11, 1879, in Spring Valley, some four miles northwest of town. Here a base of 9,000 feet in length, over 183 feet range of level, was twice measured with a Stackpole compensated steel tape, giving a difference of 0.083 feet in the two runs. Triangulation, with an average length of side of one mile was developed; primarily upon the pentagonal plan, and so continued as far as the character of the country, condition of angles, and topographical necessities made advisable.

Owing to lateness of season and consequent small party, both triangulation and topography were carried on together—a very objectionable method. A gradientor was used in triangulation; in topography, a plane table. The scale chosen by home office was three miles to one inch for horizontal, and fifty feet interval between contours. Later in the season, however, by advice and consent of the director, the scale of 1 : 10,000 was adopted as being the more convenient and best adapted for thorough representation of so varied topography.

The field season lasted ninety-three days, being closed by heavy snows. The result of the season was: Triangulation stations established, 47; square miles of topography obtained, 25.

A furnished house was rented in Eureka, and during the winter a survey was made of the town, and office work of computation and compilation was performed.

Early in 1880 recommendations and estimates for completion of the Eureka survey, including about one square mile of the more important mining region upon ten-feet contours, was asked for by, and furnished to, the director. Consequent upon plan approved and authority granted, it is confidently expected that the Eureka survey will be completed by December 1, 1880.

Camp was formed on May 10, but inclement weather prevented the obtaining much topography before middle of June. Since that date progress has been very rapid, and by making a triangulation party and two plane-table parties, there has this season, to date of June 30, 1880, been accomplished: Triangulation stations occupied, 141; square miles of topography obtained, 36. Making a total to date of: Triangulation stations, 188; square miles of topography, 61.

My grateful acknowledgments are due and tendered Mr. George H. Wilson, assistant topographer, and Mr. G. Olivio Newman, in charge of the triangulation, for constant energy displayed in prosecution of their labors and interest manifested in development of the Eureka surveys.

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

FRED. A. CLARK, *Topographer.*

Respectfully forwarded through Mr. Arnold Hague, geologist in charge, division of the Pacific.

UNITED STATES GEOLOGICAL SURVEY,
*Virginia, Nev., October* 10, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to submit to you the following report of my work under the survey during the past year.

My attention has been directed, under your orders, to three subjects:

First. A reconnaissance of the San Francisco district in Southern Utah, the Eureka district in Nevada, and the Bodie district in California, with a view to laying plans for comprehensive reports upon each of them in the near future.

Second. A statistical investigation of the mineral industries west of the Mississippi. On this subject I have made a separate report, as special agent of the census.

Third. A detailed investigation of the geology of the Comstock Lode, which is still in progress, and which cannot be satisfactorily completed for some months to come.

In the following pages, I shall have the honor of reporting upon the first and last of these subjects, in such detail as seems appropriate.

## RECONNAISSANCE OF THE SAN FRANCISCO, EUREKA, AND BODIE DISTRICTS.

The San Francisco district, which I visited in October, 1878, lies in Beaver County, Utah, about a short range of mountains, with a nearly north and south trend, bearing the same name as the district. The most southerly of these mountains, the Grampian, is apparently a monoclinal, though not improbably a faulted anticlinal composed of highly metamorphic and dislocated quartzites and dolomites, dipping to the west and north at angles of from twenty degrees to twenty-five degrees. These rocks are probably Carboniferous. They contain no fossils, but fossil deposits occur within a few miles, and the age could most likely be inferentially established without difficulty. Next north of the Grampian is a granite mountain, and cutting both metamorphics and granite are dikes of Tertiary volcanic rocks, which cover the country for a long distance to the east.

Among the volcanic rocks I have identified microscopically are hornblende-andesite, augite-andesite, trachyte, and rhyolite. The andesites crop only to a slight extent, but there is reason to believe that they are extensively represented at a short distance from the surface.

The granite, the metamorphic rocks, and the volcanic rocks all show ore-bearing veins, but the great mine of the district, the Horn-Silver, is on the contact between the metamorphic and volcanic rocks at the foot of the Grampian Mountain. At the surface the east wall of the Horn-Silver is trachyte, but large masses of andesite certainly underlie the trachyte at a short distance to the east, and it is probable that it forms the east wall at a short distance underground. The walls are exposed in only one or two places in the mine, and not to a sufficient extent, at the time of my visit, to enable me to make any satisfactory determination.

The Horn-Silver is a vast ore-body, nearly or quite without waste, and the estimate of 500,000 tons in sight did not appear to me excessive. This is the estimate of Mr. W. A. Hooker, of New York, who carefully measured and sampled the mine. The ore is essentially anglesite, with occasional small masses of galena and disseminated particles of ruby-silver and horn-silver. It also contains selenium in some form. The mine is absolutely dry even at the six-hundred-foot level; indeed, it is so dusty, that the miners are frequently affected with lead colic.

The Carbonate mine is some three miles east of the Horn-Silver. It seems to be on a fault in andesite breccia, and presents a vein of a few feet in width, in which the galena ore fills interstices between attrition pebbles. There are, further, a great number of prospects in the district in course of development, but their importance lies in the future.

The Horn-Silver owns its own smelting works, and proposed setting up a new plant. The smelting process will afford a very excellent opportunity for an interesting metallurgical study.

The Eureka district is so well known that my short visit there, in November, 1879, enables me to add but little to the general fund of information on the subject. My efforts were mainly directed to familiarizing myself with the deposits, and making arrangements for the purchase of the mine maps, &c.

The ore-bearing formation is metamorphic limestone, with traces of stratification lying on quartzite, and overlaid by shale, all of Silurian age. In this body of sedimentary origin are distributed irregular chimneys and pockets of ore, consisting in part of galena, but for the most part of sulphate and carbonate. I see some reason to believe that a portion of the carbonate has been deposited by substitution for limestone, but this point could not be absolutely determined without more time than I had to give it. The limestone has been crushed and faulted repeatedly, and in different directions, but the dynamical action seems to have preceded the formation of the ore-bodies, since these exhibit no trace of faulting. The ore-bearing limestone lies on the slope of a short anticlinal fold, but probably extends into the adjoining synclinal, and a decrease of dip may be looked for shortly below the present workings, which reach to fifteen hundred feet below the surface.

The ore, which contains about 25 per cent. of lead and 50 ounces of silver, is smelted at Eureka, and the argentiferous lead produced by the Richmond Company is concentrated and refined on the spot. The concentration process employed is the Luce and Rozan modification of the Pattinson process (Pattinsonizing with steam agitation). So far as I know, these are the only works in the country in which this interesting process is in operation.

The principal mines of the Bodie district, which I visited early in December, 1879, are situated on the crest of a ridge running north and south, forming a spur of the Sierra chain. The mines are sunk on a system of veins cropping out on the crest of this ridge, which seems to be propylite throughout.

At the northern and highest end of the ridge the rock is much decomposed, and the pyritous minerals are converted into gossan. The vein matter is soft, and the gold free, but highly argentiferous, being worth only ten or twelve dollars per ounce. South of the Standard and Bodie mines, at the north end of the spur (the only ones yet on a paying basis), the decomposition has not proceeded so far. At the Noonday the ore carries pyrites, argentite, and antimonial ores of silver as well as gold. The gangue at the Standard appears to be mainly quartz and clay. Farther south calcite appears in connection with the quartz, and at the Noonday is very plenty, though the calcite is often coated with a fine deposit of quartz crystals.

One hears much at Bodie of what is termed "white cap" or "blue cap," extending from the Addenda mine, which is intermediate in position between the Bodie and the Noonday, south. I examined the new shaft of the Addenda mine, which was down some hundred and fifty feet at the time of my visit, and several prospecting shafts between the Addenda and the Noonday, with a view to ascertaining the character of this surface rock. It turned out to be merely partially decomposed porphyry, the iron of which is only protoxidized. The structure of the ordinary country rock is entirely preserved, but the material has become as soft as chalk. The softening seems to take place rapidly on exposure. In places which, as I was informed by the owner, had been hard blasting ground six months previously, and where the remains of drill holes were still visible, I was able to chop the rock to a smooth shining surface with a hatchet. The rock here presented the appearance of having been decomposed from fine cracks toward the centers of the lumps, the kernels growing rounder as they diminished in size. It is possible that the small balls of hard rock, which are frequently found in the clay of the veins, have been formed in this way, though they are not improbably attrition pebbles.

The Standard Company was putting up an amalgamation mill while I was in the district, on the plan in use at Virginia, but with many improvements. It will undoubtedly be the most perfect mill of its kind in the country.

### THE COMSTOCK LODE.

My examination of the Comstock Lode was begun towards the close of the month of April, and has since been much interrupted by the attention necessary to organize a statistical staff under the census, and by the superintendence of the collection of the mineral statistics of the Great Basin and the Pacific slope. It will be some months before the examination of the geology, mineralogy, chemistry, and physics of this supremely important mining* district can be satisfactorily completed, and I therefore desire to state explicitly that the views here expressed are subject to modification, or even reversal, by the results hereafter to be obtained.

The Virginia Range belongs to the system of Great Basin mountains of approximately meridional trend, which has been investigated by the geologists of the Exploration of the Fortieth Parallel. By them it has been shown that this system has resulted from a post-Jurassic disturbance, attended by the phenomena of folding and compression acting horizontally. The system as a whole, and the Virginia Range in particular, has also passed through an era of disturbances in Tertiary and post-Tertiary time, during which the vertical component of the dislocating force was greatly in excess of the horizontal. This disturbance consequently resulted in a great amount of faulting throughout the whole region, but was not attended by compression or folding.

The era of post-Jurassic disturbances was marked at or near the Comstock Lode by the emergence of three massive rocks: granite, diorite, and diabase. During the Tertiary and post-Tertiary no less than eight different volcanic rocks have been ejected. These are propylite, quartz-propylite, hornblende-andesite, dacite, augite-andesite, trachyte, rhyolite, basalt. Of most of these rocks there have probably been a number of eruptions, and of one of them, trachyte, there are two varieties representing separate eruptions, which differ so greatly and constantly from

* Up to January 1, 1880, the Comstock had yielded in twenty years about $325,000,000 worth of bullion. The total length of shafts and galleries is above 250 miles. The number of men employed in the mines in January, 1880, was 2,800, earning average wages of $4 per day. At the same date 340 men were at work in the amalgamating mills.

one another in habitus and composition, not only in this locality, but throughout the Great Basin, as to deserve distinction as old and new trachyte.

Every one of these rocks occurs within a mile and a half of the Comstock Lode, and there is a point, somewhat east of its southern end, from which a circle can be drawn with a radius of one and a quarter miles inclosing occurrences of all eleven of them. Within this insignificant area are found about one-third of the whole known number of well-defined species of massive rocks, and there are probably few localities of the same size in the world which present so great a lithological variety. Taken in connection with the phenomenally rich and extensive vein formation of the Comstock, this complicated occurrence of massive rocks raises the geological interest of the locality to a level with its politico-economical importance.

The duration of the post-Jurassic eruptions we have perhaps no means of measuring. The Tertiary volcanic activity seems to have begun near the dawn of the Tertiary period, since which time solfataric action has probably never ceased, for traces of it are still perceptible, though on a geologically insignificant scale. The whole region has been deluged by the eruptions, and only in one or two spots have small areas of metamorphic rocks been re-exposed by erosion.

It is at the focus of this enormously prolonged volcanic activity that the Comstock Lode has been formed, and perhaps the exceptional scale of the deposit is due to the exceptional length of time during which those surface influences whose tendency is to produce the infinite dissemination of matter have been interfered with by volcanism.

If the great number of eruptions which have taken place at Virginia give the district an extraordinary interest, they increase in an equal degree the difficulty of arriving at true conclusions with respect to its geological history. Let the reader imagine successive eruptions of each of eleven different rocks within a circle of two and a half miles in diameter, in combination with a period of folding, and a second era of faults, and fancy what confusion must have resulted. If it shall prove that I have been able to make any progress toward the elucidation of the mysteries of the district, it is due in an incalculable measure to the fact that I have had before me the discussions of my predecessors, and been able to begin where they left off. The mines have also been developed to a truly astonishing extent. The Yellow Jacket shaft is, with one exception, the deepest in the world; and the total length of shafts and galleries on the lode amounts to several hundred miles. I also have the advantage of current microscopical rock determinations, a check and guide at the command of none of the geologists who have hitherto reported upon the lode.

Thus far I have come upon but one rock until now unknown in the district. This is diabase (augite and plagioclase), which is of course one of the older rocks, and appears to have immediately succeeded the diorite. Its dynamical influence will presently be evident. Augite-andesite, which was detected by the exploration of the fortieth parallel, is found to occupy a much larger area than was supposed, but does not occur in direct contact with the lode.

The Comstock Lode has a nearly north and south strike. For a considerable portion of its length it is in immediate contact with the diorite mass of Mount Davidson on the west, while propylite forms its eastern wall. But about half way between its known extremities the diorite curves westward, while the lode continues its southerly direction between propylite walls. It has an average dip of about forty-three degrees to the east. It has long been supposed that the Comstock was a contact vein between propylite and diorite; but such is not the fact, as can be readily proved by constructing a section of the country from either of the published contour maps. From such a section it appears that the angle between the line of dip of the lode and the very steep face of Mount Davidson is greater than is compatible with the supposition that the former is a continuation of the latter.* On a level with the Sutro tunnel (1,900 feet) enormous masses of diabase have been found on the hanging wall of the vein, and the same rock has been detected at intervals for more than a mile north of this point. The southern portion of the lode has not yet been investigated with a view to the occurrence of this rock, but the number of points at which it has already been met with seems to make it fairly certain that the Comstock fissure was formed, not by the intrusion of the Tertiary volcanic rocks, but in the post-Jurassic era, and shortly after the extrusion of the diorite. Local observations, as well as general considerations, lead to the belief that no great amount of faulting accompanied the intrusion of the diabase, and that solfataric action did not immediately set in; but the line of fissure was determined, a fact which explains the coincidence of the present line of the lode with the projecting mass of Mount Davidson for a certain distance, and its independence of the contact between the propylite and diorite at the point where this contact sweeps to the west around Mount Butler. It is a mere accident that this line of contact happens for a certain distance to coincide with the faulting plane, and were the propylite a few hundred feet deeper, both walls of the Comstock would be propylite throughout their entire length.

The system of fissuring initiated by the diabase in post-Jurassic times has been developed to an enormous extent during the Tertiary and post-Tertiary, during which the dislocating action was, as has been mentioned, more nearly normal than tangential to the earth's surface. The faulting force seems to have acted nearly in the plane of the Comstock fissure. As we proceed either east or west from this plane, parallel fissures are met with for a long distance; but in both directions the evidences of motion decrease in proportion, but not in *direct* proportion, to the distance from the vein. A vast time has undoubtedly elapsed between the earlier and later faulting movements. Here, as elsewhere, it is probable that the earth's crust, once fissured, never regains its coherence, and any fresh disturbance results in a fresh movement on the old planes of fracture.

