



## *James Hervey Simpson and the first record of San Juan Basin geology*

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# JAMES HERVEY SIMPSON AND THE FIRST RECORD OF SAN JUAN BASIN GEOLOGY

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**Abstract**—James H. Simpson, a lieutenant in the Army Corps of Topographical Engineers, reported the first extensive geological observations of the San Juan Basin while accompanying the Washington Expedition against the Navajos in 1849. Simpson's record of this expedition also includes the first American descriptions of the Jemez Springs area, the ruins at Chaco Canyon, Canyon de Chelly, and Inscription Rock (El Morro), as well as much information on the Hispanic, Pueblo and Navajo inhabitants of New Mexico shortly after it came under American control. He also named Washington Pass, in the southern Chuska Mountains, and Mount Taylor. This paper summarizes the day-to-day progress of the expedition, and discusses Simpson's geological observations and interpretations along the route in the light of present knowledge of the geology of this area.

## INTRODUCTION

Until the first decade of the 20th century, little was known of the geology of the interior of the San Juan Basin. Early exploration and initial geological study of northwestern New Mexico began shortly after the American conquest but was limited to the more accessible regions around the periphery of the basin. James Abert in 1846 (Abert, 1848), Jules Marcou with the Whipple Expedition in 1853 (Marcou, 1855, 1858; Blake, 1856), and J. S. Newberry, returning from the Ives Expedition in 1858 (Newberry, 1861), provided a record of the geology along the well-traveled route from Albuquerque through Laguna and Zuni Pueblos to Fort Defiance, Arizona. The northeastern part of the San Juan Basin, approximately from Aztec to Cuba, was surveyed and studied in fair detail by Newberry, with the Macomb Expedition of 1859 (Newberry, 1876). Members of the Wheeler Survey, particularly E. D. Cope, explored the area around Regina and Cuba in 1874, where Cope discovered the first Eocene vertebrate fossils in New Mexico (Cope, 1875). Another member of that survey, the geologist Oscar Loew (1875, p. 103), referred to the area west of the Nacimiento Mountains and north of Mt. Taylor as "the Nacimiento Desert," a "barren waste" consisting of "a continuous series of mesas and valleys hardly equaled anywhere on the globe." In the following years a few generalized geological observations, mainly in connection with the Chaco Canyon ruins, were reported by people such as Jackson (1878) and Holsinger (1901).

It was only after 1900, when U.S. Geological Survey geologists began studying the stratigraphy and coal deposits of the San Juan Basin, that the detailed outlines of the geology of the central part of the basin began to be filled in. Even so, Storr's (1902) summary of the coalfields of New Mexico made no reference to the coal-bearing strata in the interior of the basin, and Schrader's (1906) reconnaissance map of the rocks of the San Juan Basin displays formations only around its margins, with the interior a large blank area geologically, except for a few points where coal had been reported. Shaler (1907) was the first to indicate in a general way the outcrop areas of the Cretaceous and early Tertiary strata within the interior of the basin.

Prior to this, the only substantial record of the geology of the heart of the San Juan Basin were the observations of James Hervey Simpson, a lieutenant in the Army's Corps of Topographical Engineers (Fig. 1). In 1849, Simpson accompanied a military expedition against the Navajo Indians, which crossed the basin from the Nacimiento to the Chuska Mountains, and reached Canyon de Chelly before returning via the normal east-west route through Zuni and Laguna Pueblos. (Fig. 2). Although not trained extensively in geology, like all members of the Corps of Topographical Engineers, he had received a broad education in the natural sciences, and understood the importance of maintaining an accurate, detailed record of the topography and geology of the new areas he explored. Simpson's journal of this expedition (Simpson, 1850b) is not only a remarkable early record of the geology of his route, but also includes the first detailed descriptions of the ruins at Chaco Canyon and the inscriptions at El Morro, as well as a wealth of information on

the Pueblo, Navajo and Hispanic inhabitants of the territory, and its fauna, flora and geography.

Simpson's journal was reprinted, with annotations and historical commentary, by McNitt in 1964, but little attention was devoted to Simpson's geological observations. Further, Simpson's journal is not known to many modern geologists, and his accounts of the geology of areas he examined in 1849 are often omitted from discussions of previous studies of those areas in modern reports (e.g., Allen and Balk, 1954; Summers, 1976). This paper focuses on the geological features Simpson recorded and interpreted, and relates his observations to the geology of the areas he passed through as it is now known.

One must keep in mind that the purpose of the expedition Simpson accompanied was military, not scientific; opportunities to explore areas



FIGURE 1. James H. Simpson in 1865, 16 years after his San Juan Basin explorations (from McNitt, 1964).

