ART. XLVII.—*On the Geology of Western Wyoming;* by THEO. B. COMSTOCK, B.S., Geologist of the Northwestern Wyoming Expedition, 1873.

THE Northwestern Wyoming expedition sent out in June last, by General Ord, charged with the exploration of the headwaters of the several rivers having their sources in the northwestern corner of Wyoming Territory, having returned from the work in the field, it is proper to make known, in a general way, the results of their explorations. The work of preparing the reports for publication has already begun, but it will require several months for the complete elaboration of the material collected for study.

It is proposed, in this paper, to give a simple resumé of the results of the field labors of the writer, with such references to the general results of the expedition as may be necessary by way of explanation. It will be distinctly understood, however, that the writer is alone responsible for all statements herein made concerning the labors of others as well as his own.

The working corps was organized as follows:

Captain W. A. JONES, U. S. Engineers, Commander.
2d Lieut. S. E. BLUNT, 13th U. S. Infantry, Astronomer.
Dr. HEISMAN, Ass't Surgeon, U. S. Army, Surgeon.
Dr. C. C. PARRY, Botanist and Meteorologist.
Prof. THEO. B. COMSTOCK, Geologist.
LOUIS VON FROBEN, Chief Topographer.
GEORGE C. HITT, Assistant to the Astronomer.
J. D. PUTNAM, Assistant to the Meteorologist.
PAUL LE HARDY, FRED. W. BOND, CECIL GABBETT, Assistants to the Topographer.
CHAS. T. CREARY, FRED. MILLARD, GEORGE JEWETT, General Assistants.

The members of the expedition left Omaha, June 2d, 1873, proceeding, via Union Pacific Railroad, to Fort Bridger, Wyoming Territory, at which point the labors of the scientific corps were begun. While awaiting preparations to move, I visited the Uintah Mts., in order to obtain some idea of the great Tertiary Lake basin through which we were intending to pass on our march northward,* and, if possible, to make the ascent of Gilbert's Peak. Mr. J. D. Putnam accompanied me with a mercurial barometer. With great difficulty we succeeded in reaching Henry's Fork, but found it impassable, running a perfect torrent, and so rapidly rising from the melting of the snow that we were driven out of the narrow valley by the overflow. The sections exposed, however, were sufficient to show the structure of this rim (the southern) of the Green River basin, which is not materially different from that of the Rocky Mountain

*See paper by Prof. O. C. Marsh, "On the Geology of the Eastern Uintah Mts." Amer. Jour. Science, III, vol. i, March, 1871.

system in general, except that the rocks of Mesozoic age cover the older formations to a greater extent than common. Overlying these, with a very slight dip, and jutting against the northern slope of the Uintahs, are the immense fresh water Tertiary deposits, now eroded to an almost incredible extent over the whole basin, which has an area of over 20,000 square miles. The junction of these beds with the older deposits is much obscured by an accumulation of drift material, but at several points along Henry's Fork of Green River, rocks underlying conformably the red sandstones, which I have referred to the Mesozoic, are seen.* The surface Tertiary beds of the southern and western portion of the basin appear to belong to Hayden's "Bridger Group," of Upper Miocene age,† being composed of dull-colored clays with beds of sandstones of considerable thickness, usually brownish, or dull yellow or gray, and having more or less of a concretionary structure.

Upon our return to Fort Bridger, the train moved northeast through South Pass to Camp Stambaugh. Along our route the Bridger group is exposed at the surface over a considerable extent of country northward and eastward from Fort Bridger, as far as Little Sandy Creek and beyond, forming the top layers of numerous isolated "buttes,"‡ giving them, when the clays predominate, the so-called *grizzly* aspect alluded to by Prof. Marsh.§ It is impossible, without more extended study, to *define* the lower limit of the Bridger group, but it passes gradually into a series of marls and limestones containing quantities of the remains of fresh water forms of life, with laminated layers literally filled with the remains of land plants. The famous "petrified fish bed," well exposed near Green River station, Union Pacific Railroad, belongs to this group, which, following Hayden, is called the Green River group. The buttes of this formation not crowned by a considerable thickness of the beds of the Bridger group, have not the grizzly appearance of the latter beds. The Green River beds are of Lower Miocene age,