These planes of fissuring are traceable in the diorite to the west of the vein, as well as in the diabase and propylite on the east wall, and far out into the trachyte at a distance of two miles, as well as in the Comstock lode itself.

It has been supposed that these planes of fissuring indicated a bedded and nearly horizontal flow of diorite and propylite. Under this theory, the elevation of Mount Davidson is accounted for by a folding of the flow-beds. Such an hypothesis appears to me untenable. Not only is it contradicted by the evidence of the whole remarkably uniform geology of the Great Basin, but it is entirely incompatible with the observations made throughout the world on dioritic occurrences, and with many of the phenomena exhibited on the spot. Diorite, so far as is known, is not a rock which ever flows, in the proper sense of the word; that is, it does not

*The Hon. Clarence King informed me privately, and before assigning me to this district, that he had come to the conclusion, from an inspection of the west wall, that the Comstock lode was on a faulting plane. Before having an opportunity of inspecting the west wall myself, I came to the same conclusion on very different grounds.

run or spread out in sheets by its own weight, though, like granite, it has unquestionably been in a plastic condition, and capable of intrusion under heavy pressure into fissures of greater or less magnitude. Both diorite and propylite, had they ever been in a sufficiently fluid condition to be capable of a bedded flow, must have exhibited a more or less rhyolitic structure, if the flows succeeded each other at moderate intervals; or had they been separated by very long periods of time, the partings between the beds would have been marked by detritus. Neither of these indications is found parallel to the fissure planes. Propylite, it is true, occasionally shows a rhyolitic structure for a few inches in thickness, probably from some local modification of its composition; but I have met with no occurrence of this sort where the flow plane was not at a high angle to, and evidently independent of, the fissure system. The parallelism of the faulting action, as already mentioned, also extends into the trachyte, a rock still ejected from some volcanoes; its behavior as an eruptive mass is therefore known from actual observation. Moreover, while the fissure system, as such, shows a remarkable degree of parallelism and regularity, there is no approach to the absolute parallelism observed in stratified rocks or in bedded flows. Only a general regularity, with numerous local inconsistencies, is observable; indeed, the fissures often meet and cross one another. In short, the supposition of a system of faults accords with the nature of the rocks, and with the general geology of the Great Basin, while the hypothesis of bedded flows does neither. As may be supposed, the faulting of the east and west country does not show itself in parallel fissures alone. The friction of the faulted sheets grinding over one another has produced fractures innumerable in all directions, though perhaps mainly at right angles to the fissure system. In this way the rock is so broken up that it is in most places a matter of difficulty to obtain a specimen of an appropriate size for the national collection.

While the principal faulting action has been on lines parallel to the Comstock fissure, there is evidence of a certain amount of motion on planes at right angles to this direction. Such movements have been noticed more particularly in the Sierra Nevada Mine, and indicate a sinking of the country to the north of the lode. Possibly this movement was a consequence of the eruptions of trachyte, which has accumulated in enormous masses in that direction.

The vein matter of the Comstock consists of crushed and decomposed country rock, clay, and quartz. The country rock in and near the vein contains large quantities of pyrite and calcite; gypsum and some other minerals are not uncommon. The quartz is for the most part crushed to a fine mass, which has been compared to that of ordinary commercial salt. A careful examination of every occurrence I have met with shows that this quartz was once crystallized, and has been crushed by the movement of the hanging wall on the foot wall. The particles show crystal faces and fractures; they are also of a glassy sharpness, readily producing painful cuts. That the crystals have not yielded to any internal force is evident from the fact that bunches of crystals are not uncommon, through each individual of which the same crack can be traced, showing a common and an external force.

The force requisite to crush the extensive bodies of quartz to their present sugary condition must have been enormous, but I cannot think it greater than that evinced in the condition of the east country. It is well known to mill men that in spite of the superior hardness of quartz it is one of the easiest rocks to crush in a stamp-battery, because it is far more brittle than even limestone, and the behavior of quartz under the action of blasting-powders is similar. In my opinion, the force which has reduced cubic miles of the volcanic rocks of the east country to fragments which do not average the size of an orange was quite sufficient to crush the quartz as we see it.

The Sutro Tunnel, starting from the Carson Valley, penetrates the east country for a distance of twenty thousand feet, and strikes the lode near the middle of its productive portion, and over nineteen hundred feet below its highest croppings. An admirable section of the country is thus afforded, and it has been carefully studied. The rocks passed through are as follows: For the first ten thousand feet old and new trachyte alternate with augite-andesite; decomposed propylite and hornblende-andesite follow for nine thousand feet; for one thousand feet before the lode is reached the rock is diabase; while beyond the vein the diorite of Mount Davidson is encountered. Thus there have been at least seven eruptions on this line.

The determination of rocks in the Sutro Tunnel and on the lode is a matter of great difficulty. The rocks for two miles east of the Comstock, underground, are in an advanced stage of decomposition, and for the most part the color, structure, and even the form of the original crystals is altered beyond recognition. Numerous microscope-slides of the rocks have been made, but it is the exception when the freshest rocks which can be obtained give satisfactory results. Some of the rocks will probably turn out indeterminable, but every effort is being made to fix beyond question the maximum possible number of occurrences.

The usual processes of decomposition of the mineral constituents of rocks either do not prevail under the peculiar chemical conditions present, or suffer an unusual number of exceptions. Thus I have found demonstrable occurrences of epidote pseudo-morphic after augite, and of undichroitic viridite (green earth?) after hornblende. Such occurrences are not unknown elsewhere, but here they seem common. There are also many transformations which may easily mislead the observer. Pyrite is frequently found surrounding hornblende in such a way as to simulate deceptively the black border characteristic of hornblende-andesite. It can be detected with low powers in strong incident light. Hornblende also sometimes acquires in decomposition an opaque border of a whitish color. With high powers the light color is not perceptible. It is believed too that the real black border of magnetite is not infrequently entirely removed by decomposition.

Thus, while it is impracticable with the rocks from these mines to infer the original minerals from the secondary products, as, *e. g.*, green hornblende from epidote, the permanence even of magnetite cannot be relied upon, while what at first sight appears to be magnetite often proves to be pyrite, or some other secondary product.

It may be mentioned here as a small addition to the knowledge of the volcanic rocks that the propylite from the head of Ophir Ravine, described by Prof. Zirkel as a typical hornblende-propylite, contains minute fluid inclusions, with moving bubbles. These are common in quartz-propylite, but Prof. Zirkel nowhere mentions finding them in hornblende-propylite. Fluid inclusions swarm in the diabase and diorite. In a slide from the diabase in the Sutro Tunnel there are quartzes with far more liquid inclusions than in the quartz of the granite from Clark's Peak, in the North Park, Colorado, which Prof. Zirkel mentions as containing "the largest number of fluid inclusions that any rock constituent has ever been seen to hold." The fluid appears to be carbonic acid. In one of my diorite slides is an admirable hexagonal liquid inclusion in quartz, with a mobile bubble, the movements of which can be followed with a magnifying power of only sixty diameters.

Of the chemical phenomena of the lode it is almost too soon to speak, for there has been no time nor opportunity as yet for analysis or chemical experiments of any sort. An important discovery has been made in the Yellow Jacket shaft, where at a depth of three thousand and sixty-five feet a body of intensely hot water (170° F.) has been struck, which is impregnated with hydrogen sulphide. There can be no chance of mistake here, for the water was under a high pressure, and was encountered at the greatest depth yet reached on the lode. In the Sierra Nevada I also found water running from a diamond drill-hole, which smelt strongly of hydrogen sulphide, but it turned out, on inquiry, that the drill-hole passed near to and was draining an old winze. In this latter case the odoriferous gas was, no doubt, due to the reducing action of the wood-fiber on soluble sulphates. But at the Yellow Jacket no such source of error exists, and it follows as a necessary consequence that the workings have reached the level of solfataric action. This jet is the last remnant of floods of water highly heated, and charged with active chemical reagents, which have poured through the rock for ages or eons. While all rocks, or nearly all, are permeable to water, the Comstock region is exceptionally so, for the faulting action has created capillary fissures everywhere, which no pressure can ever close. I believe it to be the sulphurous water ascending through the rock which has disseminated pyrite through it. That the pyrite is secondary is evident on inspection, for in numberless occurrences it is plain that the pyrite has replaced hornblende to a greater or less extent. This substitution can be followed with ease under the microscope, where all stages between the first attack of the bisilicate and complete pseudomorphs can often be found in the same slide. Highly heated water charged with hydrosulphuric acid will attack ferrous compounds like hornblende, and form pyrite. It will also attack feldspar, forming free silica and alkaline solutions, and it may be that the Comstock has been filled with quartz in this way. Sandberger, too, has shown that the bisilicates are, at least in many cases, the source of our metallic ores. To account for the rise of the waters through the country rock, rather than through the fissures, it is only necessary to suppose the fissure closed on some one straight or sinuous line, a supposition presenting no improbability, but rather great likelihood. The indefiniteness of the east wall of the Comstock in places (for at some points no wall could be better), is also easier of explanation on the supposition that the siliceous solution has entered the fissure through the east wall than on any other theory with which I am acquainted, for under these circumstances a partial disintegration of the east wall would inevitably ensue.

The ore channels of the Comstock lode presented a considerable theoretical difficulty, so long as the Comstock was regarded as a contact deposit; but if a fault has taken place, this difficulty, in a great measure, disappears, for, as is well understood, a vein on a faulted surface not a mathematical plane presents numerous contractions and expansions, allowing a free circulation of liquid currents in some directions and obstructing them in others.

It has been maintained that the Comstock was not a vein at all, but a sort of *Fahlband*, and that the quartz was deposited by substitution for the propylite. I am not able to find evidence for this hypothesis. The fissure, it is true, is largely filled with broken country rock, or "horse," in a highly decomposed condition; but in the interstices, often narrow and vein-like, between these fragments of rock, the quartz frequently shows the comb-structure peculiar to masses of crystals which have separated out upon an unattacked surface. That this structure should always be perceptible is not to be expected, because here, as elsewhere, it is obliterated when the narrow opening is completely filled. Moreover, the masses of horse matter imbedded in quartz ordinarily maintain perfectly sharp, angular outlines; and to this rule I have seen no exceptions unaccompanied by sufficient evidences of motion to account for a departure from a primary form of fracture. But it is well known that wherever any process of solution attacks bodies of angular outline, it is the corners which most rapidly yield, and the kernel of undissolved material approaches more and more to a spheroidal form. A process of substitution, however, is necessarily a process of solution, and the absence of any evidence of this spheroidal development appears to me conclusive against the hypothesis, even were there no chemical difficulties in the way.

One of the most striking characteristics of the Comstock lode, indeed its most obtrusively striking characteristic, is the intense heat which prevails in its lower levels. No mines in the world approach them in the height of the temperature observed, except, perhaps, those of the Sulphur Bank, in California.*

The highest temperature on record in other districts, so far as I know, is 125 degrees, which is given by Mr. J. A. Phillips as that of the water in the Hall Clifford mine. On the twenty-seven-hundred-foot level of the Yellow Jacket, I found water at 153 degrees, and the air and rock at 126 degrees. At the bottom of the Yellow Jacket shaft the water has a temperature of 170 degrees Fahr. At the Forman shaft observations on the temperature have been taken at every hundred feet during the sinking. They show an average increase of one degree for every 34.2 feet. If these temperatures be plotted it will be found that they vibrate about a straight line, representing the rate just mentioned; and the maximum variation from the regular increase is only 4.5 degrees. Considering the irregularities in the nature of the ground which are encountered in sinking a shaft, and the inevitable influence of surface temperature, this variation cannot be considered as extraordinary. For my part, I can see no adequate explanation of the intense heat except that it is a remnant of volcanic action. That the spring at the bottom of the Yellow Jacket shaft is an active solfatara I do not doubt, and I see no reason for seeking a theory to account for it different from that which is universally held in regard to similar occurrences in the immediate neighborhood of active volcanoes. An attempt has been made to account for this heat on the theory that it is produced by the kaolinization of the rock; but there appear to be very valid objections to the acceptance of this hypothesis. It is still uncertain whether kaolin results from the decomposition of triclinic feldspar or not. According to Tschermak's investigations, the decomposition of plagioclase results in the formation of a hydrated aluminium silicate containing a single molecule of water of hydration, and not two, as is the case with kaolin. No experiments have ever been made, so far as I am aware, determining, either directly or inferentially, whether heat is liberated or absorbed by the kaolinization of feldspar. In this process three steps are involved: the dissolution of the mineral into an aluminium silicate and an alkaline silicate; solution of the alkaline silicate, and hydration of the aluminium silicate. Of these three steps it is probable that the first two will absorb heat. It is also probable that the hydration will liberate heat; but whether much or little is unknown. Of the heat of hydration, all we

* The rock at the Sulphur Bank, in California, is a recent basalt, which appears to have partly overflowed the bed of Clear Lake. The mine is almost altogether an open working, and the heat consequently produces none of the technical difficulties experienced on the Comstock.

know is that the different molecules of water in hydrated salts are combined with different degrees of chemical affinity, varying according to an unknown law. The hypothesis also appears to me to prove too much. Countless mines throughout the world have been sunk in feldspathic rocks; yet few of them show any abnormal temperature, and none exhibit phenomena comparable to those of the Comstock lode. I hope to contribute to the elucidation of this question by direct experiment.

With a view to obtaining light on the underground phenomena, I have paid considerable attention to the surface geology of the Washoe district, and shall present a new map of the surface geology on the excellent topography laid down by Lieutenant Wheeler's party. The map published by the Fortieth Parallel Exploration is, of course, correct in its main features; but dacite, not having been established as a rock species at the time of that investigation, is blended with quartz-propylite, and of course the order of succession was not established. It is hoped that the present inquiry may throw light on this subject. It also appears to me desirable to embrace a slightly greater area, and to trace contacts somewhat more in detail than has hitherto been done.

One of the delicate questions that arise in the surface geology of a district like the one under discussion is that of erosion; for the continuity of strata, which, either in its presence or by its absence, is so significant in stratified areas, is here wholly wanting. There is only a single datum which can be relied upon in eruptive regions as affording a sound basis for more or less probable hypothesis and calculation. It is self-evident that *the line of contact between two rocks of different ages was also a line in the surface of the older rock at the time it was covered by the later.* The eruptions in the Washoe district have been so numerous, and the contacts are so many, so long, and so sinuous, as to afford fair hope of furnishing material for an approximate reconstruction of the topography at different eras. But for this purpose they must be laid down in great detail upon the contour map. The evidences of erosion throughout the sedimentary areas of the Great Basin have been clearly read, both qualitatively and quantitively, and it will be interesting to compare the one chain of evidences with the other. That a great amount of erosion has taken place in the Washoe district is evident from a glance at the deeply carved mountains and the precipitous cañons.