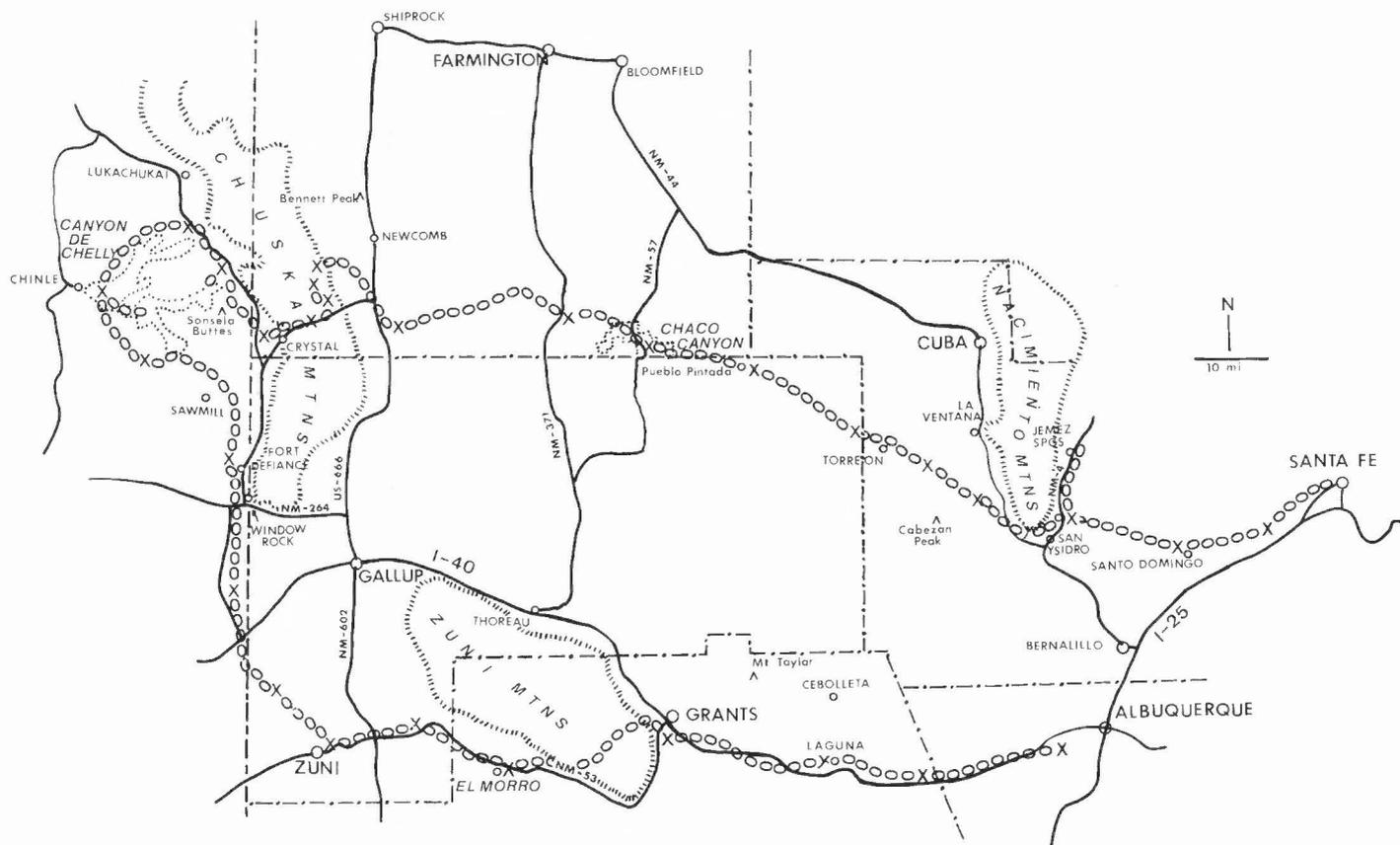


FIGURE 2. Map of northwestern New Mexico, showing Simpson's route on the Washington expedition (line-of-ovals pattern). In a few places (see text), Simpson's route diverged from that of the main expedition. Campsites are indicated by X symbols along the route.

of interest away from the main route of the expedition were limited. Further, because he was not a geologist, Simpson produced no geological map of the areas he traversed, although a map of the geographic and topographic features was prepared by his artists. Nor was he able to determine the ages of the rocks he examined, in contrast to the trained geologists such as Marcou and Newberry who explored New Mexico in the 1850s. However, in the context of the expedition's purpose and Simpson's background, the quantity, detail and accuracy of his geological observations are remarkable.

In this account, I have chosen to quote Simpson's journal (Simpson, 1850b; all page numbers for Simpson's words cited here refer to that reference) extensively, allowing him in effect to convey his geological observations and interpretations to the reader directly. In some places, his words also express his feelings about what he was seeing, as the first scientifically trained American to view the San Juan Basin, a region of diverse and impressive geological features. By reading his journal, one gains an appreciation not only of what he observed, but of the texture and flow of life in New Mexico nearly a century and a half ago, and of the attitudes of the newly arrived Americans toward the original residents of the territory. That time, and the technology and day-to-day existence of the people, seem very remote to us now, but Simpson's journal, and others like it, also reveal many unexpected points of reference and similarity, that suggest that people really haven't changed much. And of course, for the most part, the landscapes and geology Simpson observed in 1849 haven't changed at all.

