ART. XXII.—*Explorations of* 1872: *U. S. Geological Survey of the Territories, under Dr. F. V. Hayden; Snake River Division.**

THE party gathered at Ogden, Utah, during May and June; and its scientists explored a considerable stretch of territory in the neighboring portions of the Wahsatch Mts.. while animals and supplies for the season's work were slowly got together.

Upheaval and folding have here proceeded on a vast scale, the main front ridge of the Wahsatch range consisting of an immense anticlinal, somewhat complicated on its front (western) face by subordinate folds, which would be apt to confuse one who passed hastily over them. Except where portions of these folds remain, the front of the ridge is here mainly composed of gneissoid rocks, showing strong westerly dips: while the crest and eastern slopes are composed of quartzites and limestones, also with strong dips but easterly ones. The general section of these upper strata is as follows:

1. Gray and drab limestones, largely siliceous	3000 ft.	Carboniferous.	
2. Ferruginous quartzites	2000 to 2500 "	Devonian?	
3. Blue and gray magnesian limestones, part pebbly	1900 to 2000 "	} Upper? and	
4. Gray calcareous shales	1000 to 1200 "	} Lower Silurian.	
5. White and ferruginous quartzite, base pebbly	1500 "	Potsdam.	

From discoveries made farther north, it became evident that at least the lower part of the limestones of No. 3, together with

* This notice has been prepared for this place by Prof. Frank H. Bradley, Geologist of the Expedition in the Snake River Division.

probably the whole of No. 4, must belong to the Quebec Group. The upper part of No. 3 may possibly represent the Upper Silurian, since the characteristic Niagara coral, *Halysites catenulatus*, was obtained by Dr. Hayden, in 1871, in Box Elder Cañon, about 25 miles north of Ogden, from a bed of limestone which appears to belong to this member of the section. The quartzites of No. 2 give no indication as to their age, but are referred to the Devonian merely on account of their relative position. The Carboniferous limestones of No. 1 are in some places quite fossiliferous, though mostly not so. On a hasty trip to the mining districts of Little Cottonwood Cañon, about eighteen miles southeast of Salt Lake City, the lower part of this series of limestones was found to include some layers containing Subcarboniferous fossils allied to or identical with forms common at Spergen Hill, Indiana.

Leaving Ogden on June 24th, the party followed the roads running north along the base of the Wahsatch Mts., crossing Bear River just below the point at which it breaks through the range, and reaching the divide between the Great Basin and the Columbia drainage, at a point on the Montana stage-road, about eight miles above Malade City. As we pass northward, the range loses much of its elevation; and, about Malade, the upper strata disappear, while the mass of the mountain is composed of variously-colored limestones, with intercalated shales and sandstones, most of which contain very numerous Trilobites, Brachiopods and other fossils characteristic of the Quebec Group. Mr. Meek is of the opinion that the fossils, so far as studied, will not justify a reference of the beds to an horizon higher than what has elsewhere been called Calciferous, though he admits the impossibility of distinguishing certain pygidia, which are rather common in one of the lower layers, from those of *Bathyurus Saffordi*. About 2,000 feet of strata are here exposed: and it is probable that more detailed study than it was possible to give, at the time of our visit, would show a distribution of species in the successive layers which would correspond with progress in time during their deposition. As Malade City is only a few hours ride by stage from Corinne, it is to be hoped that collectors, who may be passing over the Central Pacific R. R., will visit the locality and work out the details of the section.

The terraces surrounding the Salt Lake Basin, of which thirteen were counted near the mouth of Ogden Cañon, where the river currents had been checked by the lake when at its higher levels, though only three are prominent along most of the border of the basin, run above Malade City; and the uppermost one apparently coincides so nearly with the summit of the divide as to leave one in doubt whether or not there was

formerly a dribbling outflow from the Great Basin to the Columbia. There certainly was not any very *abundant* outflow at this point: but, from all reports, large outlets did exist, from the head of Malade River across to Bannock Creek, and from Bear River, by the way of Red Rock Pass, to Marsh Creek, a tributary of the lower part of Port Neuf River. Still another outlet existed, though it probably had but small volume, from the bend of Bear River Valley, near Soda Springs, across to the head of the Port Neuf. These should be examined in detail. In descending Marsh Creek, two terraces are very prominent; and a third is dimly outlined at about a thousand feet above the stream.