The subject of electrical currents discoverable in ore bodies, which was raised by Fox some fifty years since, has been taken up in connection with the investigation of the Comstock lode. Definite results have not as yet been reached, but the experiment will be pursued until the subject can be thoroughly discussed; and a similar series of experiments will be made at Eureka. It is not impossible that owing to the small percentage of metal in the low-grade ores now being extracted from the Comstock, negative conclusions only will be reached at Virginia, while different results may be looked for among the ore bodies of Eureka, which carry about three hundred times as much metal. Should definite laws connecting the occurrences of ores with those of electrical currents be discovered, it is probable that they would be adaptable to the discovery of ore bodies, as well as fertile in scientific interest.

My final report upon the Comstock lode will embrace, besides a discussion of the subjects mentioned and many others, a map of the mines, with all the workings complete up to January 1, 1881, probably on a scale of 100 feet to the inch; a contour map of the surface claims, on a scale of 1,500 feet to the inch; a contour map of the surface geology, on the same scale; an east and west geological section of the country through the Sutro Tunnel; and maps of the underground geology of the mines, embracing three complete horizontal sections of the lode at different levels; six vertical sections, and one longitudinal vertical projection. Much of the mapping is already done, but the whole investigation cannot be completed until the winter.

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

G. F. BECKER,
*Geologist-in-charge.*

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF MINING GEOLOGY,
*Newport, R. I., September* 10, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to transmit herewith a report of the progress of work performed in the laboratory of the United States Geological Survey.

Very respectfully, your obedient servant,

RAPHAEL PUMPELLY,
*Geologist-in-charge*

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF MINING GEOLOGY,
*Newport, R. I., September* 9, 1880.

Prof. RAPHAEL PUMPELLY,
*Chief of Division:*

SIR: In regard to the progress of the chemical work of the United States Geological Survey, Division of Mining Geology, I have the honor to report as follows:

Since the first of October, 1879, the laboratory has been equipped and furnished in the most economical manner compatible with the character of the work required. The mechanical preparation of the samples, including the crushing and grinding of the ores, has been most thoroughly and effectively provided for, and all danger of contaminating one sample by another, or substituting one for another, most carefully guarded against.

The apparatus and contrivances used will be described in detail. For the chemical work everything necessary for rapid and careful analysis has been provided; and, besides the actual number of determinations made, much work for the investigation of and improvement in methods has been carried on, in order that, by close adherence to a high standard, only the most accurate and reliable results may issue from the laboratory. Without counting duplicates, of which a large number have been made, the actual results may be stated as follows:

| | |
|---|---|
| Complete analyses, including separate analyses of insoluble siliceous matter | 29 |
| Containing separate elements determined | 696 |
| Partial analyses, consisting of determinations of various elements in the different samples, from phosphoric acid alone to insoluble siliceous matters, silica, oxide of iron, alumina, manganese, sulphur, phosphoric acid, and titanic acid | 259 |
| Containing separate elements determined | 833 |
| Total number of samples | 288 |
| Total number of elements | 1,529 |

These include some of the samples taken from nearly all portions of the iron field in the United States, including Michigan, Wisconsin, New Jersey, Virginia, North Carolina, Georgia, Alabama, Tennessee, and Missouri.

Very respectfully, your obedient servant,

ANDREW A. BLAIR,
*Geologist and Chemist.*

DEPARTMENT OF THE INTERIOR, CENSUS OFFICE,
No. 155, NEW MONTGOMERY STREET,
*San Francisco, Cal., Sept.* 13, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, San Francisco, Cal.:*

SIR: I have the honor to submit the following report of work done under your direction since the date of my appointment as special agent Census Office, October 1, 1879:

The monograph which I have been instructed to prepare upon the History of the Comstock Lode is not a memoir of merely local importance or interest; it is the record of a struggle which has materially affected the mining interests of the world. It is the story of the birth of the silver-mining industry in this country. It portrays as well the most vigorous growth of that industry. By the contest waged on this lode against the forces of nature, contributions of the first importance to mining science have been made, the foremost practical miners of America have been trained, and more than three hundred millions of silver and gold have been wrested from the earth. Through the contention of its rival locators our national mining legislation was mainly shaped,* and the colossal lottery of mining stock speculation grew out of the opportunities there first offered. From this starting point the silver mines of the great inland territories have been sought out and developed, and no subsequent discoveries can rival the influence of this lode, though they may perchance excel it in richness and magnitude.

The progress of such a struggle cannot be shown by a schedule of results—a chain, so to speak, of statistical tables. Product alone is here a husk, barren of instruction, compared with the true kernel for students, the method of production. An adequate history of the Comstock lode will, therefore, prove a record of action—of a drama of industry enacted in the mountains of Nevada.

In the preparation of this record I have endeavored to make my inquiries and notes as exhaustive as possible. With a few unimportant exceptions, every facility has been offered me for obtaining the most authentic and trustworthy information accessible.

Unusual privileges have been extended to me for consulting the libraries of the pioneer societies of San Francisco, Sacramento, and Virginia City, the State Libraries at Sacramento and Carson City, the Mercantile Library and Mechanics' Institute Library of San Francisco, and, most serviceable of all for my purpose, the private collection of Mr. Hubert H. Bancroft, of this city. I have thus been enabled to examine all catalogued printed material relative to Western Utah and Nevada mines.

The files of the California and Nevada newspapers contain by far the largest store of information, but the work of collation is necessarily slow and laborious. Of the Virginia City Territorial Enterprise, the most important record, only one approximately complete file has been preserved—the property of the Merchants' Exchange of San Francisco, stored with

*Hon. William M. Stewart, "Legislation in 1866."

extreme care in the vaults of the Nevada Bank. I have examined every number of this journal, taking from it all material which I could utilize, and have made equally thorough notes from the Gold Hill News (November, 1863–'77), the Sacramento Union (1853–'70), the San Francisco Evening Bulletin (1858–'64), the San Francisco Daily Alta (1858–'65), with frequent reference to the last three papers mentioned at other periods.

From the California Courier (1849–'51), the Sacramento Transcript, the Placerville Democrat, the San Francisco Herald, the San Francisco Chronicle, and a number of other journals, I have also obtained information of value.

In the investigation of the early locations and titles on the Comstock, and the subsequent litigation, I have consulted the voluminous records in the offices of the county clerk and district recorder at Virginia City, and have used all due care to make citations and references exact and serviceable.

Through the kindness of the managing editors of the leading California and Nevada newspapers I have been enabled to make the most extended inquiries in regard to the discovery of gold and silver in Western Utah and other undetermined points, and have been put in correspondence with pioneers and prospectors from London, Canada, to Portland, Oregon.

In all instances I have taken pains to verify and supplement printed and manuscript data by direct personal inquiries, and desire to acknowledge my particular indebtedness to Hon. William M. Stewart, Mr. John W. Mackay, Mr. Isaac E. James, superintendent Sierra Nevada Mining Company; Mr. Isaac L. Requa, superintendent Chollar Potosi Mining Company; Mr. Phillip Deidesheimer, superintendent Hale & Norcross Mining Company; Mr. Alpheus Bull, Mr. William E. Wright, city editor Territorial Enterprise, and Mr. Almarin B. Paul (a few of those identified with the early and later history of the lode whom I have questioned), for their marked courtesy in communicating all desired information.

The characteristic features of the mining towns on the Comstock lode, and the work carried on above and below ground, have been objects of close personal observation, and I have embraced every opportunity, as well of studying the home life, habits, and modes of thought of the miners and prospectors of Nevada.

In order to familiarize myself with the topography of the region, I have traveled on horseback and on foot over many sections of the Virginia range, and have ridden from Pyramid Lake through the valley of the Carson and its adjacent ravines, over the Sierras, following the old emigrant trail, to Sacramento. In the course of this journey I was enabled to collect such complete records from the books of the toll-stations at different points that an approximately exact estimate can be formed from them, in connection with supplementary data obtained from forwarding agents, of the amount of freight transported across the Sierras to the Comstock mining district, and the cost of building up a mining city in a barren mountain range.

During the first eight months of this investigation my work has necessarily been mainly one of inquiry, collection, and arrangement for use. In June last I began to write the memoir which I have planned. This work was temporarily suspended, however, in July by the requirements of the new charge of directly supervising the collection of certain of the statistics of the mining districts of the Pacific Coast, with which I was intrusted by your assignment.

Upon the completion of this collection I shall be enabled to prepare my report upon the history of the Comstock lode and the discovery of gold and silver in Western Utah, and to submit it for approval within an estimated period of four months.

Very respectfully, your obedient servant,

ELIOT LORD,
*Special Agent Census.*

No. 1910 ARCH STREET,
*Philadelphia, September* 14, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to present a brief report of the work assigned to me by you, in connection with the United States Geological Survey under your direction, for the fiscal year ending June 30, 1880.

In accordance with your instructions, I commenced a systematic digest of the results of the field-work and of the geological reports which had been prepared by me or under my direction for several years past, to be included in one volume.

The area proposed to be considered in this report embraced that portion of the Rocky Mountain region of the United States that lies north of New Mexico and west of the 94th meridian.

A limited classification of the work into divisions may be made, as follows:

1. A historical account of the labors of preceding explorers and geologists in the same field.
2. The general geographical features of the entire area.
3. The stratigraphical geology in detail, or the historical succession of the various formations, with a summary of the general geological features of the entire area.
4. The metamorphic and igneous rocks of the area.

These divisions will, of course, appear in sections or chapters, and may be modified or changed as the conditions may require.

On all these subjects more or less material has been collected and a mass of notes taken, which will be useful. Some of the more difficult problems in western geology, about which there have been, and are now, differences of opinion among geologists, have been considered with some care. The Laramie Group, with the overlying Tertiary deposits, has been studied so far as the time would permit.

I regret that I cannot present a more detailed report, and would not have any portion printed in a fragmentary or incomplete condition at the present time.

During much of the early portion of the fiscal year my health was in such a condition that but little work could be done, but it is now entirely restored.

Trusting that the above statement may be sufficient for your present purposes, I beg to remain,

Respectfully, your obedient servant,

F. V. HAYDEN, *Geologist.*

SAN FRANCISCO, *October* 1, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to submit the following notes upon the volume on "The Mechanical Appliances used in Mining and Milling on the Comstock Lode," which I am engaged in preparing under your direction.

The results of my work will consist of a volume of text and an accompanying atlas. In order to convey a correct conception of the magnitude of the Comstock machinery, it is necessary to illustrate the text by full and accurate drawings of the appliances as constructed, showing whole machines and the various important parts.

It is designed that this work shall present to the general mining world an insight into the magnitude, cost, and extent of such machinery as is now to be found in use nowhere in the world except on that great and deeply-explored lode, the Comstock.

Useful and desirable as such an exposition of the design and scale of existing machines may be, it still leaves an important and greatly desired object unaccomplished; for in all mechanical appliances, for whatever purposes they are used, their design and construction is undertaken to accomplish a certain end with the least expenditure of capital possible; and it therefore becomes necessary to determine by experimental tests, and to set forth by calculations, the excellence and efficiency of all such appliances as they are found in actual use.

Such experimental determinations, coupled with drawings and descriptions, will give to the people of the United States information as valuable as it has been difficult heretofore to obtain, enabling engineers to decide the losses due to the conversion of heat, motion, and force into work, and the extent to which such mining appliances are desirable in mining pursuits, where the capital to be expended is a known quantity.

For these and other considerations, therefore, the work is divided into two distinct parts; the first giving accurate drawings and descriptions of all the appliances now in successful operation at the various mines and mills on the Comstock. Among the chief features of this division will be large, double-plate atlas drawings of the principal hoisting-works, such as the Forman shaft, Yellow Jacket hoisting-works, Chollar, Norcross, and Savage combination shaft, and the Mexican, Union, and Sierra Nevada shaft.

The various styles of wood-framing used for shafts, gallows frames, and buildings will be included; also such minor appliances as the miner's pick and shovel, cars, cages, skeets, water or bailing tanks, chairs, sheaves, giraffes, and underground winze engines, as well as other appliances for underground hoisting, sinking, pumping, and ventilation.

The text will be liberally illustrated by page plates of all details requiring a larger scale than the general plates.

Nowhere in the mining world are there published records of pumping engines handling over 3,000 feet of vertical pump-rods and pumps, as can be seen daily at work at the Yellow Jacket shaft; while at the Mexican, Union, and California and Consolidated are to be found hoisting-engines whose piston speed is 1,400 feet per minute while extracting ore; a speed which, if ever equaled under like circumstances, has never been exceeded.

In the department of the reduction of ores, I shall present an exposition of the California battery and pan mills, giving full drawings of the machinery and framing as a whole, with details of all the important parts, such as mortars, cams, stamps, pans, settlers, agitators, quicksilver system, &c.

With these will be given cuts and descriptions of the machinery furnishing and developing the necessary power for driving the mill machinery.

The second part of the report, but first in importance in an engineering and mining point of view, will detail the result of my experimental determinations of the work accomplished by the various appliances in use, so far as it is possible to determine it.

These results, when discussed and arranged, will form a sound basis from which engineers and mining men may understand the limit of their expectations in the mechanical and practical accomplishment of the large mining undertakings. They will be able to foresee the results of proposed mechanical methods, without waiting for the results of unprofitable expenditure or wasted capital.

The result of careful scientific determinations of the comparative efficiency of the woods used in mines and hoisting works will be presented, both as burned under boilers in use and from a chemical determination of the composition of the fuels, so that comparative results of the value of experiments may be made, when desired, with the same machinery, in other parts of the world.

A very large number of indicator and chronograph cards have been taken from machines, the diagrams of which will be embodied in the work, showing the velocity, power, and efficiency of the pumping and hoisting machinery, and the quantities of fuel necessary to produce the various results of hoisting ore and pumping water from the lower levels by surface engines; also by the use of compressed air and steam in the pumps used in the inclines and winzes underground. The power and efficiency of the different air compressors and machines using compressed air has been and will be determined whenever possible, and the results relating thereto discussed and illustrated.

In order to carry on these experiments, and to eliminate, as far as possible, all errors of mechanism, the instruments, indicators, chronographs, thermometers, electrical apparatus, &c., used in these mechanical investigations have been contrived and constructed with great care by the most experienced mechanical instrument-makers in Europe and the United States.

Having thus combined in one volume the design, construction, use, and efficiency of the mechanical appliances for the mining and milling of the precious metals of the Comstock lode, I believe that the results accomplished by the present machinery, as set forth, will indicate the proper road to be followed in the design and construction of machinery, and in the proper application of the laws of dynamics and thermodynamics, so that the point of maximum efficiency, to which all like appliances can be made to approach, may finally be reached.