* The red sandstones which I here refer to the Mesozoic are regarded by Marsh as of Cretaceous age, from the fact that "they have below them, farther down the stream, calcareous beds containing undoubted Jurassic fossils." (Marsh, this Journal, vol. i, March, 1871, p. 3.) The rocks which I noticed below the red sandstones are mainly laminated shales, abundantly ripple-marked, but containing no fossils that I was able to detect.

† "Geol. Survey of Wyoming," etc., by F. V. Hayden, 1870: Washington, 1872, pp. 55, 58.

‡ The term "butte" is used indiscriminately in the west to designate *all* isolated hillocks or eminences standing out prominently in the topography of a country, if the breadth does not exceed the height. In this paper, its use is restricted to *hills of erosion* in stratified rocks.

§ Those *buttes* which are largely composed of indurated clays are scored by numerous water channels or gullies, which run down their sides in a branching and radiating manner, causing, at a little distance, that peculiar shaggy appearance which has given them the name of "Grizzly Buttes."

and overlie conformably a thick deposit of sandstones and arenaceous rocks, which, though varying sufficiently to admit of division into minor groups, are best considered here under the comprehensive name of Eocene. Careful notes and collections have been made, which will enable me to classify these beds.

On the western slope of the Wind River Mountains, near South Pass, no signs of strata older than the Tertiary were discovered, but the evidence of powerful glacial action is abundant. Several comparatively low ridges or folds in the metamorphic rocks are passed over before reaching the main divide or axis of the range, beyond which the original structure is very largely obliterated by various kinds of erosion, and the filling in of the gravels and finer material of the drift. In the metamorphic schists and gneissoid slates of the Wind River Mountain nucleus, occur the auriferous quartz veins of the Sweetwater mines. Several days were spent in company with Capt. Jones in a somewhat detailed survey of the various mines in this vicinity, including a study of the veins in the neighborhood of Miner's Delight, beyond Camp Stambaugh. The gold of this region occurs in thick veins of impure quartz, associated with considerable silver, and more or less of iron pyrites. The greater portion is disseminated through the vein rock, but it not unfrequently is found native in cavities in the quartz, in fair sized nuggets.

From Camp Stambaugh the route lay northwest along the eastern base of the Wind River Mountains, as far as Camp Brown on the Little Wind River, thence across the Wind River Valley, over the Owl Creek Mountains, and across the valley of Owl Creek above the junction of its forks.

The geology of the eastern slope of the Wind River Mountains is quite simple, affording many fine sections exposing representatives of all of the great groups of sedimentary rocks, from the Silurian to the Cretaceous inclusive, conformable to each other, and dipping away from the underlying metamorphic rocks at an angle of 20°. On one of my trips into these mountains I discovered limestone strata of Silurian age, containing remains of Trilobites and Corals not yet determined, but which for the present I refer to the Potsdam Period. The Devonian strata are best represented by the Oriskany sandstone, containing quite abundant remains of *Spirifer arenosus*. The rocks belonging to the Carboniferous age would seem to be almost wholly Subcarboniferous, containing *Orthis Michelini*, *Lithostrotion Canadense*, a *Chonetes*, and a species of *Poteriocrinus?*. Other fossils collected, but undetermined, may prove the existence of later Carboniferous strata, however.

A problem of no little difficulty is the definition of the lines of junction of the Triassic with the Jurassic, and the Jurassic with

the Cretaceous. It is sufficient, however, for our present purpose, to state that the Triassic beds are represented by thick deposits of bright red sandstones, which are overlaid by lighter, or buff-colored sandstones of Jurassic age, and these again by sandstones and shales, with interstratified brown lignite beds, and occasional seams of coal, which, I cannot doubt, are of Cretaceous age.* Special attention has been given to this question, and it is hoped that ample material has been collected for its solution.