### THE WASHINGTON EXPEDITION

At the time of the American occupation of New Mexico in 1846, the Navajos were regularly raiding Pueblo and Mexican settlements, as they had been doing for centuries. The new administration strongly believed in its obligation to protect the people from these depredations. Late in 1846, Colonel Stephen Doniphan had been dispatched to bring

the Navajos to terms. He signed a peace treaty with them near the present site of Fort Wingate, but the U.S. Congress failed to ratify the treaty and the Navajos doubtless had little concept of its meaning and no inclination to change their way of life simply because Americans had arrived in the territory (McNitt, 1964). With the Mexican-American War still in progress, and an open rebellion by Taos Indians and Mexicans early in 1847, the occupying American forces were spread thin and mostly restricted to garrisons in a few towns. Navajo raids continued.

Lieutenant Colonel John M. Washington arrived in Santa Fe in October 1848, to assume his duties as military and civil governor of New Mexico. He organized volunteer militia to augment his regular troops, and sent them frequently into the field to discourage Indian activity. However, his forces were insufficient to compel the Navajos (as well as the Utes, Apaches and Comanches) to cease their raiding. During the summer of 1849, with Indian attacks on the rise and some reinforcements heading to New Mexico from the east, Washington began to plan a major punitive expedition against the Navajos.

At this time, a column of troops under the command of Captain Randolph B. Marcy, escorting a large wagon train of immigrants and gold-seekers to California, was approaching New Mexico. Among the military officers was Lieutenant James Simpson, aged 36, who had joined Marcy's expedition near Fort Smith, Arkansas, in April 1849. Simpson's mission was to explore and survey the wagon road from Fort Smith to Santa Fe, and assess the potential of this route for a railroad.

Simpson had graduated with Marcy from West Point in 1832, and in 1838 had been transferred to the Corps of Topographical Engineers. During the next ten years he was engaged in constructing roads and improving harbors in the East; immediately before receiving orders to join Marcy's expedition, he had been supervising the construction of a lighthouse in Michigan. This expedition was his first venture west of

the Mississippi River. Once in the West, Simpson proved to be an adaptable and perceptive explorer, who produced an excellent written record of his observations, interpretations and recommendations. He was almost continuously in the field in the West from 1849 to the outbreak of the Civil War (Goetzmann, 1959).

Marcy's party entered New Mexico about 15 June, passed westward through the Tukumcari area to Anton Chico, and arrived in Santa Fe on 28 June (see Kues, 1985a, b, for more detailed accounts). Simpson was to continue on with part of the party to California, and set about fitting out the expedition, but on 2 July he received orders to stay in Santa Fe and prepare a report on the Fort Smith to Santa Fe route. This he did, completing it on 13 August. The report was rushed back to Washington, D.C., where it was published in January 1850 (Simpson, 1850a). On 14 August, orders were issued in Santa Fe for Simpson to accompany an expedition led by Colonel Washington, "to make a movement against the Navajo Indians."

## THE GEOLOGY ALONG THE ROUTE

### Departure

The expedition departed Fort Marcy without fanfare on the morning of 16 August. It consisted of 55 artillery and 120 infantry troops, their officers, assorted interpreters, an Indian agent and his assistants. One 6-pound field gun and three 12-pound mountain howitzers, each howitzer weighing 550 lbs and carried by mule, represented the heavy weaponry. Most of the supplies were loaded on wagons, but these were discarded in favor of mule trains at Jemez Pueblo because of difficulties in pulling them through uneven sandy terrain. A viameter attached to a wheel of the field-gun carriage recorded the number of rotations, and thus distance traveled in a day. Scientific instruments were restricted to a thermometer and sextant, which Simpson employed each evening to make astronomical observations necessary to determine the latitude and longitude of each camp. The lack of a barometer for accurately determining elevations was lamented by Simpson in his report. Two brothers, Richard H. and Edward M. Kern, were employed to sketch the scenery, topography, buildings, and other items of interest, and to produce a map of the area traversed.

### Santa Fe to Jemez Pueblo

The party traveled 16 mi to the southwest during the first day, camping at Cieneguilla, near the present La Cienega. Simpson recorded no direct observations of the geology of this area, but Sun and Baldwin (1958) published a detailed study. On 17 August the expedition proceeded west down the canyon of the Santa Fe River for 6 mi and emerged from the base of La Bajada Mesa, then continued to Santo Domingo Pueblo, forded the Rio Grande, and established camp across from the pueblo—a day's march of nearly 15 mi. The Rio Grande was reported to be about 300 yds wide, between 3 and 4 ft deep, with many bars and a soft bottom in places that stalled two of the wagons. Simpson noted plates of selenite in small windows of the lower stories of buildings in the pueblo.

Simpson found the canyon of the Rio de Santa Fe to be quite interesting (p. 61):

Varying in depth from one hundred to one hundred and fifty feet, the Rio de Santa Fe trickling through it, its mesa (table) heights on either side are crowned by overlying basaltic trap. This trap shows eminently, in particular localities, the blackening, scoriaceous effect of fire; and in some places is to be seen underlying it an earthy formation of an ashy character, and in others a reddish porphyritic rock in beds slightly dipping towards the east. At the mouth of the cañon, on its north side, is a well-defined ash-colored formation of an argillo-silicious [*sic*] character, dispersed in layers, and presenting, with striking and pleasing effect, the appearance of the *facade* of a highly-finished piece of Grecian architecture. This object cannot fail to attract the notice of the traveller.