Very respectfully, your obedient servant,

W. R. ECKART, *Civil Engineer.*

## MINERAL STATISTICS.

Foremost among all nations in the production of the precious metals, ranking first in resources of petroleum, coal, and iron, and abundantly endowed with nearly every mineral substance demanded by the civilized arts and sciences, the United States has conspicuously failed to gather and publish systematic statistical knowledge of the yearly mineral productions.

With the present rapid growth of industrial enterprise, with the complete interdependence of the arts, the least possible contribution to be made by the Federal Government should be a lucid, correct report of the production in each branch of mineral industry. Yet, legislators, econ omists, capitalists, and intelligent artisans are driven to scattered newspaper statements and the occasional disconnected publication of Federal and State governments for information which should be within the reach of all.

Important as a statistical and technical knowledge of crops is to the practice of agriculture and the disposition of its products, it is even more so in the department of mineral industry, since the mechanical arts in a multitude of instances depend on an artificial association of mineral productions from widely separated regions.

The accurate knowledge of the mineral resources of a given State by its manufacturers is not enough to foster successful industry. For the safe and profitable conduct of business, a knowledge of operations in other and the most distant States is often vitally necessary. For instance, the great iron industry of Michigan and Wisconsin depends largely on the utilization of its ores in distant States, in combination with ores of other States and the coal and flux of still others.

Silver ores, valueless from their rebellious nature at the mines which yield them, are transported into neighboring States, there mixed with others of differing chemical constituents, and profitably worked. Close the few quicksilver mines of California, and you close a greater number of gold mines in Georgia. Not to multiply illustrations, every master of the mechanical arts, every intelligent manufacturer, requires, either for the construction of his plant or the prosecution of his industry, a knowledge of the mineral resources not only of his immediate region, but of distant States.

It is estimated that the mere raw products of the mineral industries do not fall far short of four hundred millions of dollars annually, and it requires no gift of extraordinary foresight to reach the conclusion that a few years will bring the yield to a thousand millions.

Until Congress extends the field of the geological survey over the region east of the 100th meridian, this bureau will confine its own operations in the department of mineral statistics to the industries of the far west. For the present year, however, with the approval of the Secretary of the Interior, the geological survey has been intrusted by the Superintendent of the Census with the collecting of the statistics of the precious metals, iron, coal, petroleum, copper, lead, quicksilver, and zinc for the census. In order to conform to the requirements of laws governing the census and the survey, the Geological Director and several of the corps of geologists have been constituted special agents of the census, without pay from the census appropriation; and in addition to this small staff, experts, duly appointed by the Superintendent of the Census, have been detailed from the Census Bureau and ordered to report to the Geological Director.

By this combination of the forces afforded by the census with the survey, the director is able to make a thorough beginning, and will furnish the Census Bureau and Congress with a thorough exposition of the production of the metals, coal, and petroleum, the most important branches of the mineral industry. In this combined labor care has been exercised that only census employés should be detailed to work in the region east of the 100th meridian.

In the disposition of this force of experts, the region east of the 100th meridian has been placed under the charge of Prof. R. Pumpelly, who has personally directed the operation of gathering the statistics from his office at Newport, R. I., where he has remained in charge of the laboratory of the Geological Survey. The work in Montana, Dakota, Wyoming, Colorado, and New Mexico has been given to S. F. Emmons, geologist-in-charge, to be directed from his office in Denver. To George F. Becker, geologist-in-charge, were allotted the States and Territories of California, Oregon, Washington, Idaho, Nevada, Utah, and Arizona.

In order to successfully conduct so complex an investigation as the production and economies of the mineral industry, an elaborate series of schedules were framed during the past winter and put in print.

The scope of these codes of inquiry has been not merely an accumulation of data as to the output by weight and value of the mineral products, but it involves a deep analysis into the methods and economies of the successive steps of the industry.

It is proposed to arrive at a close approximation to the capital embarked and the money value of the plant now in use, to trace the cost of each process, to present a review and discussion of wages, and to state correctly the consumption of labor, power, and material; or, in other words, to give the aggregate cost of the various productions.

The technical schedules which form the basis of this inquiry relate to the following subjects: Metallic mines, coal mines, petroleum, charcoal-burning, hydraulic gold mines, hydraulic ditches, ore-dressing works, amalgamating mills, stamp batteries, pan amalgamation, roasting furnaces in amalgamating works, alternate amalgamation and concentration of battery sands, alternate concentration and amalgamation of battery-sands, arrastras, smelting works, preliminary operations for the same, smelting in shaft furnaces, smelting in reverberatory furnaces, desilverization by zinc, Pattinsonizing, improving of lead, cupellation, quicksilver reduction in general, quicksilver reduction in furnaces, quicksilver reduction in retorts, and quicksilver condensers.

Beside this, over the eastern half of the United States, where the work is wholly conducted from the funds of the census, the following mineral substances of commercial value are being investigated with a view to present a full report of the statistics of production and the technical methods of obtaining the commercial products:

Apatite,
Asbestos,
Arsenic,
Antimony,
Cobalt,
Copper,
Corundum and emery,
Cements (hydraulic),
Fluor spar,
Feldspar (for potash),
Gold,
Grahamite,
Graphite,
Gypsum and plaster,
Grindstones, millstones, hone-stones (novaculite, &c.),
Glass sand,
Green sand,
Infusorial earth,
Iron ores,
Iron pyrites,
Kaolin,
Lead,
Lithium,
Buhrstones,
Borax,
Bismuth,
Chrome,
Manganese,
Mica,
Molybdenum,
Mercury,
Niter,
Nickel,
Peat,
Quartz,
Roofing slates,
Serpentine,
Slate,
Silver,
Slate pencils,
Soapstone (steatite),
Soda,
Talc,
Tin,
Tungsten,
Zinc.

Upon each schedule is printed an extract from the census act of March 3, 1879, covering sections 14 and 15, and a notice that all the answers to the inquiries propounded by the schedule will be confidential as to each separate manufacturing or mining establishment.

The experts into whose hands the schedules have been placed for field work have been instructed to assure all producers of the confidential nature of the information given, so far as individual establishments are concerned. They are instructed to assure all mineral proprietors that the items of the schedules will only be used in preparing aggregates and averages for States, Territories, and counties, and for the discussion of purely technical results; but that in no case will such presentation of material be made as would expose the private business of any concern.

Under this assurance there have been almost no refusals to give the desired information. The schedules are being rapidly filled, and a mass of material is being accumulated which will enable the survey during the coming winter to produce a valuable statistical volume, which should furnish full and elaborate data for the discussion of nearly all the mechanical and technical stages of the processes which are employed in the industries of the metals.

While the schedules are, in general, amply full to cover all the essential details of the industries, the experts have been instructed to report any technical local peculiarities, and any interesting features in the geology or exploitation of mines; and all are required to return specimens, of a uniform size, of the ores and inclosing rocks of every mineral deposit visited. These specimens, carefully labeled, will amount to many thousands, and will form the most important economical feature yet added to the mineral department of the National Museum.

With the money and force at command, it is hardly to be expected that this first gathering of the statistics of the mineral industries should be either perfect or exhaustive, but enough results are now in hand to clearly prove that for general accuracy and for technical fullness the present investigation has never been approached. By the first of next January the full investigation will have closed, and it is hoped that the early spring will find the consolidated results ready for discussion and publication.

Beside the material to be furnished by the technical schedules, it is designed to present an account of the methods of discovery of precious metal deposits, the various legal aspects of their ownership, and a review of the chief features which characterize Western mining civilization.

The leading outlines of the various subsidiary industries which depend upon mining industry will be described; and, in general, the business methods by which mining towns grow up and are sustained.

The following is a list of the special experts employed in this joint labor of the two bureaus, with their assignment to the special agents in charge of the three territorial divisions into which the United States has been, for the convenience of this special work, divided.

*List of census appointments.*

| No. | Name. | Occupation. | Date of appointment. | Remarks. |
|---|---|---|---|---|
| 1 | King, Clarence | Expert special agent | July 1, 1879 | |
| 2 | Willis, Baily | Special agent | July 10, 1879 | Promoted July 1, 1880. |
| 3 | Leffingwell, Wm. H | Special agent | July 17, 1879 | Resigned. |
| 4 | Wheeler, O. D | Disbursing clerk | July 18, 1879 | |
| 5 | Pumpelly, Raphael | Expert special agent | Sept. 2, 1879 | |
| 6 | Blair, Andrew A | Disbursing agent | Sept. 2, 1879 | |
| 7 | Hoffman, Chas. F | Special agent | Sept. 29, 1879 | |
| 8 | Lord, Eliot | Special agent | Sept. 29, 1879 | |
| 9 | Becker, Geo. F | Special agent | Mar. 6, 1880 | |
| 10 | Emmons, Saml. F | Special agent | Mar. 6, 1880 | |
| 11 | Rogers, Alfred M | Special disbursing agent | Mar. 27, 1880 | |

*List of census appointments*—Continued.

| No. | Name. | Occupation. | Date of appointment. | Remarks. |
|---|---|---|---|---|
| 12 | Johnson, Chas. F | Expert special agent | Aug. 1, 1879 | With Prof. Pumpelly. |
| 13 | Brooks, Thomas B | Expert special agent | Aug. 1, 1879 | Resigned March 30, 1880. |
| 14 | Putnam, Bayard T | Expert special agent | Oct. 11, 1879 | Promoted July 15, 1880. |
| 15 | Gooch, F. A | Expert special agent | Oct. 23, 1879 | Promoted July 1, 1880. |
| 16 | McKinlay, Robt | Expert special agent | Sept. 10, 1879 | |
| 17 | Fay, Geo. A | Expert special agent | Nov. 21, 1879 | Promoted July 1, 1880. |
| 18 | Benton, E. R | Expert special agent | Feb. 27, 1880 | |
| 19 | Chauvenet, Wm. M | Expert special agent | Oct. 23, 1879 | |
| 20 | De Blois, N. James | Clerk | Jan. 7, 1880 | |
| 21 | Kensett, Jas. W | Clerk | Mar. 2, 1880 | |
| 22 | Smith, Chas. E | Clerk | Oct. 20, 1879 | |
| 23 | Ohm, Herman | Expert special agent | Feb. 27, 1880 | Promoted July 1, 1880. |
| 24 | Dawley, Wm. P | Clerk | Jan. 7, 1880 | Promoted July 1, 1880. |
| 25 | Craig, James | Janitor | Oct. 20, 1879 | |
| 26 | Alsop, Edward B | Expert special agent | May 24, 1880 | |
| 27 | Smock, Jno. C | Expert special agent | May 24, 1880 | |
| 28 | Hall, L. B | Expert special agent | June 2, 1880 | |
| 29 | Allen, Chas | Expert special agent | June 2, 1880 | |
| 30 | Fellows, W. A | Expert special agent | June 2, 1880 | |
| 31 | Lander, Wm | Expert special agent | June 2, 1880 | |
| 32 | Hotchkiss, Jed | Expert special agent | June 2, 1880 | |
| 33 | Orton, Edward | Expert special agent | June 2, 1880 | |
| 34 | Benson, Ira F | Expert special agent | June 2, 1880 | |
| 35 | Potter, W. B | Expert special agent | June 2, 1880 | |
| 36 | Chamberlain, T. C | Expert special agent | June 2, 1880 | |
| 37 | Fulton, John | Expert special agent | June 2, 1880 | |
| 38 | Little, George | Expert special agent | June 2, 1880 | With Prof. Pumpelly |
| 39 | Cantrell, Jas. G | Expert special agent | June 2, 1880 | |
| 40 | Proctor, Jno. R | Expert special agent | June 2, 1880 | |
| 41 | Bennett, Ensign | Expert special agent | June 2, 1880 | |
| 42 | Wilber, Francis A | Expert special agent | June 12, 1880 | |
| 43 | Nicholson, Frank | Expert special agent | June 14, 1880 | |
| 44 | McKee, David | Expert special agent | June 14, 1880 | |
| 45 | Comstock, Wm. O | Expert special agent | June 14, 1880 | |
| 46 | Harper, Jas. P | Expert special agent | June 15, 1880 | |
| 47 | Gregg, John C | Expert special agent | June 15, 1880 | |
| 48 | Haile, C., jr | Expert special agent | June 18, 1880 | |
| 49 | Wilson, Jas., jr | Expert special agent | June 26, 1880 | |
| 50 | Irving, Roland D | Expert special agent | July 3, 1880 | |
| 51 | King, Chas. F | Expert special agent | July 12, 1880 | |
| 52 | Finley, C. B | Expert special agent | July 13, 1880 | |
| 53 | Day, Wm. C | Expert special agent | July 14, 1880 | |
| 54 | Roy, Andrew | Expert special agent | July 13, 1880 | |
| 55 | White, Jno. F. | Expert special agent | July 13, 1880 | |
| 56 | Eldredge, Geo. H | Expert special agent | July 15, 1880 | |
| 57 | Dale, T. Nelson | Expert special agent | July 20, 1880 | |
| 58 | Haller, Saml. F | Expert special agent | July 22, 1880 | |
| 59 | Phillips, Henry A | Expert special agent | July 24, 1880 | |
| 60 | Wilson, Jos. M | Expert special agent | Aug. 11, 1880 | |
| 61 | Smith, Oscar E | Clerk | Aug. 13, 1880 | |
| 62 | Shaler, N. S | Expert special agent | Aug. 18, 1880 | |
| 63 | Campbell, A. C | Expert special agent | Aug. 30, 1880 | |
| 64 | Potter, Charles | Expert special agent | May 31, 1880 | With Mr. Emmons. |
| 65 | Harrison, R. B | Expert special agent | May 31, 1880 | Resigned July 31, 1880. |
| 66 | Curtis, Jos. H | Expert special agent | May 31, 1880 | |
| 67 | Cunningham, Jno. M | Expert special agent | May 31, 1880 | |
| 68 | Hammond, Jno. H | Expert special agent | May 31, 1880 | With Mr. Becker. |
| 69 | Huntley, Dwight B | Expert special agent | May 31, 1880 | |
| 70 | Williams, Albert, jr | Expert special agent | May 31, 1880 | |
| 71 | Nordhoff, Walter | Expert special agent | May 31, 1880 | With Mr. Emmons. |
| 72 | Sharp, Wm | Expert special agent | May 31, 1880 | With Mr. Becker. |
| 73 | Leavens, Henry W | Expert special agent | May 31, 1880 | Resigned August 10, 1880 |
| 74 | Atkinson, Stephen E | Expert special agent | June 23, 1880 | |
| 75 | Schaeffle, E. H | Expert special agent | June 23, 1880 | With Mr. Emmons. |
| 76 | Fisher, Wm. B | Expert special agent | June 30, 1880 | |
| 77 | Noyes, Theodore W | Expert special agent | July 13, 1880 | |
| 78 | Herdman, John E | Expert special agent | July 13, 1880 | With Prof. Pumpelly. |
| 79 | Fawcett, W. L | Expert special agent | July 14, 1880 | |
| 80 | Brown, Jos. G | Expert special agent | July 15, 1880 | With Mr. Emmons. |
| 81 | Foster, Wm | Expert special agent | July 24, 1880 | |
| 82 | MacArthur, G. P | Expert special agent | July 30, 1880 | |
| 83 | Wilson, Chas. F | Expert special agent | Aug. 3, 1880 | |
| 84 | Braden, Spruille | Expert special agent | Aug. 3, 1880 | |
| 85 | Paul, A. R., jr | Expert special agent | Aug. 16, 1880 | Experts for special statistics under direction of Eliot Lord. |
| 86 | Holland, Wm. A | Expert special agent | Aug. 16, 1880 | |
| 87 | Shrader, M. D | Expert special agent | Aug. 16, 1880 | |
| 88 | O'Connell, Daniel A | Expert special agent | Aug. 16, 1880 | |
| 89 | Walton, Chas. S | Expert special agent | Aug. 16, 1880 | |
| 90 | Thompson, Percy | Expert special agent | Aug 16, 1880 | |

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF MINING GEOLOGY,
*Newport, R. I., September* 10, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: Immediately after my appointment in July of last year, I proceeded to organize the work of the division intrusted to my charge, both for the work of the survey (proper) and for the collection of the statistics of mines and mining east of the Mississippi River.