On reaching the Port Neuf, we first encounter the volcanic rocks which have filled the great plains of the Snake River Basin. The valley of the Port Neuf is floored with basalt, which escaped from one or more old craters near the bend of Bear River, and flowed between sixty and seventy miles, at least, if it did not indeed extend itself far beyond that, over the plains of the Snake. In the upper cañon of the Port Neuf, the stream flows on or in the lava beds, being constantly broken, at short intervals, by small falls over dams of calcareous tufa deposited from numerous springs along its course: but, in the lower cañon, it has fewer breaks, and runs mostly in channels excavated in the Quebec Group limestones and Potsdam quartzites of the adjoining hills, while the basalt stands as a high table in the center of the valley, broken only at the edges, where the stream has partly undermined it by removing the gravel of the old stream bottoms over which the lava originally flowed.

As we reach the plains, we find them underlaid by from three to five layers of basalt separated by beds of sand and gravel, showing as many repetitions of the volcanic eruptions, occurring after long intervals, during which intervals the mountain streams brought down and distributed widely over the plains immense amounts of well-rounded pebbles and sand, consisting mainly of quartzites, limestones and metamorphic rocks, but including also some of the lavas themselves. Upheaval has gone on here until a very recent period; since upturned porphyries and basalts, interlaminated with Pliocene sandstones and limestones, occur at many points along the foot-hills bordering the plains; but such disturbance seems to have now nearly or entirely ceased.

Reaching Fort Hall on July 3d, wagons were "turned in," a pack train was outfitted, fresh supplies were secured, and the party started again, on the 12th, across the broad lava plains to the northward, leaving for a time the Paleozoic rocks which form the mountain ranges and which are overlaid (unconforma-

bly?), about Fort Hall, by Jurassic limestones and sandstones and by the Pliocene rocks aforesaid. Vast accumulations of drifting sand cover portions of this eastern edge of the great plains, driven by the southwest winds which sweep up the valley for a large portion of the year.

Crossing Snake River, at Taylor's or Eagle Rock Bridge, the stage-road was followed to Market Lake, where the party bid adieu to civilization and struck out into the mountains. At the junction of Henry's Fork with the main Snake, two crater cones were found, standing upon the river bottoms within walls of basalt which bound the immediate valley of the present stream, and so evidently of comparatively modern date. The cones consist almost entirely of tufaceous sandstone, apparently formed under water, and inclosing many pebbles which evidently came from one of the beds of river gravel under the basalt, through which the eruption took place.

The Sand Hill Mts. were visited, and gave some evidence of having been once a volcanic crater, though the bounding walls are now so much broken down as to make their original continuity somewhat doubtful

In approaching the Teton Mts., the basalts, which are, in some parts, cut up by cañons 700 feet or more in depth, were left behind; and more ancient porphyries formed the foot-hills of the range. The axis of the range was found to consist of granites, gneisses and schists, overlaid unconformably by from fifty to seventy-five feet of compact ferruginous quartzite, supposably of Potsdam age, followed by about 300 feet of partly compact, partly shaly, glauconitic sandstone, and about 400 feet of blue, impure, thin-bedded and partly shaly limestones, both belonging to the Quebec Group. These limestones yielded a few small Trilobites. They are followed by about 600 feet of a heavy-bedded, drab to light buff, vesicular, magnesian limestone, containing no fossils except small fragments of crinoid stems, but referred with little doubt to the Niagara Group. This is followed immediately by over 2000 feet of compact, gray to drab, Carboniferous limestone, often quite cherty and mostly rather barren, though a few beds are rich in fossils.

Among the metamorphic rocks of the axis of the range, the most interesting bed is one of trap, some 60 or 70 feet thick, regularly bedded between layers of granite, laminated rather than columnar, and supposed to have been deposited by outflow over the ocean bottom during the accumulation of the original sediments of which the granites were formed. The great age of the bed, at least, is proved by its outcrop being covered, at one point, by the Potsdam quartzite, which shows no sign of disturbance; so that it *cannot* have taken its pres-

ent place as an *intrusive* rock, since the commencement of the Paleozoic. The metamorphic rocks are exposed throughout an area about thirty miles long and perhaps four miles wide. From this, the newer beds dip away in every direction, at angles varying from 15° to 30°. No disturbance of the porphyries at the foot of the range was observed, which should have given evidence of any upheaval of the range continued to modern times.