An interesting and peculiar fold in the sedimentary strata, making a parallel ridge to the mountains, causes a kind of trough to be formed, with a double exposure of the Mesozoic beds, thus greatly aiding human industry by bringing to the surface again the valuable deposits of gypsum, which occur abundantly in the Triassic rocks, as well as the more or less valuable coal deposits before alluded to. To this folding of the strata may also be traced another economically important result to this highly favored section. I refer to the existence of hot and cold sulphur springs, and oil springs producing by evaporation a valuable asphaltum. I shall have more to say of this and other features of the Wind River Valley on some future occasion.

Fine exposures of the Jurassic and Cretaceous rocks are seen in the outlying ridges of the Owl Creek Mountain system, with numerous fossils. A species of the Lamellibranch genus *Gryphæa* is remarkably abundant in the Jurassic limestones, which are here nearly vertical.

The fresh water Tertiary beds jut against the older deposits almost exactly as those of the Green River basin overlie the red sandstones of the Uintah Mountains, and like them they are nearly horizontal. In composition, they are buff sandstones and conglomerates, with a few beds of marls and limestones; the irregular but excessive erosion to which they have been subjected has left them so poorly exposed along our route as to make their study quite difficult. Enough material has, however, been gathered to determine their age, and probably to divide these beds into groups. I can only say at present, that the evidence seems to point toward a division of the series into at least two groups, the latter being characterized by the occurrence of shore deposits of soft sandstones and conglomerates in beds of considerable thickness, which contain scarcely any fossils, and which it may not be hazardous to regard as Upper Eocene. The upper group would then be made to include a considerable thickness of interstratified marls and laminated calcareous beds rich in the remains of land plants, apparently of Lower Miocene age.

* Dr. Hayden, "Geol. Surv. of Wyoming," 1870; "Geol. Surv. of Montana," 1871, refers coal beds of the same horizon to the "Lower Tertiary or Upper Cretaceous."

The metamorphic nucleus of the Owl Creek range is not well exposed, being covered, except in a few isolated localities, by the early sedimentary rocks.

Continuing our march, we crossed the three forks of Owl Creek, passing through an excessively rugged country, affording numerous exposures of the various sedimentary strata, as well as interesting studies in dynamical geology. I can scarcely imagine a more favorable locality for the study of surface geology than this section between the Owl Creek Mts. and the Stinking Water River. I have said nothing of the magnificent terraces, the enormous deposits of the drift, the cañons and gorges cut by the streams, nor of the no less interesting proofs of the power of the wind; and yet these are but the half of the agencies whose actions are here so plainly indicated.

From Grey Bull River to the Stinking Water Valley our course lay through a less rugged country until we reached an eminence which gave us a view of some of the minor tributaries of the South Fork, when we were obliged to descend by a very steep trail to the valley below. From this point our march was comparatively easy to the north branch of the South Fork, which we ascended to its source in the mountains east of Yellowstone Lake. Passing through a narrow pass in this range, we descended on the other side to the lake, then marched down the Yellowstone River to the bridge, and crossed, a portion of the party visiting the hot springs of Gardiner's River. From the bridge we passed up the river to the falls, from which point we struck across westward, over the divide to the East Fork of Madison River, thence through the Lower and Upper Geyser Basins of Firehole River. Ascending the Firehole River, we then crossed the divide to Yellowstone Lake at the Sonthwest extremity, following pretty closely its shore until we reached the Upper Yellowstone River, which we ascended to the "Two Ocean Water." This is a mountain stream which flows down into a little valley, where it curiously splits into two rivulets, which shed their water, the one into the Pacific Ocean by way of the Snake and Columbia Rivers, the other into the Gulf of Mexico via the Yellowstone, Missouri, and Mississippi. Descending for a short distance one of the tributaries of Snake River, our Indian guide *To-goh-te* led us through an easy pass to the head-waters of Wind River, down which we marched, returning to Camp Brown to disband.