Owing to the necessity of doing continuous work for the whole year for the census, Newport was selected as a point at which the work could be carried on without the necessity of long summer vacations, and the fact that there already existed at that point several government offices.

I was instructed to gather the statistics of the non-precious metals and of coal.

For this purpose the organization of the *personnel* was made after much careful consultation with the best informed people in the different States. In some States it was found desirable to select our agents from the State geological surveys; in other States among the corps of inspectors of mines or mining engineers, and in all cases taking those persons who were represented by trustworthy authority as being the best fitted for the purpose; and the results have proved the wisdom of the selection. The agents thus appointed, and their assistants, hold office only during the time necessary to complete the statistical work of the mining regions assigned to them.

The organization of this part of our corps is the following:

| Name. | State. | Appointment applied for. | Salary. |
|---|---|---|---|
| Edward B. Alsop | Pennsylvania | May 21 | $5 00 per diem. |
| Prof. Jno. C. Smock | New Jersey | May 21 | 5 00 per diem. |
| Ensign Bennett | Indiana | May 25 | 5 00 per diem. |
| Prof. Edward Orton | Ohio | May 25 | 6 00 per diem. |
| Prof. W. B. Potter | Missouri | May 25 | 5 00 per diem. |
| Prof. T. C. Chamberlin | Wisconsin | May 25 | 5 00 per diem |
| John Fulton | Pennsylvania | May 25 | 5 00 per diem. |
| W. A. Fellows | Pennsylvania | May 25 | 4 00 per diem. |
| Chas. Allen | Pennsylvania | May 25 | 5 00 per diem. |
| L. B. Hall | Maryland | May 25 | 5 00 per diem. |
| Jed Hotchkiss | Virginia | May 25 | 5 00 per diem. |
| W. C. Kerr | North Carolina | May 25 | 5 00 per diem. |
| Dr. Geo. Little | Georgia | May 25 | 5 00 per diem. |
| Prof. Eugene A. Smith | Alabama | May 25 | 5 00 per diem. |
| James G. Cantrell | Tennessee | May 25 | 5 00 per diem. |
| Jno. R. Procter | Kentucky | May 25 | 5 00 per diem. |
| Prof. A. G. Wetherby | Ohio | June 7 | 4 00 per diem. |
| Prof. N. W. Lord | Ohio | June 7 | 2 00 per diem. |
| Edward Hyatt | Ohio | June 7 | 2 00 per diem. |
| Edward Orton, jr | Ohio | June 7 | 2 00 per diem. |
| Francis A. Wilber | New Jersey | June 10 | 4 00 per diem. |
| David McKee | Missouri | June 12 | 3 00 per diem. |
| Wm. O. Comstock | Missouri | June 12 | 3 00 per diem. |
| Frank Nicholson | Missouri | June 12 | 3 00 per diem. |
| James P. Harper | Indiana | June 12 | 4 00 per diem. |
| John C. Gregg | Indiana | June 12 | 4 00 per diem. |
| C. Haile, jr | Virginia | June 17 | 1 00 per diem. |
| James Wilson, jr | Wisconsin | June 23 | 4 00 per diem. |
| Prof. Roland D. Irving | Wisconsin | June 28 | 6 00 per diem. |
| Andrew Roy | Ohio | July 2 | 4 00 per diem. |
| C. B. Finley | Pennsylvania | July 10 | 5 00 per diem. |
| Wm. C. Day | Maryland | July 10 | 3 00 per diem. |
| Henry A. Phillips | Pennsylvania | July 21 | 2 50 per diem. |
| Saml. M. Haller | Maryland | July 20 | 3 00 per diem. |
| Geo. H. Eldridge | Massachusetts | July 14 | 90 00 per mo. |
| A. C. Campbell | Tennessee | Aug. 2 | 4 00 per diem. |
| N. S. Shaler | Massachusetts | Aug. 15 | 5 00 per diem. |
| Jos. M. Wilson | Massachusetts | Aug. 9 | 4 00 per diem. |
| Wm. L. Fawcett | Illinois | July 12 | 5 00 per diem. |

For the purpose of gathering these statistics, we have adopted separate schedules for each of the mining industries, containing questions covering the total product of the production of the mine during the census year; its value, amount of invested capital, the consumption of labor, materials and power used in obtaining the product, and a large number of questions intended to throw light on the methods employed in the industry; and upon the condition of these industries as to mechanical contrivances; and upon the social and vital statistics of the mining communities. Besides these there are numerous questions which are to furnish material for discussions of the subjects which come properly under the province of this office. Our schedules contain also questions gathered for the benefit of the agents in charge of fire insurance, life insurance, and of forestry.

Among the special lines of inquiry which we are following is the study of the dynamic statistics in the mining industry, which I have intrusted to Mr. Charles F. Johnson.

These documents were distributed as prior schedules by the agents among the mines in each State. These, when returned properly filled in, were forwarded by the agents, directed to this office. When incorrect, they were returned to the mine, and after lapse of a sufficient time the whole State was traversed by the agents to fill in the schedules at the delinquent mines, and this has been found necessary in a large majority of cases.

The work of gathering the statistics proper is fast approaching completion; the principal States—Ohio, Indiana, Pennsylvania, &c.—having only a few counties to hear from.

Besides the schedules, the agents are supplied with note-books containing questions relating to the general industry, and to the social and vital statistics of mining communities; these note-books will be filled out by those best informed in each district, and will be used as aids in the discussion of the statistics.

As the schedules arrive at this office, they are tabulated in full, and a register will be opened to record every mine and locality of mining industry in the country; this will form the basis for the mineral register that is to be a feature of the Geological Survey.

One of the objects of transferring the gathering of the statistics of mines from the ordinary enumerators to the Geological Survey was the possibility of thus having them gathered and discussed by experts; for this purpose each mining industry will be studied as to the distribution of the raw material, whether developed or not, and statistically as to the condition of its development during the census year, and in its relations to other industries.

In this investigation it was thought best to concentrate our energies upon a study of the iron ores of the country, as being the direction in which we could be of the greatest service.

The rapid development of iron manufacture during the past ten years called into existence a vast number of mines producing ores of the most varied characters.

While many of the older of these are mentioned in the reports of the various State geological surveys, by far the greater number are known only to local consumers.

The great revolution caused in the iron manufacture by the new steel-making processes has rendered the knowledge of the chemical composition of the iron ores one of the very greatest importance.

And while the character of the ores of each group of mines was known to one or two consumers, there was no way by which this knowledge could be made useful to the whole manufacturing industry.

The importance to the whole country of an accurate study of this subject, and of the wide spread diffusion of the results obtained, is the justification of the extensive investigation which has been taken in this direction.

It was decided to make an exhaustive chemical study of all the iron ores in the United States.

The chemistry of this work was intrusted to Mr. Andrew A. Blair, formerly in the Missouri geological survey (as chemist for the iron ores), and later in the very important board appointed to test iron, steel, and other metals.

To obtain the material for this study, it was necessary that every mine, or group of mines, should be visited by an expert, and this work was intrusted to four members of the survey—Mr. Bayard T. Putnam, Mr. Bailey Willis, Mr. William M. Chauvenet, and Mr. E. R. Benton.

At each mine, the ore, as prepared for market, was sampled in a uniform manner, by taking many hundreds or thousands of chippings to insure an average sample. Wherever the mine contained varieties of ore sufficiently abundant to justify their separation, if desirable, into different classes, each variety was sampled separately, to show its influence upon the chemical character of the whole output.

The sampler entered in his special note-book a record of each sample, showing its locality, its position in the mine, and, where desirable, a sketch of the mine, and the relation of the mine to routes of transportation, and such other information as may be of interest in connection with the sample taken.

The samples have their full history and significance thus recorded in these note-books. They are then forwarded by mail in franked packages to this office, where we are provided with every convenience for preparing them for analysis and for their chemical study.

The samples have already been collected in the States of Michigan, Wisconsin, Missouri, Kentucky, Tennessee, Alabama, Georgia, South Carolina, North Carolina, Virginia, New Jersey, and Eastern New York; while Ohio, Pennsylvania, West Virginia, Maryland, Western New York, and the few localities in the Northeastern States will soon be finished.

There have been thus gathered over one thousand samples, each weighing from ten to twenty pounds. Of each finely powdered sample there is retained a considerable amount for future reference, and should it be found, at any future time, that any substance exerts an influence now unsuspected upon the qualities of the iron or steel, it will be possible to easily determine that substance if present in all of our samples, and interpolate the result into the analysis now being made.

Full sets of these samples will be preserved in the office of the Survey, in the National Museum, and in the Museum of Natural History in New York.

Accompanying each sample, there are hand specimens illustrating each variety represented in the sample, and, independently of these, triplicate sets of specimens of these have been collected, illustrating the ores and the associated rocks in each mining district for the collection in the National Museum. Besides the chemical study of the ores, there will be a microscopic study which will be extremely interesting, as it will be made parallel with the chemical study of the same samples.

We have already about fifteen hundred specimens illustrating the samples and the triplicate set of ores and rocks for the National Museum.

In the work of the Geological Survey (proper), Professor Roland D. Irving has been employed in tracing a continuation of the copper-bearing rocks of Michigan and Wisconsin through Northeast Minnesota to the British boundary. This formation, which produced so large a proportion of the world's product of copper, has been studied on the American side, both by the Michigan and Wisconsin geological surveys, and on the north shore by the geological survey of Canada.

It was thought very desirable to trace this formation through the little-studied region of Minnesota to a point where the results obtained by the American geological surveys could be compared intelligently with those of the Canada survey.

Another party is studying the distribution of iron ore in Northern Minnesota; and during the autumn of 1879, and the succeeding winter, a party was employed in making the necessary geological and magnetic observations to trace the connection between the iron-bearing formations of the Marquette district in Michigan and the new iron fields on the Menominee River, and also in tracing, by means of the magnetometer, the continuation of the Menominee iron-ore range eastward, under the overlying strata of the Silurian sandstones and limestones.

Very respectfully, your obedient servant,

RAPHAEL PUMPELLY,
*Geologist in Charge.*

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF THE ROCKY MOUNTAINS,
*Denver, Colo., October* 10, 1880.

Hon. CLARENCE KING,
*Director United States Geological Survey, Washington, D. C.:*

SIR: I have the honor to present the following report of the census work under my charge during the current year.

On assuming charge of this division of the United States Geological Survey, the following formed part of the instructions transmitted to me by you for the conduct of my work:

"Personally you will confine your investigations, till further orders, to the metallic minerals of Colorado, their geological connection, mode of occurrence, and association. District by district you will acquaint yourself with the minutest features of lodes, with the legal aspect of mining, and you will prepare to furnish for the year 1880 such statistical tables as may be necessary to show, as far as practicable, the gross and net product of each mine, district, and region, summing up in one general table the entire precious-metal product of Colorado. As far as possible you will check mine, mill, and furnace returns by the receipts of the various transportation companies, and in general trace the metal into actual market. In the case of base bullion, refining returns should be obtained if the process is completed in America; if not, note to that effect should be made."

For various reasons, but little had been accomplished in collecting the statistical information indicated above, when, being summoned by you to Washington, in January of the current year, together with Mr. Becker, you informed us that, having assumed charge of the collection of mining statistics for the Tenth Census, under General F. A. Walker, over the entire region west of the Missouri, you should place the practical direction and management of this collection in the hands of Mr. Becker and myself for the States and Territories included in our respective divisions, and directed us to prepare a system for obtaining the desired information, by means of suitable schedules, which should be filled out by trained experts and supplemented by their personal observation. Your instructions as to the information to be collected were that not only should full and accurate figures be obtained of the production during the year ending June 1, 1880, of all mines, smelting works, stamp mills, concentration and lixiviation works, quarries, and, in short, all natural sources of mineral wealth, by district, county, and State or Territory, with the necessary checks which would be afforded by the returns of mints, United States assay offices, banks, and transportation companies, but that at the same time material should be collected for making a report upon the geographical and geological distribution of ores; the more or less favorable conditions of each district as regards the costs of labor, supplies, and transportation to market; for working the same; the various systems employed in mining and smelting, and their advantages and disadvantages; the average costs of production, and average profits obtained; the workings of the present laws upon mining; the causes of litigation; in short, upon any point that would be of direct or indirect practical value to the mining industry of the country, or to science in general.

In obedience to these instructions, the schedules were prepared, each containing a series of questions, whose answers should give most complete and exhaustive information in regard to each individual mine or works, the questions arranged in each case in a given order, under the general heads: Position, ownership, geology, development, system of working, accidents, plant, consumption of labor, power and material, production, disposition of product.

The number of questions in each schedule, included under these different heads, reached one hundred and fifty, in some cases varying with the character of the works to be examined. Printed schedules were prepared for each of the following:

1. Metallic mines.
2. Coal mines.
3. Petroleum wells.
4. Charcoal burning.
5. Hydraulic mines.
6. Hydraulic ditches.
7. Ore dressing and concentration works.
8. Amalgamation mills in general.
9. Stamp batteries.
10. Pan amalgamation.
11. Roasting furnaces in amalgamation works.
12. Alternate amalgamation and concentration.
13. Alternate concentration and amalgamation.
14. Arrastras.
15. Smelting works in general.
16. Preliminary smelting operations.
17. Smelting in shaft furnaces.
18. Smelting in reverberatory furnaces.
19. Desilverization by zinc.
20. Pattinsonizing.
21. Improving of lead.
22. Cupellation.
23. Quicksilver reduction in general.
24. Quicksilver reduction in retorts.
25. Quicksilver reduction in furnaces.
26. Quicksilver reduction in condensers.