The Big Teton, named Mt. Hayden by our party, in default of any previous specific title, was found, by angular measurement, from well-determined barometric bases, to be 13,858 feet high. An attempt to carry a mercurial barometer to the summit failed of success: the reported reading of a good aneroid, at the highest point attained, indicated an elevation of 13,400 feet.*

The summits of the range are far from being "snow-covered," as reported; but huge banks of snow must last through the summer, in the various hollows of the mountain; and, in a few places, incipient glaciation was observed, though no true glacier was found, and probably none exists at the present day. In former years, however, glaciers of great size formed on these flats and in these hollows, and swept down the valleys on either side of the range, as is shown by the polished and striated rocks in the heads of the valleys, as well as by the numerous large and small boulders which line their lower courses.

Leaving the Tetons, after far too brief an examination to be at all satisfactory, though as complete as the general interests of the survey would permit, the party turned back to the valley

* This is said to have been at the summit. The writer, who reached only 12,000 feet, is not prepared to decide whether the summit was reached or not. The description of a rude building upon the crest will give the means of deciding the question, whenever the ascent shall be made by trustworthy parties. There are great discrepancies between the statements of the two persons who claim to have reached the summit. Published descriptions of the ascent are evidently enormously exaggerated, at least. (See *Scribner's Magazine*, June, 1873.) For instance, a small pond, along the route of ascent, is said to have been covered with "twelve or fifteen feet of transparent ice." Snowy ice certainly appeared over a considerable part of it, but looked so rotten that those in advance, on the outward trip, thought it not safe to attempt to cross it; and, on our return, about 4.00 P. M., Mr. Stevenson and the writer went down to the edge of the pond and dipped out cup-fulls of water for drinking. Sharp ears must those have been which heard the "hollow murmur of a creek" which "must have been twelve hundred feet beneath the surface of the snow!" The ratio of statement to fact is not constant, in the report referred to; since an eruption of Giantess Geyser, in the Upper Fire-hole Basin, is therein reported at "two hundred feet or more"; whereas the writer took angular measurements of that particular eruption, and found it to be a few inches less than sixty-three feet. How Grand Geyser can eject a solid column of water, "eight feet in diameter," from an orifice less than two feet in diameter, is an interesting question in hydraulics! Our author probably holds that a magazine writer should aim at *astonishing* rather than *instructing* those who are "verdant enough to confide in his stories of mountain life;" but it does not yet appear how his publishers could allow an article which in so many points plainly contradicts itself to appear in so respectable a magazine.

of Henry's Fork, and followed the general course of that stream to its source in Henry's Lake. The central portion of the valley is constantly floored with basalt, which was finally traced to its source in Sawtelle's Peak, which stands on the south side of Henry's Lake. The crater of this ancient volcano is still from 1200 to 1500 feet deep, about a half mile wide and something less than a mile and a half long. The range running west from this point appears to consist of volcanic rocks; and probably a row of similar craters will be found along its summit.

The foot-hills and mountains along the east side of the valley of Henry's Fork, after we pass the northern termination of the Tetons proper, consist of porphyries and obsidian-sandstones, until we reach the very head of the valley, a little north of east from Henry's Lake, where the same series of limestones and quartzites that we saw at the Tetons again appears in the divide between the waters of the Snake and those of the Madison; but, instead of the conformity before observed, the Quebec Group limestones apparently lie unconformably over the upturned edges of the Potsdam quartzites. Beneath these, metamorphic rocks form the face of the ridge to the westward and northward. The ridge west of the lake is mainly composed of metamorphic limestones with quartz bands, which are supposed to be of Carboniferous age. These include a sixty foot bed of trap, standing conformably between the upturned layers of the limestone.

The divide toward the Madison rises into a rather lofty range, whose height was not ascertained, but which must reach at least a thousand feet above the average level of the plateau of volcanic rocks which fills the broad depression toward the Tetons. In crossing here to the waters of the Missouri, one has the choice of three easy passes, all level enough for a horse to cross with a buggy, at full trot, and only one of them at all obstructed by timber. Henry's Lake was found to have an elevation of 6492 feet; from its southwestern side, Red Rock Pass crosses to the head of Beaver Head Fork of the Jefferson, at an elevation of 7271 feet; from its northern extremity, Reynold's Pass leads to the lower Madison, with an elevation of 6911 feet; Tyghee Pass, with an elevation of 7063 feet, led our party eastward into the basin of the Upper Madison.

