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[FROM AMERICAN JOURNAL OF SCIENCE, VOL. 243, OCT., 1945, PP. 527-549.]

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American Journal of Science

OCTOBER 1945

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ABSTRACT. The salient geographic features of southern Utah were briefly described and crudely mapped in 1776 by the Dominguez-Escalante Expedition. Additional information, especially for the Virgin River valley, was given by the fur traders—Jedediah Smith (1826) and William Wolf-skill (1830) and before 1870 the Mormon pioneers had explored most of Utah west of the Glen Canyon in search for agricultural and grazing land and sites for settlement. Scientific investigation resulting in maps, reports, descriptive of the topography, geology, plant and animal life, and mineral resources has been the work of Federal agencies beginning in 1853 in southwestern Utah, 1859 in the San Juan County and 1869 along the Colorado Canyon. It concerns chiefly the activities of exploring parties under the direction of Fremont, Macomb, Powell, Wheeler, Hayden, and the Geological Survey.

INTRODUCTION.

KNOWLEDGE of the topography, geology, and natural history of southern Utah came late, after adjacent regions had been explored—in fact, after most other parts of the United States had been represented by reconnaissance maps. By the middle of the nineteenth century northern Utah was fairly well known. Salt Lake was found by James Bridger in 1824, and during the decades 1830-1850 Green River, the Uinta Mountains, and the Wasatch Mountains were explored by trappers and prospectors, trading posts and military stations were established, and the old "Spanish Trail" through western Colorado and north central Utah was a much-used highway. For parts of this region maps and geographic descriptions had been prepared by Bonneville (1832-33), Fremont (1842-45), Stansbury (1849-50), Gunnison (1853), and King (40th Parallel Survey, 1868). Likewise, before 1860 the lands south of the Grand Canyon of the Colorado had been traversed many times by

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Spanish military and ecclesiastic officials, who left reports of their observations on scenic features, soil, climate, and especially the native inhabitants. The information recorded by Diaz (1540), Cardenas (1540), Oñate (1604), Carces (1775), Fout (1777), and other priests and adventurers, while traveling back and forth from Mexico or Santa Fe to California in search of suitable sites for missions, was greatly increased by the military and geographic explorations of Emory (1847), Derby (1850), Sitgreaves (1851-52), the United States and Mexican Boundary Commission (1849-1855), Whipple (1854), Parks (1855), and Ives (1857-58). Of the early Spanish explorers only Cardenas (1540) reached the Colorado River, and only Escalante (1776) crossed it. Likewise the pioneer scientific expeditions stopped at the brink of the Grand Canyon and saw little reason for going beyond. Thus Ives remarks: (1)*

"Ours has been the first and will doubtless be the last party of whites to visit this profitless locality. It seems intended by nature that the Colorado River, along the greater part of its lonely and majestic way, shall be forever unvisited and undisturbed."

For southern Utah the earliest geographic descriptions are by Escalante (1776) and the two energetic fur traders, Jedediah S. Smith (1826) and William Wolfskill (1830). But for nearly a century the famous "diary" of Escalante remained buried in the archives of Spain and Mexico. Smith's original account seems to have lain unnoticed in the government files until interpreted by Sullivan, (2) and the observations of Wolfskill have but recently been made accessible—chiefly by Camp who reproduces the record of Yount, a member of the Wolfskill expedition. (2a) For the 20 years that followed the establishment by Wolfskill of a feasible route to California, the exploratory record is barren; during this period no available manuscript or printed paper reveals knowledge of any part of southern Utah except along the Old Spanish Trail through Iron and Washington Counties. In fact southern Utah was practically unknown until systematic scouting by the Church of Latter Day Saints introduced the epoch of colonization.

Between 1850 and 1870 officials of the Church had become familiar with the water supply, the soil, and farm lands in Ash, Virgin, Parunuweap, Kanab, Johnson, Sevier, and Paria Val-

* Numbers in parentheses indicate the references at the end of the paper.

leys, and along the base of the Hurricane Cliffs; with the timber and grazing resources on the Markagunt and Kaibab Plateaus and Pine Valley Mountains; and with the grass lands on the Kolob Terrace and south of the Vermilion Cliffs. Before 1880 the potential agricultural resources of the Upper Sevier, the Escalante, and the San Juan Valleys were known. For the purpose intended—primarily the selection of sites for settlement—these Mormon explorations were remarkably complete. On them were based the developments that have given southern Utah its unique position among regions dependent on irrigation farming and stock raising. However, these surveys were concerned almost wholly with matters that immediately affected the welfare of the adventurous pioneers and therefore in a geographic sense lacked many desirable features. They are represented in the literature by brief newspaper items that say almost nothing of the topography and drainage and are unaccompanied by maps. Notable exceptions are the records of the expedition led by Parley P. Pratt (1851) into Ash Creek, Santa Clara, and Virgin Valleys; the report of the master scout John D. Lee and his associates (1852) that made known the geographic features of Markagunt Plateau, the upper Parunuweap Valley, and the Vermilion Cliffs; and the account of Capt. James Andrus (1866) of his journey up Paria Valley and into Potato Valley (Escalante Valley); and the several reports of Jacob Hamblin that concern his search for feasible crossings of the Colorado canyons, finally resulting in the establishment of Lees Ferry (1870). Thus it has come about that the scientific knowledge of southern Utah—mapping and the description of the topography, geology, plant and animal life, mineral resources—is recorded by Federal surveys, beginning 1853 in southwestern Utah, in 1869 along the Colorado canyons, and in 1859 in the San Juan country. It concerns chiefly the work of parties under the direction of Fremont, Macomb, Hayden, Wheeler, and Powell.