Printed instructions were also prepared for the experts to be employed, which contained as well directions concerning the manner of conducting their investigations, keeping their government accounts, &c., as in regard to the manner of preparing schedules for special work or industries not included above, such as salines, lime-kilns, brick-yards, and, in short, any production of mineral matter obtained directly from the earth and not manufactured. They were also instructed to obtain from each mine specimens of the ore (average quality), gangue, and country rock on the hanging and foot walls of the vein or deposit respectively; and to obtain full and accurate copies of all State and district mining laws and regulations, when such were in existence.

Printed circulars were likewise prepared to be sent to all postmasters, mine recorders, and express agents, with blanks and addressed envelopes inclosed, requesting them to send to the office a list of all mines, mills, smelting works, &c., in their respective districts.

The necessary machinery of the investigation having been prepared, suitable persons were sought to fill the position of experts, the requirements for which position involved not only a technical education which should enable them to understand the theory of the various processes and systems examined, but also a practical experience and residence of some duration in the mining regions, and actual work among mines and smelters.

The limits of my division including the Territories of Montana, Dakota, Wyoming, and New Mexico, and the State of Colorado, it was at first considered that one expert to each would be sufficient. I afterwards found it would be necessary to have a special expert for the mines and works of Leadville and its vicinity; and later, additional experts have been temporarily engaged, in order to secure the completion of the work before the winter snows, which promised to be unusually early this season, should close the approaches to the many mines in this district which are situated at altitudes of ten thousand feet and over.

I was fortunate in securing the services of Messrs. W. G. Sharp, Charles Potter, E. H. Schaeffle, W. B. Fisher, William Foster, and J. E. Hardman, to whom were later added Messrs. J. G. Brown, T. W. Noyes, G. P. McArthur, C. F. Wilson, and Herman Garlichs. Mr. R. B. Harrison, superintendent of the United States mint at Montana, volunteered quite early in the season to assume charge of the district of Montana, but had commenced only a few weeks when, for some as yet unexplained reason, he sent in his resignation, thus causing the loss of nearly a month's time ere the position could be filled and his substitute arrive at the field of work. With this single exception, the work has progressed without any serious obstacles, and all the gentlemen associated with me have shown great intelligence, patience, and perseverance, in an occupation which tries these qualities to the utmost. The actual business of collecting the desired information was commenced as soon after June 1, 1880, the close of the statistical year, as circumstances would permit. The country had been divided up into districts as nearly equal in extent of work as the preliminary information obtained through our circulars would enable us to make. Under this division, one expert was assigned to Montana, one to the Black Hills and Wyoming, one to Northern, Central, and Southern Colorado, respectively, and one to New Mexico; additional experts being assigned to different regions as the progress of the work showed the need of them. Some of the gentlemen employed have already finished the work assigned to them, others will have completed their labors very shortly, and before the close of the calendar year all will have been released from their labors, and the material collected securely lodged in our safe, connected with the Denver office, ready for tabulating and deducing the various interesting generalizations we expect to obtain.

The results of our work thus far are in general favorable beyond our expectations. In carrying on investigations which from the necessities of the case are somewhat inquisitorial in their nature, we anticipated a great deal of reluctance on the part of owners and superintendents in answering our numerous questions, many of which at first glance might not seem pertinent to the simple gathering of statistics of production. In the large majority of cases, however, not only has the desired information been most freely given, but often volunteer assistance to the extent of individual power or means has been freely proffered to the experts in carrying out their investigations. Naturally this has been the case with the more intelligent portion of the mining community, who readily see that a few moments' or even hours' time taken from their business is not thrown away when it contributes to the success of a work which will enable them at a glance to see truly the varied conditions of mining industry in different sections of the country. In one or two cases persons have been found who questioned the right of government to inquire into their private business, as they expressed it, forgetting that the wealth they are drawing from the earth is practically a free gift to them from that government, and that the work is undertaken not for the personal amusement of those who conduct it, but for the benefit of the class to which they belong. More frequently difficulty has been experienced in the case of those with whom the press of business was such that they could hardly give the necessary time to our experts; more especially has this been the case in Leadville. They should, however, not forget that a definite engagement made with an officer of the census ought to be as binding as any other business engagement, and that by not keeping it they are the cause of much unnecessary expense and delay to the work. On the other hand, the number of producing mines bids fair to fall very much below the number estimated by means of our returns from postmasters, &c., who, with the prevailing local pride, doubtless included as producing mines a very large number which would not strictly come under that head. It is as yet too early to estimate the number of mines, &c., from which returns will have been obtained, for although the time of actual field work is already well advanced, many schedules are still in the hands of experts, wanting some partial data for their final completion, and no small number in transit. The total number of completely filled out schedules returned to this office amounts to about 400, and an equal number of specimens representing the geological and mineralogical characteristics of mines examined are in our case ready for study and determination. Still more useless would it be at this time to try to give any estimate of the total annual production of the precious metals of the region under examination, since until absolutely all the schedules have been received, and the returns carefully compiled, any such estimate would amount to little more than a rough guess. The returns furnished by the schedules will, I find, have to be received with more or less distrust. The occupation of mining, its search after the unseen and unknown, its sudden and unlooked-for vicissitudes, the supposed importance of keeping up an excitement in order to attract capital, have in many cases so biased the moral sense of otherwise honest men that they seem to consider it a duty they owe to themselves and the community in which they live to exaggerate the production or value of any mining property in which they may be interested.

What obtains in this respect with the individual applies also to communities, and I have had occasion to know cases where published circulars of the daily or weekly output of certain camps (when, for some reason or other, not necessarily injurious in itself to the permanent value of the camp, there had been a serious falling off in the day's or week's production) had given, instead of the actual amount of ore or bullion produced, that of some more favorable week or day.

From this it will be seen that the figures obtained by us will be likely to differ from those compiled from such sources. We have numerous checks by which to rectify the production of smaller mines—the accounts of the banks and smelting works which buy the ore or bullion; those of the transportation companies through which it is shipped to market. The larger companies are generally conducted on good business principles, their books and accounts systematically kept, and the value of their product controlled by frequent assays, so that the returns given by them may be considered sufficiently reliable, but it is most astonishing to find, as I have, whole districts, relatively important producers, in which the mine owners in general keep no regular accounts, and have no assays made of their ore. They pay the mills so much for reducing their ore, and take the bullion returned by the mill, without any means of knowing what proportion of their product has gone down the stream in the form of sluices and tailings.

Mining, when properly conducted, is a legitimate and most profitable business, but to succeed in the long run it must be conducted on legitimate business principles. In the early days of mining in this country, when only the cream of the mineral deposits was skimmed off, their exceptional richness admitted of profits even when these principles were utterly neglected. But the establishment of mining as a permanent industry involves the treatment of low-grade ores and the investment of a considerable amount of capital.

Now, capital is essentially timid, and until it is practically proved that mining can be conducted as honestly and systematically as any other business, such as manufacturing or railroading, it will never flow in any steady stream into mining investments. One of the most important practical results to be hoped from our investigations will be the encouragement of capital to embark more freely in mining enterprises. Actual figures of production will be published for each district, county, and State or Territory, which will be free from bias or prejudice in favor of one region over another, or of suspicion of interested motives in making a good show for the industry generally. The condition of our Western mines is now in such a flourishing state that the most literal and conservative accuracy will make a sufficiently favorable showing, while the exaggeration which many are induced to indulge in tends to make the Eastern public incredulous of any statement which may be made, however truthful, if it comes from a source which may be suspected of being in the slightest degree interested.

Not only will the quantity and value of precious metals produced be given, but also the average cost of producing the same—the cost of labor, of provisions, of timber, of iron, steel, powder, and all the factors, respectively, which go to make up that cost; the position of each district with regard to lines of communication, its facilities for getting its product to market, &c., all very important items of information to the investor, for many mines which may produce rich ore are as yet practically worthless, because of its peculiar situation in respect to some important item entering into the cost of production, which renders it greater than the net price to be expected from the product. By means of the results obtained from our tables, we shall be enabled to criticise and compare the systems of working, or processes employed in various districts, and thus far-separated regions or newly-opened mines may be enabled to profit by the practical results obtained by their fellow-workers under similar conditions to their own, and get the benefit of their experience. In a scientific as well as practical direction, the geological data obtained and the specimens collected will be of inestimable value.

The latter will be carefully examined mineralogically, chemically, and miscroscopically, and with more or less exactness we shall be able to give the probable age of the different deposits, the average character of the ores of each district, the geographical distribution of each class of ore, and many practical suggestions to guide the prospector or miner in his search for the precious metals. The collection of ores thus obtained will be systematically arranged, and will form the nucleus of a collection of average ore specimens of all the known mines in the country, which it will require but little labor hereafter to complete from year to year, furnishing material for any future investigations, and affording a most valuable means of practical illustration of the mineral wealth of different parts of the country. Data will be obtained in regard to the various employments connected with mining and its allied industries, upon the health of the workmen, as well as the prevailing accidents to which they are liable, and suggestions offered as to the means of preventing them. Comparisons will be instituted from the data obtained, as to the condition of the mining classes as contrasted with those engaged in other industrial pursuits, in reference to wages, average diet, the hardships which they undergo, and the advantages they enjoy.

Thus the workingman, as well as the capitalist, will derive benefit from our investigations, and if the practical results of our work are at all commensurate with the amount of labor involved in obtaining them, their value to the mining public generally should be very great.

Very respectfully, your obedient servant,

S. F. EMMONS, *Special Agent.*

DEPARTMENT OF THE INTERIOR, CENSUS OFFICE,
*Virginia, Nev., October* 10, 1880.

Hon. CLARENCE KING,
*Special Agent Census:*

SIR: The collection of mining statistics has usually been confined, or nearly confined, to data respecting the production of ores and metals. The gross result of an industry, however, does not constitute its sole importance, nor is this the only point which can be investigated statistically. In mining, it is true, the main source of wealth is the earth itself, and the industry is, like agriculture, strictly productive. But mining cannot be prosecuted without drawing upon some industries for supplies, and in its turn furnishes others with raw material. This well-understood interdependence of human pursuits makes it desirable for the public at large that information should be collected concerning many other features of the mining industry besides its mere production. Such, for example, are the position of the mines relatively to the lines of communication; rates of freight; sources whence the various supplies consumed are drawn; the points to which the products are distributed; and many more. For the sake of those directly interested in mining enterprises—a large and growing class—information of another kind is desirable, namely, a record of general methods of management and working as they have been developed in the various districts of our enormously extended mining region. It is the purpose of the present investigation to gather, sift, and collate all such facts, in such detail as seems likely to serve any general purpose.

The region west of the Rocky Mountains has been divided into seven districts, and in each of them a special expert is now at work. These gentlemen were carefully selected out of a large number, on evidence of their special fitness for the business in hand. Their names and the districts to which they have been assigned are as follows:

Cunningham, J. M.—Washington, Oregon, and California east of Coast Range and north of Nevada County, California.

Curtis, J. S.—Nevada, south of Central Pacific Railroad, and California east of Sierras.

Hammond, J. H.—From the crest of the Sierras to the Sacramento and San Joaquin Rivers, from the north boundary of Nevada County south, and the Bodie district.

Huntley, D. B.—Utah.

Leavens, H. W.—The Coast Range, and interval between it and the Pacific shore.

Nordhoff, W.—Arizona.

Williams, A., jr.—Idaho, and Nevada north of Central Pacific Railroad.

The limits of the districts were decided upon for the purpose of equalizing the labor in each as nearly as possible, and with a view to completing the inquiry within six months. In the mean time, of course, no general results can be given, but the character of the results anticipated can be foreshadowed.

At present no approximately complete list of the mines west of the Rocky Mountains exists, nor any accurate mining map. It is well known that the mines of this region lie in belts, conforming in direction to the numerous parallel ranges of mountains which stretch from north to south between the Pacific coast and the Wahsatch Range just east of the Great Salt Lake. The different mineralized belts carry different ores. Thus, the Coast Range of the Pacific carries coal, quicksilver, and some other less important minerals; a copper and iron belt lies at the west foot of the Sierra Nevada; the gold belt occupies the slope above the copper; just east of the Sierra Nevada comes a silver-bearing zone, the most important point of which is the Comstock Lode; through Central Nevada and Arizona, in a less well-defined belt, occur many rich silver mines, in some of which lead is an important constituent, while in others it is absent; finally, extending through Utah, and just west of the Wahsatch Range, is a chain of argentiferous lead mines. The returns of the special experts will show the geographical position of each mine, and also its position relatively to the lines of communication. They will further enable us to trace out more in detail this curious and important parallelism in the mineral belts. It is a well-established fact that these belts are directly connected with the geological formations of the several regions, and these are already known with great minuteness in some portions of the country, while of others our knowledge is scanty or wholly wanting. As it is a portion of the duty of the experts to make certain geological observations on the occurrence of ore bodies, and to collect specimens of the ore and ore-bearing rocks, our knowledge, both of the ore-bearing formations and of the occurrence of ores in these formations, will be greatly extended. The investigation will serve as a geological reconnoissance, and will further give a more practical bearing to the information obtained by former geological surveys.

The extent and character of the investments which have been made in mining are being elaborately investigated. It is well known that, especially in California, many mines are owned by foreign companies, and many more by non-resident individuals and associations. But the extent of such ownership can only be guessed at until the returns of the experts are complete. The extent of the plant, and its cost at the various mines, mills, and smelting works, will show some curious features. Building works in the remoter parts of this region involves enormous expenditures. On the other hand, many elaborate works have been erected on the mere hope of discovering ore, and been practically abandoned. In some cases valuable ore was subsequently discovered in the neighborhood, and the fortunate owners were able to secure excellent machinery and buildings for an insignificant fraction of their cost. Works are to be found in the Great Basin, the machinery of which has been paid for, perhaps, at a higher price than any of a similar kind in the world, and some which has been purchased for less than it would have brought as old iron in an industrial center. The opening up of the ground is as much an investment of capital as the erection of works. Taking into consideration the almost desperate physical conditions of most parts of the Great Basin, the mere numerical statements of the total length of the shafts and galleries in the various districts will call up a striking picture of invincible industry. The Great Basin is essentially a great sage-brush desert, where water is so scarce that men perish miserably of thirst every year, and in its southwestern portion it is also the hottest area on the western hemisphere; yet the linear extent of the mine galleries which have been excavated in this region during the past twenty years will probably fall little short of a thousand miles.