The upper cañon of the Madison shows some grand scenery —vertical walls, projecting cliffs and deep amphitheaters alternating on either side of the swift flowing river of transparent water, bordered by grassy banks, and overhung by dense groves of pine and spruce. At the mouth of Gibbon's Fork, the party saw the first of the boiling springs which are so abundant in this region; and, in a few miles more, the Lower Geyser Basin of the Fire-hole Fork was reached, at about 3.00 P. M., of August 14th. Dr. Hayden's party had arrived at this appointed

rendezvous, from Bozeman, about five hours earlier, a strangely close connection for trips of a month, without communication.

The geysers of the Fire-hole have been so fully represented in this Journal, that it seems best to pass them with but brief mention, and that rather upon generalities than upon particulars.

The bedding of the volcanic sandstone which forms the mountain boundaries of the basin indicates this as probably the site of an old crater of huge dimensions, whose eruptions long since ceased, but whose fires still heat the rocks at depths accessible to the waters which readily permeate these porous strata, and which escape in springs of various temperatures up to 200° or a fraction above the normal boiling point at this elevation.

At several points, masses of this volcanic sandstone are found perforated by irregular holes, evidently formed by solution of the siliceous ingredients in the escaping hot waters. By this process, degradation of the hills and enlargement of the basin are in progress. On the other hand, the deposition of various forms of geyserite from the siliceous waters is raising the floor of the basin, in some places; though, even here, the disintegration of the laminated deposit, by the combined action of sun and frost, and its erosion by large and small streams, will, on the whole, more than equal the increase. The deposition of the solid geyserite, which is far less soluble than the silica of the surrounding rocks, gradually stops up the vents below; and the flow is thus forced back to higher levels, and so constantly removes more and more of the bordering beds.

Besides the pretty regularly laminated deposits of the more quietly flowing water, there is great variety in the forms of deposition in the more turbulent portions. The immediate orifice of a geyser is almost universally beaded; and this character extends to greater or less distances, according to the distribution of the falling water. Surfaces that are frequently bathed in steam, without much spray, are nearly always pearly, as if the steam itself carried enough silica to form the extremely thin layers which are essential to pearly luster Surfaces constantly bathed in water, without much disturbance, are commonly covered with prickly points. In the little pools about the geysers, there are many concretions, more or less rounded below by constant attrition, and sometimes rounded also above, by constant rolling: but, more generally, the upper surfaces, and occasionally all, are roughened into very various beads and points. In nearly every pool, except where ebullition is so strong as to break up such tender tissues, there are gelatinous vegetable forms, sometimes in broad thick sheets, sometimes in clumsy branching forms resembling sponges, sometimes in long waving fibers. The former kinds are generally either green or

rusty-brown, and are most abundant in pools of comparatively moderate temperatures; while the more slender forms are commonly white, and are most abundant in the rapidly-flowing outlets of the hot pools, where they are continually reproduced as the channels fill up with newly deposited silica which buries the older fibers, so that, in breaking the crust, we frequently find laminæ filled with moulds of the fibers, sometimes so closely set as to resemble the grain of silicified wood. The only other living forms seen in the hotter pools were a few larves of *Helicopsyche*, which were found in a pool of the temperature of 180°. Very numerous skeletons of Diatoms occur in the sediment of even the hottest pools; but no living ones were found in springs of much over 100°.

The process of silicification of wood and other tissues is well shown in many cases: all stages of the process may frequently be seen in the same pool.

The eruptions of a few of the larger geysers are accompanied by violent subterranean pulsations, from 70 to 73 per minute; while others give no sound, except that of the mere rush and splash of the water.

Neighboring vents exhibit various degrees of sympathy. In some cases, a large vent is surrounded by several small ones, which are active when it is quiet and quiet when it is active. Again, the large and the small may be active together and quiet together. Large vents side by side are sometimes in full sympathy and sometimes totally independent.