The term cañon was apparently judged to be sufficiently unfamiliar to his readers that Simpson felt the need to define it in a footnote (p. 61): "The word cañon is most generally applied to a deep and narrow valley, enclosed on either side by escarpments. It sometimes, however, means a shallow valley."

Simpson's observations in the canyon of the Santa Fe River can easily be related to features mapped by modern geologists. The "basaltic trap" on either side of the canyon is part of an extensive series of basalt flows—the Cuerbio basalt—that forms the surface of La Bajada Mesa. Bachman and Mehnert (1978) dated parts of this flow sequence at about 2.8 Ma; the flows issued from a cinder cone between the canyon and I-25 to the south. Within the canyon, from east to west, strata of the Oligocene Espinazo, Eocene Galisteo, and Upper Cretaceous Mancos formations are exposed, with Santa Fe Group sediments cropping out around its western mouth (Kelley, 1978). A small intrusion in the canyon tilted the sedimentary sequence eastward (Disbrow and Stoll, 1957), producing the "reddish porphyritic rock in beds . . . dipping east" noted by Simpson. The well-sculpted "argillo-silicious" rocks at the mouth of the canyon are exposures of poorly indurated, friable sandstones of the Zia Formation, of Miocene age (Kelley, 1977). More extensive outcrops of this soft, easily eroded formation occur near Zia and Jemez Pueblos, to the northwest.

On 18 August the party marched a distance of 26.6 mi to Jemez Pueblo (Fig. 3), across a landscape of arroyos, sand hills and basalt-covered mesas. Four miles from the last camp Simpson noted (p. 63) "an outcrop of silicious limestone containing, sparsely, some particles of felspar [*sic*]," probably a small exposure of what another, better-known explorer would call the "Santa Fe marls" (Hayden, 1869), the present Santa Fe Group. Early in the day they crossed the north side of the San Felipe volcanic field, erupted about 2.5 Ma, which is locally covered with unconsolidated sand and gravel (Kelley and Kudo, 1978). Ascending a large area of tableland, Simpson (p. 63) recorded seeing, almost due west and 35 mi in the distance, "the remarkable peak called Cerro de la Cabeza"—Cabezon Peak, the large, late Tertiary volcanic neck that forms a prominent landmark in the Rio Puerco Valley.

The expedition advanced to the heights overlooking the Jemez River Valley, where Simpson viewed the surrounding panorama (p. 63):

As I anticipated, a noble view extended itself before me. There lay, far off towards the northeast, the Santa Fe Mountains; to the southeast, the Placer Mountain and Sandia Mountain; intervening between them, and just discoverable, lying beyond the gleaming waters of the Rio Grande, the little town of Santo Domingo; to the north and northwest, stretching far away, were the Jemez mountains; to the south, mesa formations, crowned with basaltic trap; and everywhere else, sparsely scattered over mountain and plain, the dwarf cedar.

The party remained camped near Jemez Pueblo for three days, from 19 through 21 August, while supplies were transferred from wagons to mules. Simpson did not remain idle. On 20 August he and four companions left camp and rode north up San Diego Canyon toward "Los Ojos Caliente," the hot springs.

Our course, which lay directly up the valley called the Cañon of San Diego, was slightly east of north. Soon after leaving camp, we passed some red-colored argillaceous rocks, well stratified, the dip of stratification on either side being anticlinal, and the gorge which we threaded being coincident with the line of strike. An upheave, therefore, must, in all probability, have taken place, the resulting force of which was doubtless normal to the line of strike. A sinking of the two series of stratification at the foot of their respective slopes could indeed have caused the like effect; but, the first mode of accounting for the phenomenon being the simplest, it is most reasonable to suppose it to have occurred. (p. 65)

New Mexico Highway 4 follows Simpson's route, and the landscape he viewed is essentially the same as the modern traveler sees from an automobile. The red argillaceous rocks just north of the pueblo are exposures of the Meseta Blanca Member of the Permian Yeso Formation. Simpson's description of anticlinal dips on both sides of the canyon is difficult to understand, as the late Paleozoic units within the canyon dip only slightly, with no perceptible indication of anticlinal structure (Wood and Northrop, 1946). However, while camped near Jemez Pueblo he must have observed the east side of the southern end of the Nacimiento Mountains, rising to the west. Here, the Triassic Agua Zarca Formation of the Chinle Group and underlying Permian strata form a broadly synclinal structure, with its high, west-dipping east limb exposed along the west side of the canyon. This may have led him to believe that the canyon was incised into the axis of an