The methods pursued in mining, and the reduction of ores, and their cost, form a branch of the investigation which will be of special interest to all who are directly or indirectly concerned in the industry. Three very important advances in the technology of mining and milling have been made in California and Nevada. These are, the improved stamp battery; the system of amalgamation in iron pans, and the handling of auriferous gravels by jets of water under a head of many hundred feet, the so-called "hydraulic washing." All of these subjects have been very ably handled in our mining literature, but improvements are made every year, and there exists at present no record of practice exceeding in extent the more or less incidental observations of a single engineer. Such details of construction, adjustment, and management as seem to have a direct bearing on the efficiency of these and other processes involved in mining, milling, smelting, &c., have therefore been carefully selected for investigation, and questions bearing upon them form a portion of the schedules. We shall know the method of timbering practiced in every mine in the country; the weight of a car of waste or ore; the weight and drop of every stamp; the details of the construction of every mortar; the method of directing of all hydraulic nozzles; the styles of riffles used in sluices; the pressure of blast in every furnace, and hundreds of other details, so selected as to give a sufficiently complete idea of the whole practice. A proper exposition of these matters, which can be made without in any way betraying confidential information, cannot fail to be of the greatest benefit to the mining community. It will promote more careful work in existing mines and mills, and facilitate an appropriate selection of machinery and methods in new enterprises.

The cost of working is being examined, not only from a monetary point of view, for this varies enormously with the geographical and geological position of the mines, but as well with reference to the consumption of labor, power, and material involved. The number of hours' work done in each establishment, the quantity of fuel burned in the production of power, and the quantities of a variety of supplies consumed, will be as accurately known to us as it is ascertainable from the books of the various owners. Of course, no details of any man's private business will be made public, but this material can readily be generalized in such a way as to give information as precise as the public has any right to. Accidents and their causes will be fully examined, and as these in several European countries form a regular topic of official investigation, very interesting comparisons can be made. It is inherent in the nature of the country and genius of the people, that less elaborate precautions against accidents should be taken here than in Europe. On the Comstock lode, too, there exists a danger nowhere else encountered, for there it is not uncommon for men to die of the mere heat of the mines. On the other hand, few, except enterprising, self-reliant, and wide-awake men, venture into our mines, and it seems not improbable that this may prove a compensating safeguard.

The final destination of ore and metals produced west of the Rocky Mountains is very various. Ores are, of course, largely reduced on the spot, but some go to San Francisco for treatment, some to the Atlantic States, and some to Wales. With metals, the case is similar. Some is refined at the works where it is produced, some goes east, some west, and some to Europe for separation. The returns of the experts will give the production and disposition in all cases. The inquiries will further be supplemented by the other methods of investigation of which this subject is capable, the records of the transportation companies, the banks, the mints, and the custom-house.

If no definite results can be given until the investigation is finished, the returns now daily received give an assurance that when complete they will furnish the data for such a picture of the mineral industries of the far West as has been roughly outlined in the preceding paragraphs.

In addition to the general investigation of the mines west of the Rocky Mountains, which is limited chiefly to their operations during the census year, a special inquiry into the statistics of the Comstock lode is being prosecuted, under my supervision, by Mr. O. D. Wheeler, which will extend over the whole period since the opening of this famous deposit twenty years since. This inquiry will embrace subsidiary industries, as well as that of mining and reduction. Especially interesting is the fluming of timber and fuel from the high Sierras to the railroad and the Carson River. The system has been in use, I believe, for a very long time in the Scandinavian timber districts, but has been developed to an enormous extent in the Sierra Nevada. A trough, usually V-shaped, now resting on the ground, and again supported on high trestles, is built as nearly as possible on an even grade from the timber district to some convenient station on the railway. The trough or flume is supplied with water, and the timber or fuel thrown into it is floated along at a high speed, sometimes at the rate of over ten miles an hour, to its destination. Thus the saw-mills can be placed directly in or close to the forests, and no unnecessary carriage is involved. The transportation of the sawn timber by fluming probably does not cost over nine cents per thousand feet per mile, a far smaller expense than would be involved in any other practicable method.

The water-works of Virginia City are very noteworthy. Potable water is found there only in very small quantities, and it became absolutely essential to the existence of the mines and town to bring water from a point in the Sierra Nevada, thirty miles away, at a cost of no less than $2,200,000, a large sum to stake on the permanence of an ore deposit. A remarkable engineering feature of this work is that the water is carried past a ravine by a U tube, improperly called a siphon, of boiler-iron, the lowest point of which is 1,700 feet below its upper extremities. As Virginia is not a distributing point, the consumption of the town is very accurately measured by the supplies and material transported by the Virginia and Truckee Railroad, the way bills of which have been digested, classified, and tabulated. In short, an effort is being made to obtain complete economical, technical, and social statistics of the Comstock lode, and the community to which it furnishes employment. This course is justified by its representative character and its intrinsic importance; for, during the last twenty years, it has been the most productive silver mine in the world, and has added $325,000,000 to the world's supply of the precious metals.

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

G. F. BECKER,
*Special Agent Census.*

## FORTHCOMING PUBLICATIONS.

The organization of the survey immediately followed the date at which the first appropriation of $100,000 became legally available, and as that fell in midsummer, only half the ordinary time which the seasons permit was left for field operations. At the close of the present summer, therefore, the scientific staff will have labored only one and a half field seasons—a very short time to bring their special works to completion.

Realizing very fully, however, the natural desire of Congress and the Administration to see actual results and apply the test of a critical examination to the fruits of the new bureau, I have called upon the members of the corps for an energy and intensity of labor which should not be greatly prolonged, and which affords no measure of the rate of progress on small appropriations hereafter. The gentlemen of the corps have responded with such cheerfulness and enthusiasm that I am able to promise, between the close of field-work this autumn and the opening of next spring's campaign, the completion of twelve volumes of practical and general geology and paleontology.

I give a brief and condensed foreshadowing of these memoirs.

### MINING GEOLOGY.

GEOLOGY AND MINING INDUSTRY OF LEADVILLE, COLORADO. By S. F. Emmons, geologist-in-charge.

This work will consist of (*a*) A treatise upon the geology of a tract six miles square, embracing the chief mines of the Leadville district, discussing the geological and lithological disposition of the local formations in relation to the origin, nature, and extent of the ore deposits; (*b*) Elaborate topographical and geological maps in eight sheets, illustrating the areas surveyed and showing the special configuration of the surface, the occurrence of the rock formation, and the location of all mining openings on such a large scale as to serve as the basis for any future works of engineering for the exploration, connection, or deep drainage of the mines of the dis trict; (*c*) A geological description of an area twenty miles square, including in its midst the six-mile block. The object of this division of the volume is to discuss and illustrate the general geology of the neighborhood in its relation to the larger dynamic history of this section of the Rocky Mountain chain. This is accompanied by (*d*) a topographical and geological map, upon which the described features are delineated.

The report will further contain (*e*) a special and technical description of the ore deposits, presenting especially such facts as bear upon the genesis, mineralogical constitution, area, tonnage, valuation, and continuance of the ores themselves, the economies of their extraction; and (*f*) an account of the processes of metallurgical treatment, and the yield and value of the metals produced.

In short, this book will, as far as the brief time given for its production allows, present to the public the scientific and technical information upon the Leadville district which is most anxiously desired by miners and students of mining geology and economy.

GEOLOGY OF EUREKA MINING DISTRICT, NEVADA. By Arnold Hague, geologist-in-charge.

This memoir is one of two upon the district of Eureka, Nevada. Its scope is purely geological, and it logically precedes a second memoir, which will be a technical treatise on the nature, position, extent, metallurgy, and production of the Eureka mines.

This district ranks first among those producing silver-lead ores. For a period of fifteen years it has maintained an almost unvarying prosperity; and, as a geological occurrence, an instance of vigorous mining, and an example of silver-lead metallurgy on a large scale, well merits the thorough and exhaustive treatment which it is proposed here to give.

Mr. Hague's volume gives the result of a close geological survey of a tract of country twenty miles square, embracing all the mines of the district.

Its leading interests will lie in the treatment of three special subjects: First, the great series of paleozoic strata, whose enormous bulk and thickness make up the great body of the rocks of the neighborhood; second, a series of dynamic events, which have broken this great body of paleozoic strata into individual blocks, and riven the beds with many fissures, some of which have given egress to repeated volcanic eruptions, while others have been the theater of vein action, and are now occupied by the precious metal deposits upon which the industries of the district are based; and, third, the nature of the volcanic series themselves, and their relations to the ore deposits.

This report is accompanied by an elaborate topographical map of the area of twenty miles square in grade curves, executed under the direction of Topographer F. A. Clark. Upon this foundation will be shown, in color, all the geological features of the district as delineated by Mr. Hague.

This map, like the detailed map covering the Leadville mines, is sufficiently accurate to serve for all future purposes of geological description or general mining study.

THE COPPER ROCKS OF LAKE SUPERIOR, AND THEIR CONTINUATION THROUGH MINNESOTA. By Prof. Rowland D. Irving.

This formation, which embraces a distinct geological series, has been for many years noteworthy as producing a large proportion of the world's annual output of copper.

The geological surveys of Michigan and Wisconsin have thrown much light upon the formation in their respective States; and the Canadian survey has identified the series within the Dominion of Canada.

This special work of Professor Irving has for its object the illustration of the passage of these rocks through Northeast Minnesota up to the British boundary.

It is of the utmost importance that every acre of the copper series should be known and located; and the report of Professor Irving will prove the existence of the series over a large area of comparatively new territory.

HISTORY OF THE COMSTOCK MINES. By Eliot Lord.

This volume forms one of a series of three devoted to the Comstock lode, incomparably the most valuable metal deposit known to modern times. It is impossible to embody in one report any account of the development of this great industry. Its history, its geology, and its mechanical industry have now expanded to such proportions that neither one volume nor one author is enough to cope with its abundant and rich materials.

Accordingly, I have laid out three volumes, all of which should be completed in time to present for publication before the opening of the field work next spring.

Mr. Lord's volume will describe the discovery of the Comstock lode, the great legal struggle for its ownership and possession, the singularly brilliant campaigns which the directors and owners of this wonderful deposit have made against the obstacles of nature for thirty years, in which brief period they have reached a depth only attained in Europe after three hundred years of unremitting toil.

The history of the Comstock is one of the most extraordinary exhibitions of American industrial activity which our varied enterprise affords; and this presentation of its characteristic features cannot fail to be of interest and benefit to all who, in the future of American mining, find themselves called upon to wrest from the earth its deep-hidden treasures.

This volume conducts the reader from the first discovery of the Comstock to the present day; and illustrates with great care the advance of mechanical skill and the peculiar economical features of the local labor question.

THE COMSTOCK LODE. By George F. Becker, geologist-in-charge.

In his volume, Mr. Becker will discuss the character and distribution of the rocks of the Washoe district in their bearing upon the formation of the Comstock lode. The deep penetration of the present mine openings, and the long gallery of the Sutro Tunnel, have brought to view new formations, unsuspected by the earlier writers upon the Comstock; and much new light is thereby thrown upon the succession of volcanic outflows which form the material of the country rock, and upon the chain of dynamic events which have followed one another from middle geological time, and united to form the Comstock lode.

This portion of the memoir will be accompanied by a geological map, executed by Mr. Becker on the basis of the topographical survey of the district lately completed by Capt. George M. Wheeler, Corps of Engineers, and kindly furnished by him to the Geological Survey.

Following the general geological discussion will be presented a full account of the lode itself, its dynamic history, vein structure, the discussion and classification of its materials, the form and mineralogical character of the bonanzas, together with their yield of the precious metals; also, a detailed account of the remarkable downward increment of heat which distinguishes these mines from all others upon the globe, and which renders their future exploitation not only a problem of capital and mechanical skill, but of the power of the human organism to exist and labor in the presence of intense moist heat.

This division of the report will be accompanied by an elaborate atlas, showing all the mine workings, up to date, embracing over two hundred miles of subterranean shafts and levels; and by a series of sections and projections, illustrating all the important details of structure of the lode as a whole, and the ore bodies in particular.

The volume will also embrace the results of a competent physiological study of the effect of the great heat upon the systems of the workmen.

MECHANICAL APPLIANCES USED IN MINING AND MILLING ON THE COMSTOCK LODE. By W. R. Eckart, C. E.

The magnitude, complexity, and efficiency of the mechanical appliances in use at Washoe have kept pace with the rapid development of the mining industry, until, at the present day, the more important machines are of great mechanical interest.

It is designed in this volume to present descriptions and discussions of the form and construction of the more important machines and appliances, illustrating them with elaborate working drawings, not only of the machines as put together and in use, but of all the more important detailed parts.

The volume will also present a mechanical and mathematical discussion of their actual and relative efficiencies based upon the consumption of fuels whose calorific powers are scientifically determined and accurately related to the question of cost.

COAL OF THE UNITED STATES. By Raphael Pumpelly, geologist-in-charge.

This volume will convey a statistical review of the present production of coal from all the coal-fields of the Union.

It will present a classification of the different coal-fields, an account of the character and thickness of all beds now worked, a tabular statement of the output, with the consumption of capital, labor, power, and material used in the annual production.

It will further detail the character of the more important plant, and illustrate the different systems of labor utilized in the industry. From Seattle to Alabama, from Rhode Island to New Mexico, every considerable coal mine now in operation will have been visited and technically examined, and this extensive labor will have been wholly executed from the funds of the Census, and by experts of the Census, both of which have been furnished by General F. A. Walker.

The scope and character of the inquiry, together with all the elaborate, technical schedules necessary for the proper conduct of the investigation, have been devised, directed, and will be finally discussed by Prof. Raphael Pumpelly, of the Geological Survey.

IRON IN THE UNITED STATES. By Raphael Pumpelly, geologist-in-charge.

This work, another joint labor of the Census and the Geological Survey, has been executed by Professor Pumpelly from the funds and by means of the experts of the Census.

As in the case of coal, all technical preparations for the study, the laboratory, with its enormous amount of chemical investigation, and the entire direction of the work, have been furnished by the Geological Survey.

Professor Pumpelly will not only give the statistics of production, but will show the distribution of the great iron fields, and their relation to transportation, fuel, and market. He has furthermore added an investigation of the utmost technical interest to the whole industry, namely, an elaborate chemical survey of the great iron fields, showing, in the main, the distribution of iron and its association with the various chemical accompaniments, both those which are of advantage and those which are deleterious.

This chemical survey of the iron fields will afford a large view of the special distribution of each chemical type of iron ore.

As in the case of coal, the memoir will contain an account of the capital, labor, power, and material consumed by the industry during the census year, and numerous tabulations of technical points of value to those engaged in the iron industry, as well as to all students of American political economy.

THE PRECIOUS METALS. By Clarence King, director.

Division 1 of this volume is devoted to the discovery of the precious metals in the every-day current prosecution of the industry.

It will endeavor to fully illustrate the manner in which the precious metals, veins, and deposits are now discovered in the great West, embracing an estimate of the number of prospectors engaged in this singular pursuit, their mode of life, nationality, habits, migrations, and discoveries.

It will embrace a tabular statement of the number of mines officially located during the past year.

Division 2 will describe and explain the legal steps which constitute the ownership of claims from their discovery up to the time when they became operated mines. The number of conveyances of precious metal claims by deed in the whole United States will be shown; the laws, Federal, State, and Territorial, under which these ownerships obtain, will be cited and commented upon; and an historical sketch will show the origin of the local laws and customs which have sprung up spontaneously throughout all the western mining region, and which, by a process of change and evolution, have given rise to the present controlling Federal legislation.