Dr. Hayden's party passed down the Madison on the 20th of August; but the rest of us remained in this neighborhood while supplies were brought from Virginia City. On September 1st, we started up stream, on our return to Fort Hall. About eight miles above Old Faithful, we came unexpectedly upon another basin of hot springs, with one large geyser mound, whose observed eruptions did not exceed about seventy feet in height. On the 4th, we reached the head of the stream, and spent the next day in camp, being detained by a snow storm. On the 6th, however, it cleared; and we crossed the divide to the eastward. In approaching the head of the Madison, we had expected to find within its basin the lake seen by Dr. Hayden in 1871, and named to him by his guides as Madison Lake; but we were disappointed. We found the source of the stream, however, in a pond covering about sixty acres, to which we were obliged to transfer the name Madison Lake. Upon crossing the divide to the larger lake, we found it to belong to the Snake River drainage, and therefore called it Shoshone Lake, adopting the Indian name of the Snake.

At the western extremity of the lake, we found the valley of its principal tributary occupied by a large number of hot springs,

including several geysers of moderate size. One of these showed more plainly than common how dependent the eruptions are upon the supply of water. In this, which was called the Minute Man, a series of eruptions commences with strong jets reaching from 30 to 40 feet in height. These are repeated, at intervals of from one to three minutes, for two or three hours, gradually losing force and lengthening their intervals, until the supply of water is exhausted, when they cease for about the same period. The basin and crevices having become filled again, another series of eruptions commences. Part of the water erupted, instead of flowing away, is conducted by surface channels to the back of the geyser mound, where a large opening admits it again to the inner cavities; and, as soon as, by its flow, these are again filled to a certain point, another eruption takes place. As the supply of water gets low, eruption takes place by both vents, which indicates the end of the series of eruptions. From this it appears probable that the *constant* eruption of Steady Geyser, in the Lower Firehole Basin, is due to its standing in a large pool which keeps its cavities constantly full. The *rationale* of geyser action, as given by theorists, is not satisfactory to the writer, but he is not now prepared to fully present his own views, formed solely from observation of the phenomena. It is to be hoped that means may be found, ere long, to locate a small corps of observers in this region for an entire season, so that the details of the different forms of eruption may be fully studied. If their force and period are found to be in all cases dependent upon supply of water, as above suggested, it would be an interesting experiment to surround one of the larger geysers with a water-tight retaining wall, so that erupted water should be constantly returned, and the eruption be made continuous or dependent upon the will of the exhibitor.

Shoshone Lake is surrounded by the remnants of an old gravel terrace, reaching 112 feet or more above its present level. About the mouth of the Geyser Creek, the sand and gravel materials of this terrace are more or less firmly cemented into conglomerate, porous sandstones and perfect quartzite, by deposits from the hot springs evidently made while the lake covered the terrace, the pressure of its waters probably being sufficient to check the flow of the springs which, if not so checked, would have removed the sands instead of consolidating them. Since the decline of the lake to its present level, erosion by the springs has gone on quite extensively, and is still progressing. Perforated bits of the terrace rocks and of the surrounding volcanic sandstone, like those before mentioned as occurring in the Firehole Basins, are abundant in the crater-like hollows north of the principal springs, which also show many sulphur-vents.

Shoshone Lake is about eight miles long; and its form resembles the outline of a well-filled purse. It is apparently quite deep; but its depth was not ascertained. From its eastern extremity, a large stream flows eastward, about three miles, to another lake, hitherto unnamed so far as known, which was now called Lake Lewis, in memory of Capt. Merriwether Lewis, who would otherwise be without memorial in the region which he was the first to explore, since "Lewis's Fork" of the Columbia has now reverted to its Indian name of Shoshone or Snake River. This is about two and a half miles long and from one to one and a half miles wide. The greatest ascertained depth is 108 feet. From its southern extremity, its outlet, which was called Lake Fork, flows directly south.

Leaving the main train to move southward, a surveying party passed eastward to Mt. Sheridan, the culminating point of the Red Mts. This is about 10,420 feet above the sea, and is surrounded on all sides by deep valleys, so that wide views are attainable from its summit; 475 distinct mountain summits were counted around the horizon. It also gave fine views of all the surrounding lakes, of which a small one, Lake Riddle, lies in the summit of the divide between the Yellowstone and Lake Lewis, at an elevation of 7999 feet, while Lake Lewis itself is 7750 feet, and Yellowstone Lake is 7788 feet above the sea. The lowest point of the actual divide was located at 25 feet above Lake Riddle, or 8024 feet above the sea.