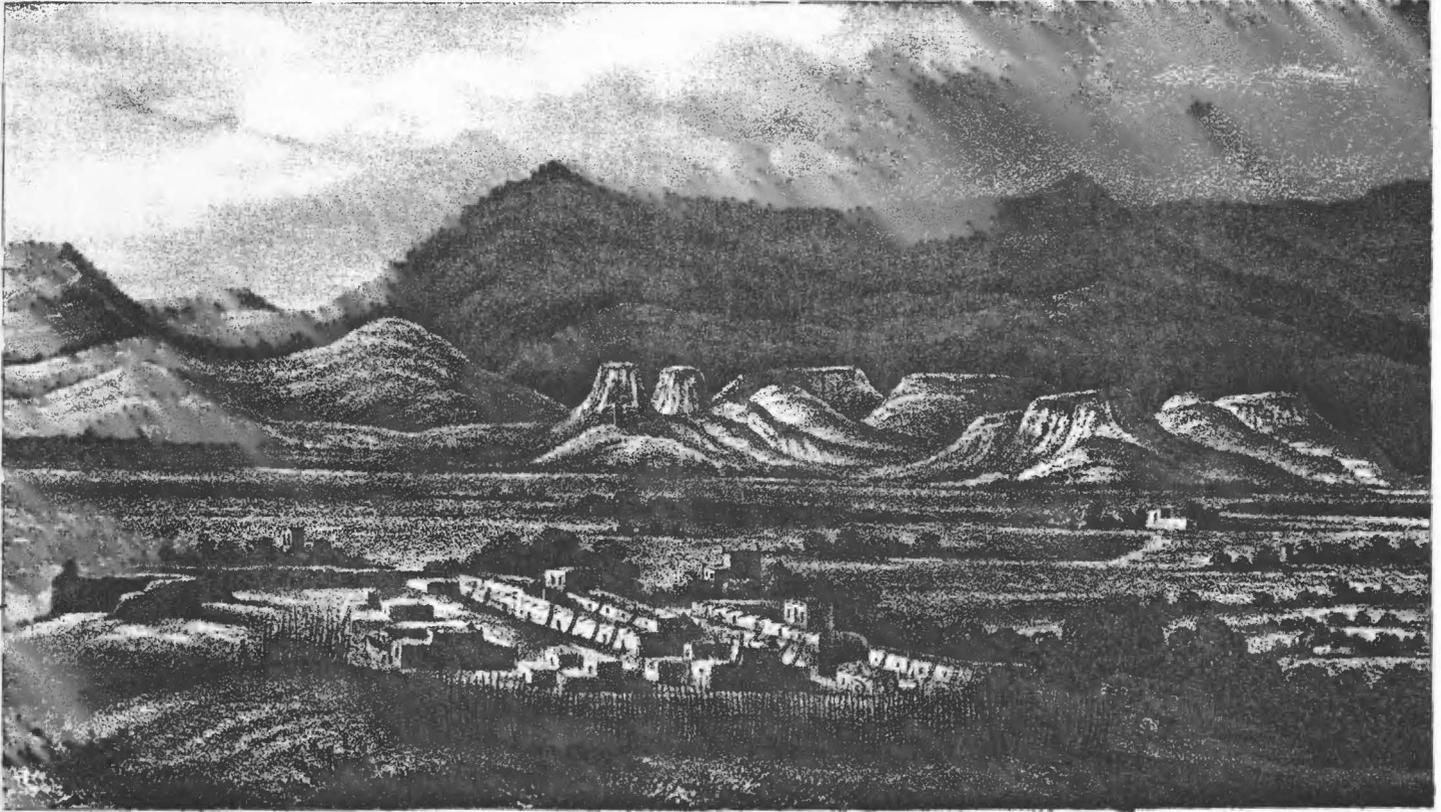


FIGURE 3. "Pueblos of Jemez from the East, August 20" (pl. 3 of Simpson, 1850b). This and the other 73 plates in Simpson's report were sketched by R. H. Kern. Pinnacles of the Zia Formation are visible to the center and right beyond the pueblo, with Permo-Triassic units forming the steep eastern slope of the southern Nacimiento Mountains in the distance.

anticline. In reality, the mouth of San Diego Canyon has been down-dropped along the San Ysidro and Jemez faults bounding the east side of the Nacimiento Mountains (Woodward, 1987). It is noteworthy that Simpson considered two hypotheses to explain his observations, and chose what he believed to be the simplest as probably being correct—an entirely modern and scientific process of interpretation.

Progressing farther up San Diego Canyon,

we found an old copper-smelting furnace, which looked as if it had been abandoned for some considerable period. It is quite small, is built of stone, and has arched ovens traversing each other at right angles, each oven being furnished with a stone grating. We picked up some fragments of copper ore (probably green malachite) which lay scattered around. (p. 65)

This is the old Spanish Queen mine, about 3 mi south of Jemez Springs town, which operated sporadically as a minor source of copper from the Abo Formation. The last mining activity, however, was many decades ago, and the traces of mine shafts and structures are fast becoming obscure as houses and trailers proliferate in the area. Early Permian plant and vertebrate fossils have been known for many decades from the Abo in and near the mine (e.g., Romer, 1960), but their discovery long postdates Simpson's brief visit.