It seems worthy of note that the first systematic records of the geography and geology of the Colorado plateaus were made by the United States Army during the course of military surveys and the search for feasible railroad routes from the Missouri River to the Pacific. Recognizing the Colorado canyons as impassable barriers, most of the Army expeditions passed through central Arizona or northern Utah. Only those led by Capt. John C. Fremont, Captain J. N. Macomb, and Lt. George

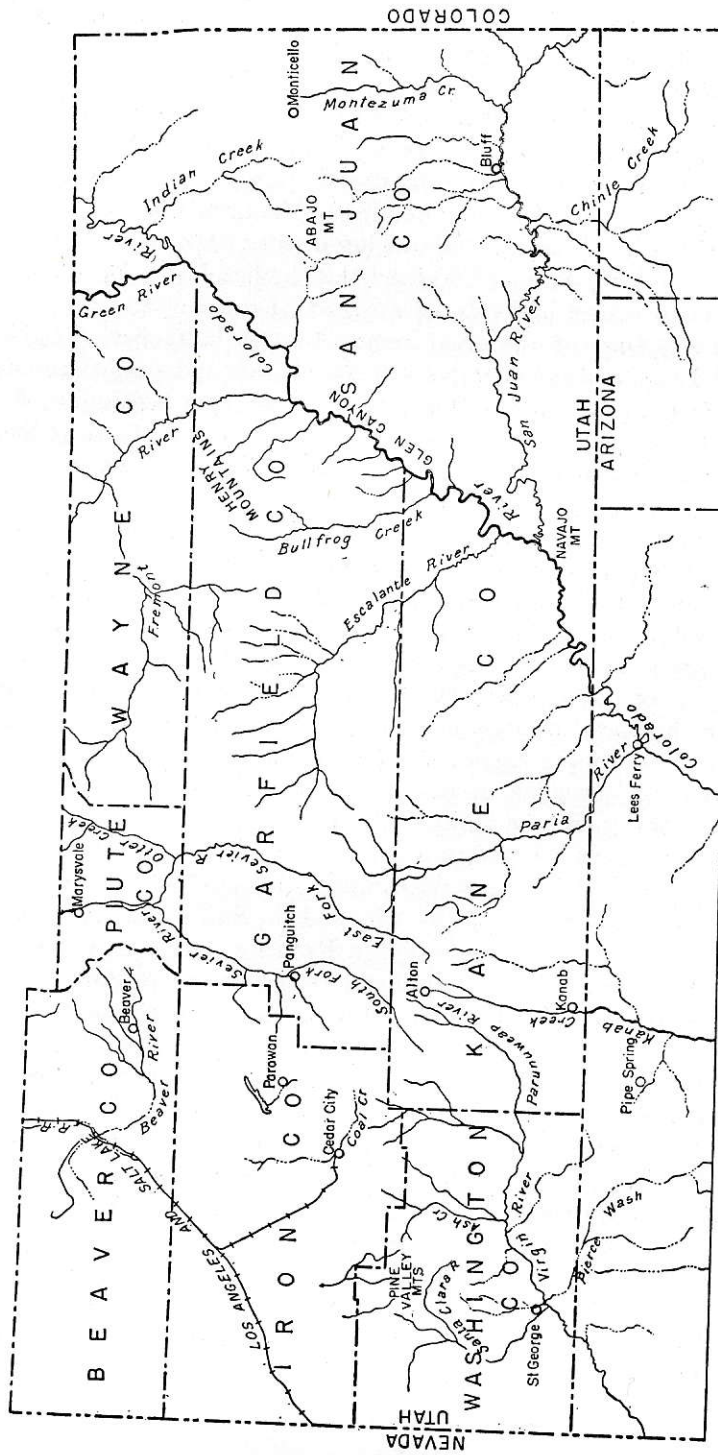
M. Wheeler conducted operations in southern Utah and in Arizona north of Grand Canyon.

EXPLORATIONS WEST OF GLEN CANYON
ENTRADA OF ESCALANTE.

The diary of Escalante (1776) and the accompanying map outline for the first time the salient topographic features of southern Utah and northern Arizona. (3) Most of the descriptions in the text, though brief and written in unscientific language, apply fairly well to the landscape of eastern Iron and Washington Counties and of Kane and San Juan Counties as analyzed by more recent surveys, and on the crudely drawn map the major mountain ranges, the rivers, and the cliffs are shown in their approximate positions. Features recognizable include the Hurricane Cliffs south of Cedar City, Ash Creek Valley (N. S. Pilar, Rio de Nuestra Senora de Zaragoza), Pine Valley Mountains, Toquerville (S. Ugolina), Virgin River (Rio de les Piramides Sulfurio), Fort Pierce Wash (?) (Arroyo de Tarai), Uinkaret Mountains, northern Uinkaret Plateau (Este la Mesa y sin Aqua), Pipe Springs (Jubuin Cariri S. Samuel), Kanab and Johnson Valleys (Sta. Barbara), Navajo Wells, the Kaibab Plateau, lower House Rock Valley (S. Bartolome), Paria River (Rio Santa Teresa), Sentinel Rock Creek (Rio San Diego), and the Indian ford across the Colorado (El Rio Grande Colorado) now known as the Crossing of the Fathers. On the map the rugged lands in the Zion Park region (Sierra Blanca) and the Kaiparowits Plateau are represented and also the Table Cliffs (Sierra de los Suacaros) as seen from a distance of 40 miles.

FREMONT EXPEDITIONS.