In addition to this tables will be given showing the number of mines owned and worked privately, the number held in corporate ownership, with the corporations localized in different States and Territories, and finally, a discussion of the system of mining corporations in relation to corporation laws and stock-board regulations, wherever American mines are owned, including France, England, and Holland.

Division 3 will consist of the results of a technical examination of the precious-metal mines of the United States (gold, silver, and quicksilver), which will embrace a statement of actual production for the year, localized by States and Territories, and full, technical statements of the characteristics of the industries, showing by elaborate tables the consumption of capital, labor, power, and material.

Division 4 will consist of a statistical and politico-economical study of the general aspect of the mining industry, its relation to locality and population, the civic institutions and business methods which have grown up in mining communities, and the legal and financial machinery by which this singular business is conducted. In the technical portion the director is aided by S. F. Emmons and G. F. Becker, of the survey staff, and in the department of political economy by Eliot Lord.

LESSER METALS AND GENERAL MINERAL RESOURCES. By Raphael Pumpelly.

This work, like the memoirs on coal, iron, and the precious metals, is made from the funds of the Census under the conduct of the Geological Survey.

The report will contain statistical statements of the production of the lesser metals—lead, copper, zinc, bismuth, chromium, cobalt, nickel—together with a partial review of the production of the following substances: Apatite, asbestos, arsenic, antimony, buhrstones, borax, bismuth, chrome, cobalt, copper, corundum and emery, cements (hydraulic), fluor-spar, feldspar (for potash), grahamite, graphite, gypsum and plaster, grindstones, millstones, honestones (novaculite, &c.), glass sand, green sand, infusorial earth, iron ores, iron pyrites, kaolin, lead, lithium, manganese, mica, molybdenum, mercury, niter, nickel, peat, quartz, roofing-slates, serpentine, slate, slate pencils, soapstone (steatite), soda, talc, tin, tungsten, &c.

The above four volumes, joint works of the Census and the Geological Survey, together with statistics of petroleum to be furnished us by General Walker, will enable us to present the first general summary of the leading mineral productions of the United States.

Owing to the insufficiency of money and means, and the enormous multiplicity of industries and wide extent of territory, it has been impossible to make an exhaustive survey of some of the really important substances, such as clay, building-stones, fire-clay, hydraulic cement, salt, alkalies, borax, &c.

It is intended that the statistical portions of these four volumes shall be combined in one volume on the mineral resources of the United States, which shall form the first of an annual series to be brought out by the Geological Survey.

It will be seen by the above notes of forthcoming volumes that a very large proportion of the labors of the survey has been given to purely economical questions. The Director felt that, with the mineral industries in their present hopeful condition, and in view of the wide-spread ignorance of the magnitude, importance, and technical facts of these industries, it was his duty to bend the energies of his bureau first of all to the production of immediate results of strictly practical value.

A very small proportion, therefore, of the funds and force at his disposal have been diverted into the department of pure geology. Three volumes, however, are forthcoming.

UINKARET PLATEAU. By Capt. C. E. Dutton, Ordnance Corps, geologist-in-charge.

A very large amount of geological work, of which some interesting portions were nearing completion, have been inherited by this bureau from the geological survey lately under charge of Maj. J. W. Powell.

Of these, the district of the Uinkaret Plateau, bordering the great cañon of the Colorado, forms one of the most interesting parts. Capt. C. E. Dutton, of the Ordnance Corps, having been placed in charge of the division of the Colorado, is bringing to a close his geological examination of this peculiar district.

His report, accompanied by topographical and geological sheets, and illustrated by geological views from the pencil of Mr. Holmes, cannot fail to be an important contribution to our geological knowledge of one of the most striking features of the earth's crust.

LAKE BONNEVILLE. By G. K. Gilbert, geologist-in-charge.

It has been well known to the geological world for several years, through the writings of Mr. Gilbert and of the Director of the survey, that the basin of Utah is the bed of a great extinct lake, whose existence is as clearly proven as that of any of the existing seas.

This remarkable sheet of water existed in the glacial age, immediately preceding the present geological period. Its area was fully equal to that of Lake Huron.

Unlike the other extinguished oceans of the past, whose existence has been caused by the upheaval of the earth's crust, this lake has vanished from purely climatic causes.

It has simply dried up, leaving a few residuary lakes, of which Great Salt Lake is the chief. In the process of desiccation it has left a wonderful record of climatic oscillations and variations.

The desert climate of Utah and Nevada is one of the interesting physical features of the United States, and the oscillations of the moisture of this climate through periods of years since the occupation of these Territories by American emigrants have given rise to eager speculation.

Is the desert growing still drier or is it gaining in moisture are questions upon the lips of every intelligent settler in that region.

The volume of Mr. Gilbert will show the character and magnitude of those past climatic oscillations which have changed the aspect of the basin of Utah from a well-watered and green area to a country wholly desert, except when reclaimed by the enterprise of man.

Mr. Gilbert's volume is illustrated by topographical maps of the extinct lake, and numerous maps and diagrams showing the geological action of the receding waters.

DINOCERATA. A monograph on an extinct order of Ungulates. By Prof. O. C. Marsh, paleontologist.

This volume is a detailed monograph, illustrated by fifty-five quarto plates.

Among the recent geological discoveries in the Western Territories none is more remarkable than the bringing to light of enormous amounts of the remains of extinct animals.

The great collections of Cuvier from the Paris basin are already eclipsed by the immense yield of fossil bones from the Tertiary and Cretaceous strata of the far West.

This volume embraces a complete exposition of a new zoological order peculiar to America, and possesses high scientific importance as a contribution in the field of American paleontology.

## FUTURE OF THE SURVEY.

In the history of the United States—whatever may be the political or social result of this century, whatever may be the final adjustment of the machinery of national government—upon one great field of American activity, the pride of to-day and the judgment of the future will agree. That field is the development of our material resources. In the industrial conquest of a continent the tide of victory has never ebbed.

In possessing ourselves of this broad, virgin area we have shown a power, unprecedented in the slower past, to discern, to seize, and to utilize the national wealth with which the United States is so liberally endowed.

With an energy never relaxed, with an originality which has revolutionized and improved nearly all industrial methods, we grasp the problem of material development, and grasping, solve it. Just as is the pride of all Americans in this signal achievement, every intelligent student of the country knows that we are yet at the very threshold of the industrial life of the Republic. We have only begun; we have the great work still before us.

The modern method of distributing population by means of that network of railroads which is rapidly threading the last remaining wilderness, greatly accelerates the progress of the industries. There are no longer blanks on our maps marked "unexplored," nor are there untrodden fields for the pathfinder. The epoch of the pioneer is practically passed. Our fifty millions will equalize its grasp on the different sections by rapid migration till the population finds an equilibrium with the local resources. That equilibrium will soon be attained. Our real industrial problem is, then, to utilize with the highest technical skill and with the utmost scientific economy all elements of national wealth.

As a general proposition, it is true that the practical genius of the people, acting in the political and social freedom peculiar to our system of government, is enough to insure the success of our industrial efforts. At the same time, the government which grants and secures this freedom of action, has the power, and, I hope to show, the duty to bestow one sort of aid which can come from no other hand.

The great extent of the United States and the widely separated sources of the national resources render the acquisition by private citizens of information on almost any single product always difficult, often impossible.

As a direct result of the size of the country, the government and people have long been uninformed as to our primary industries; those, I mean, which yield the raw materials—mineral, vegetable, and animal.

To the Agricultural Department we owe the first reforms from this condition of wide-spread ignorance. In the realm of mineral productions the only efforts made to acquire any positive knowledge have been the highly useful, but feebly endowed, works of the late mining commissions, whose investigations were suffered to end for lack of appropriations.

To-day no one knows, with the slightest approach to accuracy, the status of the mineral industry, either technically, as regards the progress and development making in methods, or statistically, as regards the sources, amounts, and valuations of the various productions.

Statesmen and economists, in whose hands rest the subjects of tariff and taxation, have no better sources of information than the guesses of newspapers and the scarcely less responsible estimates of officials who possess no adequate means of arriving at truth.

In no other intelligent nation is this so; on the contrary, mineral production is studied with the most elaborate effort. England, France, Germany, Austria, Russia, and Italy consider it essential to know, from year to year, not only the source and aggregates of amount and value of mineral yield, but many lesser facts relating to the modes and economies of the industries.

Upon considering the extent of country over which our minerals occur, their wonderful variety and yet unmeasured amounts, it cannot fail to be apparent that no private individual or power is competent to do what ought long since to have been done, namely, to sustain a thoroughly practical investigation and exposition of the mineral industry.

By way of example, and to show how hopeless it is to look to any other source than the government for this service, I select iron.

The best instance of what private association has done in the acquirement of knowledge relating to an American mineral industry is the result reached by the "Iron and Steel Association"; but a glance at their highly valuable performance shows how fragmentary and imperfect it is, and inevitably must be.

Individual States, notably Pennsylvania, Michigan, Wisconsin, Missouri, and Kentucky, have made admirable contributions to the knowl edge of American iron, but no common plan underlies their works. They have barely skirmished along the picket lines of the business.

I apprehend no economist, legislator, iron-master, or mine owner would for a moment hesitate to admit that the sum total of information now available on the subject is utterly insufficient for the most intelligent and profitable pursuit of the industry.

The very foundation facts as to the exact chemical nature, geological occurrence, and geographical location of available iron bodies are unknown. In the roughest and most general way perhaps they are known, but in detail, and with the exactness required by modern metallurgy and modern economy, they are not.

The adaptability of iron ores for the increasing number of delicate processes designed to produce special products to meet particular mechanical needs, depends on the presence or absence of minute quantities of accessory elements in the ore. To-day we are ignorant of the presence or quantity of these minute but controlling factors of chemical composition, except in ores of the more important and actually operated mines. As to the great bulk of the ore deposits our knowledge is blank.

The points required to be known by the iron industry are many. Chief among them are the following:

1. Geographical and geological. The position of all iron fields should be known and shown on accurate maps. Besides the general areas embracing groups of iron districts, each special district should be carefully mapped, and the geological relations, size, form, and mode of occurrence of each iron ore body or iron stratum should be illustrated by appropriate graphical methods. In this department the work should not stop with an exhibition of ores already discovered or outcropping upon the surface, but the iron areas should be constantly enlarged by the careful working out of the subterranean bodies by magnetometrical and stratigraphical methods known to geology.

2. Chemical and mineralogical. Every iron-ore occurrence should be analyzed, so that its percentage of iron, its mineralogical characteristics, its tenure of the minutest amounts of foreign substances, valuable or injurious in metallurgy, should be definitely known.

3. Metallurgical association. Besides the geographical, geological, mineralogical, and chemical facts above indicated, it is also required to know the location, metallurgical character of all the fuels and all the fluxes, and all the refractory material which must in the economy or necessities of the industry be brought together to produce iron.

In a few rare instances all these requisite materials are found in conjunction; in a vast majority of cases they are brought together from distances, which the growing cheapness of transportation is day by day increasing.

An ore from Virginia may be best smelted at Baltimore, when mixed with another from Michigan, by means of a fuel from Pennsylvania and a flux from Maryland. Products the most distant are thus daily brought together and consumed in the blast furnace.

The size of the United States and the wide distribution of iron ores and industries render it unavailing for private individuals or corporations to attempt to gather full knowledge concerning them; and, even if acquired, the competition of trade would hide it securely from the public.

It is the height of absurdity to expect all the iron-producing or iron-containing States to undertake simultaneously an investigation of this problem. If by some miracle of concurrent legislation all such States were to inaugurate the work, it would fail miserably for the want of that very comparative study and unity of method which a single well-directed corps, operated over the whole field, alone could insure.

In order to master this subject, a government corps of geologists, topographers, mining engineers, metallurgists, and chemists is necessary; and this corps must be so directed as not only to inquire into local facts and details, but to institute careful comparison of districts, so that the facts learned in one place may be made to throw light on all others.

To claim that the iron question will ever be adequately investigated as a whole, either by private enterprise or State surveys, is to betray a total lack of appreciation of the character, magnitude, and needs of the industry.

What is true of this single metal is equally true of nearly the whole catalogue of the mineral products of the United States. A few exceptional items, like quicksilver, occur in such restricted areas that private or State enterprises could contribute all the knowable facts and features of the business of production. But as a whole it is true, and can never be refuted, that the Federal Government alone can successfully prosecute the noble work of investigating and making known the natural mineral wealth of the country, current modes of mining and metallurgy, and the industrial statistics of production.

Provided Congress extends the field of the Geological Survey over the whole national territory, and appropriates the comparatively small amounts necessary for the maintenance of the organization, it will be entirely practicable to carry forward this work, and contribute powerful aid to the mineral industries. Of the desirableness, from every point of view, of the results of a general geological survey, I conceive there cannot be two opinions. That these results can only be attained by an organization under Federal patronage, is, in my opinion, scientifically certain.

Granting these two propositions, which the foes of progress may vainly strive to disprove, and there remain but two questions worthy of serious consideration regarding the future policy of this bureau. These are, first, has the Federal Government the Constitutional authority to make a geological survey over the State? and, secondly, can this nation afford the money to maintain such a survey?

In regard to the question of authority, it may be said that the Federal right derived from the Constitution to regulate internal commerce could hardly fail to carry with it the correlative right to gain a knowledge of those commodities and products which are the very material and basis of commerce; without this knowledge *commerce* is mere *transportation.*

From every analogy of past legislation, Congress has clearly assumed to possess the requisite authority. If it can investigate agricultural industry and maintain a department to execute that branch of inquiry, why not investigate mineral industry? If it can make a coast and geodetic survey over the whole United States, why not a geological survey?

Since the Constitution empowers the Federal Government to levy taxes upon the industries of the nation, there would seem to be a failure in the logic which should deny to it the implied power of informing itself as to the nature and extent of those industries.

Regarding the cost of the Geological Survey, if organized upon a permanent basis, with its jurisdiction extended over the entire United States, there need be no apprehension of the necessity for extravagant amounts.

Five hundred thousand dollars a year, the sum for a long time annually appropriated for the Coast and Geodetic Survey, will be sufficient to carry on all the work which is either necessary or desirable over the whole United States.

Beyond that scale it will not be necessary to go, and with that annual amount a report could be produced annually in each of the eight divisions of the survey which would be of inestimable value to the people and industries of each geographical section.

It is earnestly recommended that Congress extend this work over the whole United States, and place it on a basis of five hundred thousand dollars per year.

The mineral industries of the United States will soon reach an annual money yield of a thousand million dollars of value. The small Federal appropriation of half a million a year toward the development of this great field of American enterprise is certainly not an excessive contribution.

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

CLARENCE KING,
*Director*.