The head-waters of the Stinking Water,* rising in the very

* It is to be regretted that many of the geographical names in the West are so often repeated, rendering it difficult to distinguish between localities, without tedious explanation. For instance, the names Muddy, Sandy, Clear, Dry, Sage,

rugged range of volcanic origin east of the Yellowstone Basin, have cut narrow cañons through this material for a distance of more than seventy-five miles, affording rare opportunities for the study of the effects of subterranean forces. The great mass of the range is made up of a volcanic breccia, with numerous dykes and veins of porphyrite, and hornblendic trachyte. This material in some places covers unconformably the underlying aqueous rocks, thus proving its age, as would seem probable, to be later than the Cretaceous. But there is evidence, again, which points to outflows at a much earlier date; and, while there are proofs of eruptions between the close of the Cretaceous and the deposition of the Pliocene beds, there is also conclusive evidence of the outpouring of igneous material upon these same beds of Pliocene age. I do not claim that I have been able to unravel the whole of this intricate problem, but I am confident that sufficient material has been collected for a more complete elucidation of this subject than it would have been possible to reach without a survey of the section traversed during the past summer. I am extremely loth to commit myself to any decided opinion, however, until I can make a more complete study of notes and specimens.

The minor volcanic phenomena of geysers, solfataras, and hot springs, so abundantly manifested within the area reserved for the National Park, have received their due share of attention, and a large quantity of material has been collected for study. This leads me to speak of another important branch of geology, too frequently overlooked, I think, in our surveys, and yet a department of the science, as interesting as it is important, i. e., chemical geology. Throughout the trip, I have taken special pains to observe, and collect as much material as possible in this department, and I believe that I have succeeded in obtaining much valuable information by this means, which would otherwise have escaped my notice. Some interesting facts concerning the formation of chalcedony and the moss agate, the deposition of the so-called "alkali," and the silicification of the immense quantities of "petrified" wood in this region, have thus been collected, besides a mass of material concerning the erosion and weathering of the rocks, and the forces affecting or affected by the physical geography of the country. One fact, which I consider of much importance, is the abundance of ozone in the atmosphere, to which I trace much of the external reddening of many of the yellow and brownish sandstones containing iron.

Cottonwood, Beaver, etc., are each used to designate several streams within a comparatively small area. It is therefore necessary to note that the Stinking Water River to which I refer in this paper, is the important tributary of the Big Horn (Lower Wind) River, by that name, and *not* the tributary of Jefferson River, which bears the same name.

The comparatively recent discoveries of immense deposits of coal in the Rocky Mountains makes the study of its modes of occurrence, its quality, and the conditions of its formation, a subject of great economic and scientific interest, which it is desired to present in the most satisfactory manner. For this purpose, specimens from all of the important outcrops along our route have been carefully obtained, and minutely recorded. Having some opportunities for observation and study of the language, manners and customs of Washakie's band of Shoshones or Snake Indians, I was enabled to collect also a few notes, which may serve, in a small way, to assist in preserving some records of their peculiarities, ere the onward march of civilization shall forever, by conquest or assimilation, destroy their *Indian* charateristics. All of these subjects, when properly elaborated, will be incorporated in my report to the chief of the expedition, to be given to the public in due time.

In conclusion, my thanks are due to each member of the party, including the officers of our escort (Company I, 2nd U. S. Calvary) and to the officers and others at Fort Bridger, Camps Stambaugh, Camp Brown and Fort Ellis, to whom I am indebted for kindnesses too numerous for recital.

Cherishing the hope that my humble labors in the cause of science may prove of some value to others, I leave this resumé in the hands of my fellow-workers for their verdict.

Cleveland, O., Oct. 25, 1873.