On his second expedition to California, Capt. John C. Fremont spent two months (August and September, 1843) in northern Utah. His return route followed substantially the "Old Spanish Trail" along Virgin River, Santa Clara River, and the base of the Wasatch to Timpanogos Lake, renamed by him Utah Lake. In passing over the Beaver Dam Mountains, and up the Santa Clara River and Magotsu Wash to Las Vegas de Santa Clara [Mountain Meadows] in the present Washington County (May 10-16, 1844), Fremont noted the marked change in vegetation, topography, and geologic structure: the mountains "here began to be wooded with cedar and pine and clusters



of trees gave shelter to birds—a new and welcome sight—which could not have lived in the desert we had passed. . . . The stream [Santa Clara River] is prettily wooded with sweet cottonwood trees . . . a different species from any in Michaux's Sylva . . . the snowy mountains on our right [Pine Valley Mountains] showed out handsomely—high and rugged with precipices, and covered with snow for about two thousand feet from their summits down." In crossing the low divide at the head of Mountain Meadows, Fremont realized that he had left the Colorado drainage system and entered a region of interior drainage, the southern edge of the great region that includes Sevier Lake, Salt Lake, and innumerable salinas, playas, and rugged mountain masses between the Wasatch and the Sierra Nevada. "We considered ourselves as crossing the rim of a basin." For this vast area he adopted the term "Great Basin" which has become fixed in geographic literature.

On his second expedition (1843-44), also on his third expedition (1845-47), Fremont followed few trails not previously traversed by Santa Fe traders. His chief part in "breaking the wilderness" was observation and painstaking record and the preparation of comprehensive reports which aroused the interest of government officials, of scientists, and laymen. On his fifth expedition (winter of 1853-1854) undertaken to locate "a central route" for a railroad to the Pacific, Fremont traversed new country in eastern Utah and in southern Utah visited the stockaded villages of Parowan and Cedar City—the first permanent settlements (founded in 1851). His route crossed Green River near the mouth of the San Rafael—south of previously known crossings—followed the San Rafael River for a distance, then the front of San Rafael Swell to an unknown river (Fremont River) and up the river through Rabbit Valley to the Awapa Plateau south of Fish Lake. The route then led down Otter Creek (Grass Valley), down the East Fork of Sevier River, and up the Sevier to Circle Valley, and across the southern Tushar plateau to the Salt Lake-California road. The brief account of this traverse by Fremont (3a) supplemented by Carvalho, (4) artist to the expedition, and by Bigelow (5) is a story of endurance and resource.

"After we crossed the Green River the whole party was on foot." The horses were used for food. Before reaching the Sevier "we lived on horse meat fifty days." To release the pack mules for riding, all "superfluous baggage was cached—

pack saddles, bales of cloth, travelling bags, scientific instruments, gun powder, and lead; nothing was to be retained but the actual clothing necessary to protect us from the inclemency of the weather." The last stages of the journey, three days of wandering through the mountains northwest of Panguitch, was particularly hazardous. Over rough ledges through snow "up to the bellies of the animals" with "temperatures below zero" a trail was broken. "None of us had shoes; some of the men had raw hide strapped round their feet, while others were half covered with worn out stockings and moccasins. We were reduced to rations of dried horse meat" and "forty-eight hours without food of any kind." On February 7 the party entered a "defile of the mountains" (now known as Fremont Pass) and, following "the dry bed of a stream," found ruts of wagon wheels on the plain below (Buckhorn Flat). The next day the stragglers reached the settlement of Parowan, but in desperate plight. "The whole of my party were all exhausted and broken up." Several of the men had to be carried. One died on the trail. "At Parowan the Mormons treated us very kindly; every family took in some of the men, putting them into clean, comfortable beds, and kind-faced women gave them reviving food and pitying words." In a letter to his sister Fremont wrote, "The Mormons saved me and mine from death by starvation."

In an account of this expedition the *Deseret News* (July 5, 1854) reports: "the two Spaniards which Fremont sent back for some cached articles had been killed. * * * Soon after the Spaniards took out the articles, some Indians rushed upon them, killed them, and took the property, scattering the contents of the mail sacks and destroying the surveying instruments." On February 21, 1854, Fremont continued his journey to California with such members of his expedition as were able to travel, the sick remained at Parowan for several months or were taken by wagon to Salt Lake City for special treatment.

The widely distributed reports of the Fremont expeditions are outstanding contributions to western history. They had no small influence in the controversies that led to the acquisition by the United States of northern Mexico—lands in the present Arizona, Utah, Nevada, and California, and they are known to have influenced the Mormons in their choice of a field for colonization. Unlike the trappers and traders who left scant record of their travels, Fremont mapped his route, made astronomical observations for latitude and longitude, collected

plants and geological specimens, (studied by John Torrey and James Hall), and recorded information regarding forage, timber, water supplies, and the native inhabitants. His account is a straightforward geographical narrative. "The report like the maps which illustrate it will be strictly confined to what was seen, and to what is necessary to show the face and character of the country, and to add something to science while fulfilling the instructions of the government which chiefly contemplated a military topographic survey." (6)

WHEELER SURVEY.

The Wheeler Survey (officially the U. S. Geographic Surveys West of the One Hundredth Meridian in charge of Capt. Geo. M. Wheeler), was the most extensive and elaborate scientific investigation ever undertaken by the Engineer Corps of the United States Army. Though not organized on a regional scale until 1872, the Survey was in reality a continuation of the exploratory expeditions in 1869 and 1871. As described by Wheeler (7) the survey authorized by Congress (June 10, 1872)

"was a plan substantially for a complete, connected, continuous, detailed topographic survey (with associated natural history observations) of the territory of the United States west of the one hundredth meridian with primarily a resultant topographic map, scale 1 inch to 8 miles, to be in the main an aid to military administration and operations, to occupy about 15 years and to cost in all not exceeding \$2,500,000 . . . It was to have been the first great general survey of the country during its initial stages of settlement."