Twelve miles from Jemez Pueblo, the party came to the hot springs, at the present location of Jemez Springs town, and Simpson recorded his observations in detail (p. 65–66):

On examination, we found the springs to be situated within the compass of a few feet of each other, some of them boiling up immediately from the bed of a small bifurcated branch of the Rio de Jemez. The principal one, which is in the branch mentioned, issues from a small knoll or heap of boulder stones, which seems to partake both of a calcareous and basaltic character, the vent not being more than a foot above the bed from which it springs. The volume of water which issues from it may be estimated at about a gallon and a half per minute. This spring, as well as all the other principal ones, shows a limited accumulation of a crystalline deposit [sic] about its mouth, which, on account of its fine-grained character and hard-

ness, may probably come under the head of travertine. The complexion of the deposit [sic] is white, with a shade of greenish-yellow.

The group found the water temperature to be 169°F, and they cooked some eggs and raw venison in the spring water in about 20 minutes. Summers (1976) provided a detailed summary of studies of this and other hot springs in the Jemez River basin, although the earliest description he cited was that of Loew (1875). Interestingly, a table of temperatures measured at Jemez Hot Springs from 1903 to 1973 (Summers, 1976, table 13) lists none higher than 169°F, the maximum temperature measured by Simpson.

Simpson's small group then proceeded a third of a mile north, to the remains of "an old Roman Catholic Church" (now Jemez State Monument, the ruins of the Church of San Jose, dating from the early 1600s), before returning to camp. The following day was spent exploring Jemez Pueblo, while its governor recounted stories of its history, including the tradition that the New Mexico pueblos derived from the time of Montezuma and the Aztec civilization of pre-Spanish Mexico. Actually, accounts of Montezuma and the Aztecs were imported into New Mexico by early Spanish colonists, were incorporated into Pueblo stories, and interpreted by early U.S. explorers as a genuine prehistoric tradition (McNitt, 1964).

### Jemez Pueblo to Chaco Canyon

On the morning of 22 August the expedition headed southward, augmented by about 60 Pueblo Indians and 50 "Mexican" volunteer infantry, and with the supplies on mules instead of in wagons. This enlarged group followed the Jemez River for 3 mi, crossed it just above the settlement of San Ysidro, and camped 3 mi to the west, in the valley of the Rio Salado—a trek of only 6 mi for the day. Simpson visited the owner of the Spanish Queen mine in San Ysidro, who maintained, probably with some exaggeration, that 250 lbs of rich

copper ore, as well as some gold, could be extracted by one man in a day.

The following day the party proceeded northwest up the Cañon de Peñasca (the present Rio Salado valley), across the southern edge of the Nacimiento Mountains. Simpson noted low mountains to the right (north) and 300–400-ft-high mesas to the south. These mesas were described as consisting of “ash-colored sandstone, alternating with a red argillaceous friable rock” (p. 70), probably a reference to the Jurassic Entrada-Todilto-Morrison sequence above the red mudstones and sandstones of the Triassic Chinle Group.

Two miles into the day’s travels, some mineral springs were encountered, and to the south of their route Simpson noticed (p. 70),

large beds of earthy gypsum and sulphate of lime; and constituting the superior strata of the mesa was a formation, some eighty feet thick, composed of an alternation of crystallized fibrous gypsum and thin layers of argillaceous shale. At the foot of the escarpment, I picked up what appeared to be, from its taste and appearance, common salt (chloride of sodium). I afterwards noticed, four miles further on the route, another bed of gypsum.

This description is an accurate depiction of the Jurassic Todilto Formation, which covers the surface of White Mesa, immediately south of the Rio Salado. Later, 9 mi from the last camp, the party encountered gigantic conglomeratic boulders, possibly talus derived from conglomeratic lenses of the Agua Zarca Formation.

Near the end of the day the expedition emerged from the heights into the Rio Puerco Valley, and Simpson again viewed Cabezon Peak which he described (p. 70) as resembling

very much in contour, though much higher, Cerro Tucumcari, a prominent landmark about 160 miles east of the Rio Grande, on the Fort Smith route. This mountain I described in my report of that route as resembling very much in shape the dome of the Capitol at Washington; and Cerro de la Cabeza, though not so good a representation, yet cannot fail to suggest to the traveller a like resemblance.

Had Simpson’s route allowed him to examine Cabezon Peak closely, he would have noticed its igneous composition, in contrast to the eroded Mesozoic strata that compose Cerro Tucumcari.

After a day’s march of 16 mi, the expedition camped on what Simpson called a small tributary of the Rio Puerco—the Rio de Chacoli. Although McNitt (1964) was unable to locate this stream, he suggested that the camp was within gunshot of Chamisa Vega Spring. Arroyo Chaculic is shown on modern topographic maps as a tributary feeding the head of the Rio Salado, and it passes within a mile of Chamisa Vega Spring, some 4 mi southwest of Holy Ghost Spring.