Moving southward from Mt. Sheridan, the region about the ultimate sources of the main Snake was pretty thoroughly examined, the principal streams being named, for convenience in describing and mapping. Here, at length, we escaped, for a time, from the volcanic rocks which had surrounded us ever since leaving Tyghee Pass, and found ourselves among fine-grained Tertiary sandstones. Along the waters of Barlow's River, these strata include some thin seams of coal, but of no value.

The ultimate source of the main stream of the Snake is a small pond on a flat divide between that stream and Buffalo Fork. On the west side of this divide, a sharp ridge, rising about 500 feet, shows a face of quartzite gravel reaching to its very summit, where the deposit is just pierced by an outcrop of the gray trachytic lavas and red basalt, which form the nucleus of the ridge. This is one of the highest points in the immediate neighborhood, being about 8654 feet above the sea; and there was nothing to indicate, with any certainty, what had been the source and course of the large river which had distributed such immense amounts of gravel. Only the general levels imply a southern source and a northward flow. Erosion has taken place since on so grand a scale that one is compelled to consider the deposit very ancient.

Between this point and the great valley along the eastern front of the Teton range there lies a heavy body of mountains, which appears to be the "main range" of the Rocky Mts. at this point, *if such a thing exists*. At least, it is a part of the *highest mass connection* between the Wind River and Big Horn Mts. on the east, which form the northern termination of what is the main range further south, and the range west of the Three Forks of the Missouri, which there bears the name of Rocky Mts., and whose continuation really appears to be the main range further north, so far as the best maps indicate. This, of course, does not coincide with the water-divide, which curves far north above Lake Lewis and far south around the heads of the Jefferson.

After an examination of the sources of the tributaries further west, the main Snake was again reached, about twelve miles from its source, where it is already a large stream with high gravel terraces along its banks, and was followed to its junction with Lake Fork, where the main party were in camp. A few miles above this point stratified rocks were again found, consisting of Triassic? red shades and sandstones, followed by a nearly white limestone, probably of Carboniferous age. These are at one point crossed by a huge bed of basalt, filling what had probably been a stream valley through the older rocks before the eruption of the volcanic material from some vent of the Red Mt. range. At the upper edge of this belt of basalt there is a small basin of hot springs, once of considerable importance, but now nearly extinct. Other groups were found near the mouth of Lake Fork.

In descending from Lake Lewis, the Lake Fork was found falling rapidly through a narrow cañon, whose nearly vertical walls in some places reach the height of 700 or 800 feet, while not over 400 feet apart at the top. These are all of dark-colored volcanic rock.

The low divide toward the valley of Henry's Fork was examined with some care. A large stream, Falls River, bursts full-grown from the slope of the high terrace of porous obsidian-sandstones lying north of the divide, passes through the more northern of the two Beulah Lakes, and rushes rapidly downward toward Henry's Fork. From any one of several points along the first two miles of its course, this stream might easily be turned eastward into the main Snake; and the divide on the east side of the Beulah Lakes is only eight feet above the surface of the more southern one. The rocks of the divide are all volcanic.

This pass probably affords the best line of approach to the Yellowstone from the southwest. The average grade from Henry's Fork to the summit is about 54 feet to the mile.

From the mouth of Lake Fork, the valley of the Snake widens rapidly and soon spreads out into the basin of Jackson's Lake, a body of water about eight miles long and from two to three miles wide, shallow in its eastern portions, but deepening rapidly toward the west, where the foot slopes of the Teton range descend sharply into its waters. The deepest of a very incomplete set of soundings was 258 feet.

A few miles north of the north end of the lake, the Tetons begin to rise from the flat divide of Falls River; and their slopes show Silurian and Carboniferous limestones overlying the central mass of metamorphic strata, as on the western side of the range. The Potsdam quartzite was not seen here, but is probably in place. The knobs of the central portion of the valley still show some of the volcanic rocks, though these occupy less and less space as we pass southward.