This ambitious project for detailed mapping, evaluation of the natural resources, and description of the geology, botany, and zoology within an area of 1,443,360 square miles was not completed, but before field work ended (1879) and the compilation of maps and reports was discontinued (1884) the survey had made an invaluable contribution. The 50 published sheets of the Wheeler topographic atlas cover 326,891 square miles and manuscript sheets an additional 31,174 square miles—areas that embrace 66 per cent of New Mexico, 54 per cent of Arizona, 32 per cent of Colorado, 46 per cent of Utah, 60 per cent of Nevada, 41 per cent of California, and considerable areas in Idaho and Oregon. The larger illustrated volumes on geology, paleontology, zoology, botany, and archeology are introduc-

tions to fields of great scientific interest, and the 9 annual progress reports, 18 special reports, and the final comprehensive report (1886) give information about mineral deposits, timber, arable land, grazing areas, water supply, routes of travel, and native races that must have been welcomed by the host of immigrants who sought homes west of the Rockies. The reports and recommendations served also as guides in legislation.

In southern Utah studies were made by the Wheeler Survey in 1871 and 1872. In 1871 the lower Virgin River Valley was mapped; in 1872 the Survey staff of 25 scientists and engineers, 6 officers, 50 privates, 2 guides, and a score of packers, herders, and laborers mapped the region northward from the Grand Canyon well onto the High Plateaus and eastward from Nevada to the Crossing of the Fathers in Glen Canyon. Regarding his pioneer traverse of the Markagunt Plateau Wheeler (8) writes:

"Skirting the rim of the plateau a break in the wall is finally found, and the train taken down into a box canyon along a descent having an angle of fully 55° at the head of La Verken Creek. The summit of the southern rim (of the Markagunt Plateau), at an altitude of over 10,000 feet, affords one of the finest panoramic views then witnessed (1872)—the Virgin River lying at our feet, the Colorado Canyon in the distance, plateaus, canyons, and mountains to the east, mountains high and frowning to the north, and the mountains and desert to the west and southwest, the ranges bordering the Colorado, especially the Virgin. Below us lay the brown and black bristling ridges of the eroded mesas that for grandure of beauty and desolation of appearance far surpass all that words can express. Clambering along the cliff, and while securing a large haul of fossils, the crisp edge of coal crops was noticed, and prospecting which a 12-foot vein of dense bituminous coal, having both above and below a bed of shale 15 to 18 inches thick, was found, with petrified wood strewn in many directions. Fossils were found in sandstone. . . . Usually volcanic material appears on the surface of the Colob [Kolob Terrace] with occasional limestone, sandstone, and shale. There is a fine growth of grass and groves of quaking aspen."

In Long Valley (Parunuweap Valley) Wheeler followed a primitive wagon road through Glendale and Mount Carmel and on down the Parunuweap Canyon to "6-mile turn," then finding that further progress downstream was impossible for horses he ascended the canyon wall, crossed the rough, arid Moccasin

Terrace and finally reached Shunes Mountain below which the river was again in sight. In desperate need of water his party scrambled down the canyon wall to the little settlement of Shunesburg 2,000 feet below. Wheeler says:

"Our coming created a sensation, as no party, except on foot, had ever been known to pass this route, unless it were an adventurous mail-rider with a trusty-led mule, in case of great emergency. Nothing short of considerable blasting could render the trail passable even for pack animals."

A drawing of the "Wriggle Trail" at Shunesburg (reproduced as plate 55 in the Wheeler report) is the first known illustration of the great rock walls of Navajo sandstone that dominate the landscape of southwestern Utah.

The geologic work of the Wheeler Survey was done chiefly by G. K. Gilbert and Edwin E. Howell. Of his three years service with the Wheeler Survey (1871-1873), Gilbert spent the first in Nevada and western Arizona, the second in southwestern Utah and northwestern Arizona, and the third in New Mexico and eastern Arizona. In Utah (1872) he spent some days on the south rim of Markagunt Plateau, traversed for the first time the Virgin River from its source in the Pink Cliffs below Navajo Lake, through Zion Canyon, Timpoweap Canyon, and on to St. George; followed the Vermilion Cliffs through Cane Beds, Pipe Springs, Kanab, and eastward to the Paria; and made special studies of the Kaibab fold, of the Sevier fault, and the Hurricane fault. In his field notebook (1872) Gilbert makes some interesting comments.

"At Zion (Springdale) we furnished our own blankets and slept on the floor. At Rockville the same except we were furnished pillows. At Mt. Carmel we were given extra blankets and the lee-side of a corn stack. At Toquerville I slept in a wagon box with the boy; at Workmans Ranch [Goulds Ranch] on the ground with the boy again. At Kanab in a bed on a bedstead alone; at Allendale (Glendale ?) ditto with the boy.

"The north fork [of Virgin River] has opened a valley in the Cretaceous, but too narrow for cultivation. From the foot of this valley to the hamlet of Little Zion, the stream traverses, in the most wonderful defile it has been my fortune to behold, the massive sandstone of the Gray and Vermilion Cliffs, here combined in a single undistinguishable body, certainly not less than 2,000 feet in depth. At the head of 'The Narrows' the top of this bed is at the water's edge; and, as the strata rise, and the stream descends southward,

the height of the canyon walls gradually increases, until it includes the entire mass of sandstone (in Zion National Park). At the water's edge the walls are perpendicular, but in the deeper parts they open out toward the top. For a number of miles the bottom of the cleft averages 30 feet in width, contracting frequently to 20, and in many places is entirely occupied by the stream, even at its low stage."