On 24 August, the march resumed in a northwesterly direction. The expedition crossed the Rio de Chacoli, at that time a small running stream with banks 4 ft high, and proceeded up the valley of the Rio Puerco. Simpson observed (p. 71) that the valley was hemmed in to the west “by heights, with tableau tops, and precipitous escarpment walls” (Mesa San Luis and La Ventana Mesa). The Rio Puerco itself proved to be a disappointment (p. 71):

The Rio Puerco, which, from its great length upon the maps, we had conjectured to be a flowing stream of some importance, we found to contain water only here and there, in pools—the fluid being of a greenish, sickening color, and brackish to the taste. The width of its bottom, which is a commixture of clay and gravel, is about one hundred feet. Its banks, between twenty and thirty feet high, are vertical, and had to be graded down to allow the artillery and pack animals to cross them.

Simpson’s observation of the high, vertical banks of the Rio Puerco was one of the first reports of deeply incised arroyos in the Southwest; Abert (1848) also noticed incision of the Rio Puerco southwest of Albuquerque. These early observations mark the starting point for continued debates on the causes, development and prevention of arroyo incision that have continued to the present. Love (written comm. 1992) noted:

Bryan (1928, 1954) used Simpson’s observations to argue for his arroyo-development model by headward erosion. Bryan also argued that because Simpson hadn’t mentioned an arroyo in Chaco Canyon, there wasn’t one in 1849. My observations on both the Puerco and Chaco suggest a much more complicated proto-historic cycle of cut-and-fill before late 19th century entrenchment. Bryan down-played Simpson’s observations of the depth

of the Rio Puerco, mis-citing a depth of only 10 ft because Bryan wanted the arroyo to be one of his “discontinuous gullies” before integration had formed a large arroyo.

Today, the banks of the Rio Puerco in this area are still vertical, but may be considerably higher than 20 or 30 ft. Simpson observed that the sediments of the Rio Puerco valley were argillaceous, rather than feldspathic, as had been the case in streams and rivers previously crossed, a consequence of the river cutting through the dark-gray sediments of the Upper Cretaceous Mancos Shale.

After crossing the Rio Puerco, the party entered Cañon de la Copa (cup canyon), a name I was unable to locate on any subsequent map. Judging from Simpson’s account of location and topography, this canyon may be what is now called Rincon de los Viejos, which is incised into the northern end of Mesa San Luis, about 6 mi south-southwest of the La Ventana townsite on NM-44. Simpson remarked upon the beautifully stratified sandstone along the canyon walls that dipped slightly to the west, which would be consistent with the regional dip of strata toward the center of the San Juan Basin. In addition, Simpson noted (p. 72), “. . . in some crevices, and also attached to the rock, a dark pitchy substance, agglutinated with the excrement of birds, and of animals of the rat species.”

This casual observation of packrat middens was utilized by Betancourt et al. (1983) to begin a paper on the modern use of middens in the interpretation of late Pleistocene to holocene vegetational and climatic changes in the western United States. Since scientific study of rodent middens began about 1960, they have proven to be invaluable paleoecological indicators, as the dried packrat urine encloses samples of plant debris, providing a census of local plant communities that existed while the midden was being formed. Evidence derived from study of packrat middens has entered into controversies concerning past vegetation and climate in San Juan Basin badlands areas (Love, written comm. 1992), and the explanations of the rise and abandonment of Anasazi towns, such as Chaco Canyon.

Simpson went on to report (p. 72)

About half a mile further, just as we emerged from the cañon, noticing on the right of the road what appeared to be bituminous coal, I examined it, and found it to be veritably such, though of an impure, slaty character. It exists in beds a foot thick, which are, in some instances, overlaid by yellowish sandstone, and then again by calcareous rock. I noticed, in some instances, superposing the coal, loose, disintegrated masses or fragments of what appeared to be a species of jasper, the evidences of igneous influence being quite apparent from its baked and blackened aspect. The coal, when fractured, occasionally discovers resinous particles of a beautiful iridescent character, the reflections being those of garnet.

The coal beds observed here are within the Upper Cretaceous Menefee Formation, between the Point Lookout Sandstone below and the overlying La Ventana Tongue of the Cliff House Sandstone, a yellow sandstone unit that caps the mesas in this area. The coals and detailed stratigraphy here would not be studied by geologists until the early 20th century. Schrader (1906, p. 251), in one of the earliest reconnaissance coal surveys, reported a section with a coal bed “in the mesa west of Rio Puerco, 15 miles north-northwest of Cabezon,” near or at the locality recorded by Simpson. The “evidences of igneous influence” noted by Simpson do not pertain to actual igneous rocks, but to burned coal beds and overlying rocks, which are dark in color and have a scoriaceous appearance.

After a march of 13.3 mi, the expedition camped within the valley of the Piedre Lumbré, the first major arroyo paralleling the Rio Puerco to the west. This camp was perhaps 10 to 12 mi south-southwest of Mesa Portales. The following morning, 25 August, while riding north-west, Simpson looked back to the south (Fig. 4) and (p. 73)

an imposing view of *Cerro de la Cabeza* presented itself to us. There was nothing about it to detract from its towering sublimity; and as the morning sun threw its golden light upon its eastern slope, leaving all the other portions in a softened twilight shade, I thought I had never seen anything more beautiful, and at the same time grand.