The outlet of Jackson's Lake is at its southeastern corner; and the outflow escapes into the valley of Buffalo Fork, instead of following what was evidently its natural channel through a terraced valley running from the southern extremity of the lake directly south through Jackson's Hole. This change of outlet was found to have been consequent upon the influx into the old channel of the sediment-bearing stream escaping from beneath the glacier which then filled a large two-pronged valley that here opens out of the mountains. A small lake, hemmed in by the terminal moraines of that ancient glacier, now fills the mouth of the valley. A similar lake lies before the valley which receives the entire drainage of the western side of the principal peaks of the Tetons; but it is not surrounded by any conspicuous moraines; and it is questionable whether the more abundant flow of water from beneath this glacier swept away the materials as fast as they were deposited, or whether they have been eroded by the stream since the glacier melted. Two other lakes of similar character lie in the mouths of cañons farther south, and are surrounded, the first by five and the second by three large moraines.

The Teton range, as seen from the west side of Jackson's Lake, is a grand one, rising as a wall to heights varying from 5000 to 7000 feet above the level of the plain. The snow patches were already on the increase (Sept. 24th,) and occasionally squalls would make the range really snow-*covered*, for a few hours.

Just below Jackson's Lake, Buffalo Fork emerges from the mountains, a deep rapid stream, with a broad open valley bordered by rounded hills for several miles. Fine-grained gray sandstones, probably of Tertiary age, appear near the mouth of the stream, for a short distance; but no rocks are then visible, until the point is reached, about twelve miles up stream, where

the hills on either side close in to sharp cañons, 400 feet deep by 200 feet wide, with coarse gray sandstone walls. These also are supposed to be of Tertiary age. At the head of the basin, a few miles farther on, there are high rugged walls of thin-bedded limestones and sandstones, probably of Quebec Group age, though possibly capped with Carboniferous.

The valley of the Gros Ventre, which is the first stream south of Buffalo, is narrow, with precipitous slopes on either hand, walled near its mouth by Carboniferous limestones and sandstones, which are followed above by Triassic (?) red shales and sandstones, Jurassic (?) gray and buff magnesian limestones, and Tertiary (?) white friable sandstones. A large butte which stands on the bank of Snake River, opposite the mouth of the Gros Ventre cañon, shows Carboniferous fossiliferous limestones, followed below by limestones apparently destitute of fossils, which are referred to the Quebec Group, and quartzites which are referred to the Potsdam. The southern portion of the butte shows only the soft Pliocene whitish sandstones and marls, which cover the place where we should naturally look for metamorphic rocks beneath the quartzites; but, from the strike of the upper rocks, it is probable that a metamorphic axis runs across here from the Tetons *toward, if not to*, the metamorphic nucleus of the Wind River Mts. A short distance south of this point, the metamorphics of the Teton Mts. disappear beneath the limestones which come forward from the western slope and which now form the mass of the range for several miles.

The South Gros Ventre Buttes, which stand on the bank of the Snake just below the junction of the Gros Ventre, contain the last outcrop of volcanic rocks seen in this basin. The upper slopes were not examined, in this neighborhood; and it is possible that, at a higher level, these rocks may continue southward: but the general appearance of the country gave the impression that this was their southern limit,—that, before their eruption, the drainage of the region flowed northward and escaped westward through the broad and deep valley which then existed beyond the northern end of the Teton range; that that eruption dammed up the waters over Jackson's Hole, so that the Pliocene sandstones and marls were deposited beneath the lake thus formed; and that the southern outlet across the southern continuation of the Teton range was subsequently eroded to its present level, during the progress of which erosion the terraces were formed which are here exhibited on a grand scale.

At the South Gros Ventre Buttes, the party again divided, the main train crossing the Teton Pass to Pierre's Hole, and striking the Snake again where it emerges from the mountains about twenty miles from Taylor's Bridge, while a surveying party followed the river through the so-called Grand Cañon.

This had previously a reputation for being a very difficult passage, but was found to be really very easy, compared with much that the party had already passed through. A railroad could be built here with very little difficulty. Triassic sandstones appear at the upper end of the cañon; but it is mostly walled by Carboniferous sandstones and limestones, until we pass the mouth of Salt River, a little below which the volcanic rocks of the outer basin make their appearance and follow the stream closely to the Columbia. The reunited party reached Fort Hall on October 11th, and soon after broke up. Its scientific members were the following: F. H. Bradley, geologist; G. R. Bechler, topographer; R. Hering, astronomer and meteorologist; Dr. J. Curtis, surgeon and microscopist; J. M. Coulter, botanist; C. H. Merriam, ornithologist, together with several assistants and collectors.