Howell, who served two years with the Wheeler Survey (1872, 1873) and one (1874) with the Powell Survey, likewise, "traversed portions of the Sierra region of western Utah and adjoining Nevada" and the lower Virgin Valley. His reconnaissance included geographic and geologic studies of the Aquarius and Paunsaugunt plateaus, of the region about the head of the Paria River and of the cliffs and canyons in the vicinity of Toquerville.

The published reports of the Wheeler Survey are highly important contributions to the geography and geology of southern Utah. The hachure maps depict the landscape in remarkable detail and the accompanying text discusses not only physical geography but also human geography to an extent unusual for scientific reports. The geologic maps and the famous "Volume 3—Geology" prepared by Gilbert and Howell represent pioneer studies; they were treated by later surveys as source material. The volumes of botany, zoology, and archeology are standard reference works.

POWELL SURVEY.

The Spanish in their search for converts and trade and the Americans in their search for beaver hides became acquainted with the Green River and its tributaries, but saw no reason to explore the "inaccessible and worthless country" below the mouth of Price River. Likewise the military expeditions in search for routes for transcontinental railways avoided the Green River below Gunnison Crossing (village of Green River, Utah). They doubtless recalled the remarks of Capt. Macomb (9) (1859) on the country at the junction of the Green and the Grand (Colorado). "I cannot conceive of a more worthless and impracticable region." The army engineers met fewer obstacles in constructing roads through mountain ranges than in crossing the relatively flat but intricately dissected plateaus bordering the Colorado River. It remained for Major Powell

to explode the myths of "sucking whirlpools," "underground passages," and "plunging, roaring waterfalls" in the "mysterious" Colorado River by safely navigating its canyons to their mouth.

Powell first came to the plateau country in 1867 as a freelance collector of museum specimens in northwestern Colorado and adjoining parts of Utah. He quickly became "fascinated" with this little-explored region of "canyons and brightly colored rocks" and was eager to visit the even less known lands farther south. During his second field season (1868), while collecting along the Green River canyons, his nebulous wishes seem to have taken definite form in the audacious plan of descending the Green and the Colorado by boat. The opportunity came the following year. Thus began the series of expeditions that drew attention to the canyons and plateaus that make of southern Utah a region of scenic grandeur. In the words of Powell (10): "begun originally as an exploration the work has finally developed into a survey embracing the geography, geology, ethnography, and natural history of the country. . . ."

The first traverse of the Colorado River by Powell (1869) ranks high among feats of daring. As Gilbert remarks (11): "The undertaking was . . . of phenomenal boldness and its successful accomplishment a dramatic triumph. It produced a strong impression on the public mind and gave Powell a national reputation which was afterwards of great service."

Obviously Powell's pioneer traverse was planned for exploration rather than for research—to "navigate the Green and the Colorado in the shortest practicable time." The essential tasks of procuring supplies and propelling boats through 1,050 miles of unknown canyons at the rate of about 20 miles a day left little time for scientific observations beyond the recording of approximate distances and directions. Furthermore it appears that the exploring party included no professional scientists, no men experienced in designing and operating boats and, with the exception of its leader, no one familiar with the conditions that control field work. As viewed by such "river men" as Bert Loper and Norman Nevills who nowadays conduct tourists in safety and with reasonable comfort through Cataract, Glen, Marble, and Grand Canyons, the difficulties encountered by Powell are plain evidence of unsuitable equipment and inexperienced personnel.

In evaluating the work of the 1869 expedition it seems nat-

ural to find Powell "not satisfied with the results obtained" and "determined to continue the explorations of the canyon of the Colorado . . . to once more attempt to pass through the canyon in boats, devoting two or three years to the trip." In preparation for this proposed second voyage, Powell returned to Utah in 1870 and selected places where supplies might be brought to the Colorado River by pack train. In September, accompanied by Jacob Hamblin, he visited the Shiwits Indians on the Uinkaret Plateau to investigate the death of three members of his expedition of 1869 who had left the river party near Toroweap Canyon. On this traverse Powell took occasion to descend the old Piute trail from the Toroweap (Tuweap) Valley to the Colorado and to examine the most prominent peaks of the Uinkaret volcanic field. Two of these peaks he named Mount Trumbull and Mount Logan (senators from his home state, Illinois) and the third Mount Emma (Emma Dean, Powell's wife). On the Toroweap road south of Pipe Springs, Powell first noted the glorious banded wall along the south face of Moccasin Terrace.

Starting, we leave behind a long line of cliffs, many hundred feet high, composed of orange and vermilion sandstones. I have named them Vermilion Cliffs. When we are out a few miles, I look back, and see the morning sun shining in splendor on their painted faces; the salient angles are on fire, and the retreating angles are buried in shade, and I gaze on them until my vision dreams, and the cliffs appear a long bank of purple clouds, piled from the horizon high into the heavens.

In 1871 on his second traverse of the Green and the Colorado, Powell was in charge of the boat party from Green River, Wyoming, to the mouth of the Duchesne (May 22-July 14) and from Green River, Utah, as far as the Crossing of the Fathers (September 2-October 10). Here he left the river and returned to Washington by way of Paria, Kanab, and Salt Lake City.

Powell's most active season in southern Utah was in 1872 when he directed the river party on its cruise from Lees Ferry to the mouth of the Kanab Creek (August 17-September 7), traversed Kanab and Virgin Valleys, and examined the Vermilion Cliffs from Smithsonian Butte eastward through Short Creek, Cane Beds, Pipe Springs, and Kanab. From a camp in a "beautiful meadow at the head of the Kanab," Powell ascended the "wall of the Pink Cliffs" (rim of the Paunsaugunt Plateau

at Alton) and explored the broken country "where the Rio Virgin and the Sevier rivers are dovetailed together" (Gravel Pass). From the pass he conducted the pack train along the old road down the Parunuweap Valley (Long Valley), to Mount Carmel and then on foot followed the Parunuweap Canyon to the Mormon settlement of Shunesburg. This first traverse of the formidable gorge, one of the few that ever have been made, he described in detail. (12) After spending a night at the Shunesburg Ranch, Powell and companions followed the Virgin River northward into the present Zion Canyon.

"The Indians call the cañon *Mu-koon'-tu-weap*, Straight Cañon. Entering this, we have to wade up stream; often the water fills the entire channel, and, although we travel many miles, we find no floodplain, talus, or broken piles of rock at the foot of the cliff. The walls have smooth, plain faces, are everywhere very regular and vertical for a thousand feet or more, where they seem to break back in shelving slopes to higher altitudes; and everywhere, as we go along, we find springs bursting out at the foot of the walls, and, passing these, the river above becomes steadily smaller; the great body of water, which runs below, bursts out from beneath this great bed of red sandstone; as we go up the cañon, it comes to be but a creek, and then a brook. On the western wall of the cañon stand some buttes, towers, and high pinnacled rocks. Going up the cañon, we gain glimpses of them, here and there . . . These tower rocks are known as the "Temples of the Virgin."

Powell's account of his explorations (13) is in several respects unusual. As a geographic sketch of southern Utah its brevity is exasperating. Of its 203 pages, only 13 are descriptive of overland trips, and of the space allotted to the river traverses, about half is given to the Green River. Fortunately his meager reports are supplemented by the diaries of Alvin H. Thompson, (14) Frederick C. Dellenbaugh (15) and Stephen Jones, (16) who were members of river parties and the land parties during 1871 and 1872, and further supplemented by the records of the Mormon Church and by diaries of farmers and stock men from whom the explorers obtained supplies and information. At the time of Powell's visit, Glendale, Mount Carmel, and Rockville were thriving settlements and fields were cultivated on the floor of Zion Canyon.

In comparing the available documents relating to the Powell survey some inconsistencies appear. For example, the tra-

verses of the Green and the Colorado are described by Powell as of 1869; no mention is made of the second traverse (1871-1872) during which nearly all the scientific records were made. Likewise the land traverses of 1871 and 1872 are listed as 1870. The traverse of Parunuweap Canyon is dated by Powell as September 10-11, 1870; by Dellenbaugh as September, 1872; and by Jones, who accompanied Powell, as September 10-11, 1872.

The geographic maps of the Powell surveys are the work of A. H. Thompson and his associates, particularly F. S. Dellenbaugh, J. H. Renshawe, Stephen Jones, and J. K. Hillers. After mapping the Green and the Colorado to the mouth of the Paria (May 22-October 26, 1871), Thompson established field headquarters at Kanab and during the next six years completed a topographic survey of Arizona north of the Grand Canyon and of southern and north central Utah. The resulting reconnaissance map, issued in sections, is the first made for a considerable part of Utah and is still in use. It is the base on which are recorded the geologic observations of Powell, Dutton, Howell, and Gilbert, and of most later students of Utah geology, botany, and zoology. In making this map Thompson must have become familiar not only with the topographic relief but also with the areal extent of lava flows and stratigraphic units, with suitable camp sites, and sources of supply. Of particular value was Thompson's pioneer traverse of a route from Kanab to the mouth of Trachyte Creek (May 29-July 7, 1872) which resulted in differentiating the drainage of the Paria, the Escalante, and the Dirty Devil rivers and sketching the features of the Aquarius Plateau, the Water-pocket fold, and the Henry Mountains.

During the first four years (1869-1873) of the Powell Survey geological investigations were almost incidental. Except in the Uinta Mountains Powell himself gave little attention to geologic details. His contribution to geologic knowledge was his epochal analysis of the processes and results of land sculpture, gained from a regional reconnaissance of southern Utah. His reports are rich in generalization.

The geological work of the Powell survey assumed prominence with the appointment of E. E. Howell in 1874, and of C. E. Dutton and G. K. Gilbert in 1875. Dutton (17) gave chief attention during three field seasons to the structure and igneous history of the High Plateaus. He outlined the "District of the

High Plateaus of Utah" and segregated the units as recognized today. "The plateaus are not a part either structurally or topographically of the Wasatch, but belong to another age and are totally different in their forms and geological relations. The extension of the name 'Wasatch Mountains' south of [Mount] Nebo is a misnomer." In Dutton's terminology the High Plateaus, outlined by faults, canyons, or lines of cliffs, comprise "three ranges," a western range that comprises the Pahvant, Tushar, and Markagunt Plateaus, a middle range—the Sevier and the Paunsaugunt, and an eastern range—the Wasatch, Fish Lake, Awapa, and Aquarius.

To Dutton the "fascinating painted mesas," the towering cliffs and the gorges of southern Utah and northern Arizona presented such an "irresistible appeal" that in 1880 his study of the "District of the High Plateaus" was extended to include the "Grand Canyon District" and because Dutton recognized that these two districts were closely related and but parts of a much larger "Province of the Colorado Plateaus" the reports, maps, and descriptions in the published reports freely overlap. In substance the report on the High Plateaus stresses volcanism and structure; the Grand Canyon report is "chiefly devoted to a description of the methods and results of erosion upon a grand scale," but both reports deal with geography and natural resources. For the southern Utah region the Grand Canyon report rather than that on the High Plateaus is of direct interest. It deals more fully with the Hurricane and Sevier faults, the Vermilion Cliffs, the Virgin River canyons, and the great beds of colored sandstone. In fact, the vivid text by Dutton, the incomparable drawings by W. H. Holmes, and the photographs by J. K. Hillers were from the date of their publication accepted as descriptive of a region of marvelous landscapes, in which may be read with ease the story of geologic time. Fortunately the once remote scenic features are now accessible in Zion, and Bryce Canyon, Grand Canyon National Park, in Pipe Springs and Cedar Breaks National Monuments and along the roads that lead to them.

Gilbert contributed to the Powell Survey a report on the Henry Mountains in Garfield County (18)—a study that ranks in fame with his "Lake Bonneville."

The Powell surveys, in combination with surveys by Wheeler and by Hayden (for the San Juan Valley) gave the first appraisal of the resources of southern Utah and sketched the

control exercised by climate, topography, and stream habit in the distribution and type of vegetation, and the consequent necessity of treating natural conditions as the guide in economic development, even in local and minor detail. They showed that the southern counties of Utah and the adjacent "Arizona Strip" are primarily grazing districts devoid of large deposits of economic minerals other than coal, and that in most places farming is practicable only where water can be supplied artificially. It is interesting to note Powell's conclusion that 2.8 per cent of the land in the plateau country could be irrigated. During a period of 80 years skillful effort in the construction of dams and canals has increased the estimated acreage only to about 3 per cent.

It seems pertinent to note that the Wheeler and Powell surveys were exceptional undertakings carried out by exceptional men. During the course of about five years the members of the surveys mapped and interpreted the geographic features, the geologic formations, and the structural displacements in a region that covers more than 50,000 square miles—a region that previously was unknown to science. With sympathetic collaboration in the field and in the preparation of manuscripts, Powell, Gilbert, Dutton, Howell, Thompson, Renshawe, and their associates prepared geologic reports and topographic maps of high value. The line drawings by Holmes and the photographs by Hillers are obviously the work of artists, whose mode of reproduction was particularly fortunate. Furthermore, instead of many piecemeal contributions, these pioneer studies are presented in a few comprehensive volumes and atlases that were issued at about the same time, and thus the various chapters in the story of the whole plateau province could be read in a few books and in close sequence. In recent years for parts of southern Utah better maps have been made and the geology has been described in much greater detail, but the well-designed and well-written volumes of the Wheeler and Powell surveys include most of the fundamental facts, generalizations, and interpretations. Lake Bonneville, the Henry Mountains, the High Plateaus, and the Grand Canyon District remain as classics—contributions not only to science but also to literature.

EXPLORATIONS EAST OF GLEN CANYON.

ENTRADA OF ESCALANTE.

The first known reference to the geographic features of Utah east of Glen Canyon appear in the diary of Escalante (1776) and on the map prepared by Miera y Pacheco (1777 or 1778). Though his outbound route from Santa Fe to the crossing of the Green River at Jensen was in western Colorado except for a short distance along the Dolores River and the Gunnison, Escalante seems to have had considerable knowledge of the region that includes the present San Juan country. He doubtless was familiar with the reports of Fray Alonzo de Posada and Don Juan Maria de Rivera, who previously (1761) had traversed an approximately parallel and less difficult route that entered Utah near Ucola and led along the west base of the La Sal Mountains to Moab. Among Escalante's guides was Muniz, a member of the Rivera expedition who may have passed on from Rivera some of the names on the map: Rio de Nabajoo, Sierra Abajo, Sierra de La Sal, Los Cajone (Navajo Mountain ?) El Cerro Prieto (Agathla Needle) R. de N. S. de los Dolores (Dolores) and R. de los Saguaganos (Colorado below the mouth of the Dolores). Written on the map are some interesting comments, which in substance are translated as follows: The Western Sea shown on some charts as occupying the region that includes Colorado and Utah as 500 leagues (1,315 miles) wide, is firm land and thickly populated by various tribes. The mountain range at the head of Rio de S. Rafael (Colorado) is the back bone of the North American continent. Rivers on its east side enter Hudson Bay or perhaps the Gulf of Mexico; those on its west side flow to a sea at the south. Rio Colorado below the mouth of the San Juan tumbles down deep canyons between closely spaced, bare walls of colored rock.

MACOMB SURVEY.

In 1859 an expedition in charge of Capt. J. N. Macomb, Topographic Engineers, U.S.A., crossed Sage Plain on the west side of "Sierra de la Plata" and descended "Canon Colorado" (Indian Creek) to near its mouth. The homeward route was along the east base of the Abajo Mountains, down "Rio de la Abajo" (Recapture Creek) and up the San Juan to Canyon Largo in New Mexico. The descriptions given by Macomb (19) and by J. S. Newberry, geologist of the expedition, sup-

plemented by maps and colored reproduction of sketches made in the field, portray for the first time the outstanding geographic features of eastern San Juan County, both north and south of the San Juan River. The scale of the map (12 miles = 1 inch) permitted the delineation of the major drainage lines and the prominent mesas and mountains. Of his traverse northwest of Sage Plain Macomb writes:

"At the 'Ojo Verde' the Spanish trail strikes off more northwardly, to seek a practicable crossing of Grand and Green Rivers. We left the trail here, and, leaving the main body of our party encamped at the spring, with a small party of nine, went to the westward some thirty miles, under the guidance of an Indian, who had joined us many days previously, on our route to look for the junction of the Grand and Green Rivers. This part of our journey was very rough and dangerous, from the precipitous nature of the route, winding down the sides of deep and grand cañons, and it is fortunate that no attempt was made to bring forward our packtrain, as we must have lost many mules by it, and, moreover, there was not sufficient pasture for the few animals that we had with us. I cannot conceive of a more worthless and impracticable region than the one we now found ourselves in. I doubt not there are repetitions and varieties of it for hundreds of miles down the cañon of the Great Colorado, for I have heard of but one crossing of that river above the vicinity of the Mojave villages, and I have reason to doubt if that one (El Vado of los Padres) is practicable, except with the utmost care, even for a pack mule.

Looking southward across the San Juan River Macomb saw:

"Many castle-like buttes and slender towers, none of which can be less than 1,000 feet in height, their sides absolutely perpendicular, their forms wonderful imitations of the structures of human art. Illuminated by the setting sun, the outlines of these singular objects came out sharp and distinct, with such exact similitude of art, and contrast with nature as usually displayed, that we could hardly resist the conviction that we beheld the walls and towers of some Cyclopean city hitherto undiscovered in this far-off region. Within the great area inclosed by the grander features I have enumerated, the country is set with numberless buttes and isolated mesas, which give to the scene in a high degree the peculiar character I have so often referred to as exhibited by the eroded districts of the great central plateau. Here and there we caught glimpses of the vivid green of the wooded bottom-lands of the river, generally concealed by the intermediate and overhanging cliffs."

Except for the Sage Plain, "gloomy barrens covered chiefly with *Artemesiae*," the place names recorded by Macomb seem to be those applied by the Mexicans who travelled the "Old Spanish Trail" across San Juan and Grand Counties: Sierra Abajo (the Lower Mountains; Blue Mountains); Orejas del Osa (Bear's Ears; Elk Ridge); Sierra La Sal; Sierra Panoche (Navajo Mountain); Lana Negra (Skeleton Mesa); Agathla Needle; and Calabasa Mountains (the towers in Monument Valley).

HAYDEN SURVEY.

In southern Utah east of Glen Canyon the geographic and geologic information recorded by the expedition in charge of Captain Macomb was greatly increased by the "Survey of the Territories" in charge of F. V. Hayden, United States Geologist, who extended his investigations of Colorado and Wyoming westward into Utah—approximately to the longitude of Thompson, Moab, and Bluff. (20) As outlined by the Secretary of the Interior, Carl Schurz, in a letter to Hayden

"the ultimate design to be accomplished by these surveys is the preparation of suitable maps of the country surveyed, for the use of the government and of the nation, which will afford full information concerning the agricultural and mineral resources and of other important characteristics of the unexplored regions of the Territorial domain . . . you will make such scientific observations touching the geology, geography, mineralogy, and meteorology of the country surveyed by you as may be necessary for the preparation of such maps. In addition thereto you will obtain the necessary information for the preparation of charts upon which shall be indicated the areas of grass, timber and mineral lands and such other portions of the country surveyed as may be susceptible of cultivation by irrigations and will ascertain and report upon the best methods of accomplishing this result."

In accordance with the instructions issued by the Secretary of the Interior, Hayden prepared a topographic map (scale: 1 inch = 4 miles) contour interval 200 feet, a geologic map, and a map showing types of vegetation for eastern Grand and San Juan counties (1875-1876). The maps retain the names of Sierra Abajo and Sage Plain as used by the Macomb Survey and for the first time apply the terms McElmo, Montezuma, Recapture, Epsom Creek, and McCombs Creek to tributaries of the San Juan River. The mesas and towers south of the San

Juan were referred to as Monumental Valley. Two contributions of the Hayden Survey are of special interest: the first pictorial illustrations of the Sierra Abajo (Blue Mountain) region by W. H. Holmes and the first recorded description and sketches of the remarkable Pueblo ruins in San Juan, Montezuma, and McElmo Canyons, and along "De Chelly" (Chinle) Creek by W. H. Jackson.

MORE RECENT SURVEYS.

Following the pioneer studies of the Macomb and Hayden surveys and after the San Juan Valley had been colonized by the Mormons (1880), the salient topographic features of San Juan and adjoining counties were recorded on a reconnaissance topographic map by P. Holman of the U. S. Geological Survey (Abajo and Henry Mountain quadrangles, 1884). On these maps and their revised editions the new names applied are Cottonwood Wash (Macomb's Creek of Hayden), Butler Wash (Epsom Creek of Jackson), Gothic Creek, Elk Ridge, (Bear's Ear Plateau of Holmes), and Clay Hill Divide.

The first traverse of the San Juan Canyons below Goodridge (Mexican Hat) appears to have been by E. L. Goodridge in 1882. Later traverses were made by prospectors during the "Bluff gold excitement" in 1892, by Bert Loper in 1893 and 1894, and by Walter E. Mendenhall in 1894 and 1895. The canyons were examined in detail by Miser and his associates in 1921. (21) Also in 1921, a half century after Powell had traced its course, the Colorado River was accurately mapped. (22)

For many years after their publication the maps and memoirs of the Wheeler, Powell, and Hayden surveys constituted the essential scientific literature of southern Utah and adjacent parts of Arizona and Colorado. Reconnaissance studies of more recent date concern the areas not covered by the pioneer surveys—particularly the regions adjacent to Glen Canyon. (23) Since 1900 several reports and maps that describe geographic, geological, and economic features of Iron, Garfield, Washington, Kane, and San Juan Counties have been published. They are listed by Stringham. (24)

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U. S. GEOLOGICAL SURVEY,
WASHINGTON 25, D. C.

In response to the public demand for "Scientific Explorations in Southern Utah" the Zion-Bryce Natural History Association has provided this reprint under authority granted by the American Journal of Science. Additional copies of this bulletin, at twenty-five cents each, may be secured from the Zion-Bryce Natural History Association, Zion National Park, Springdale, Utah.

Offset lithography by CUSHING - MALLOY, Inc., Ann Arbor, Mich.

May 1950