Farther along, he noted “an extensive range of mountains, of a mesa and ridgy character” to the south (the San Mateo Mountains, north of Grants), and “a broken country, made up of low, swelling hills, isolated

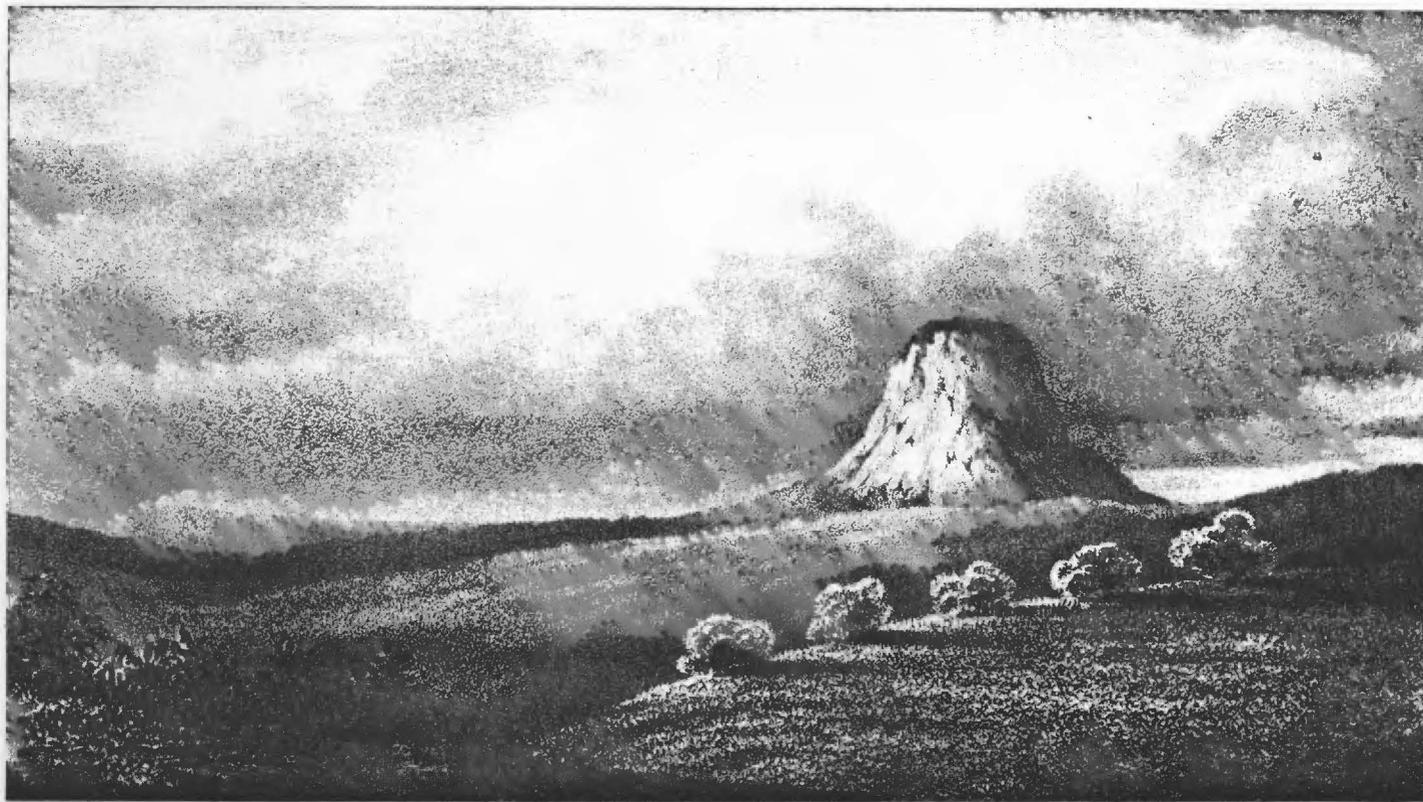


FIGURE 4. "Cerro de la Cabeza in the valley of the Rio Puerco" (pl. 17 of Simpson, 1850b). View is to the south, 3 mi west of the 24 August camp.

cones, and mesa heights . . ." Gradually the terrain became more prairie-like and rolling, and the party entered the Cañon de Torrijon (now Torreon Wash), where it stopped after a march of 13.5 mi. After camp had been established, about at sundown, Simpson and Major Kendrick (a commander of two artillery companies) took a walk "to a tableau mound, where we found, horizontally disposed, an outcrop of bituminous coal" (p. 73), with sandstone above and below. This camp was several miles northwest of the present settlement of Torreon, within the outcrop belt of the Fruitland Formation. This is the first record of Fruitland coal, and was cited by the first geologist to study the area, more than 50 years later (Shaler, 1907, p. 408). More than a century after Simpson's journey, the Fruitland Formation would begin to be mined on a large scale, and currently it produces most of the more than 20 million tons of coal extracted annually from New Mexico rocks.

On 26 August the party continued traveling to the northwest, for the first seven miles ascending to the crest of the Continental Divide near Star Lake. Simpson recognized this point "as dividing the tributaries of the Gulf of Mexico from those of the Pacific" (p. 75). He noted that instead of exhibiting the steep slopes of primary mountains, as it had been portrayed on previous maps, or the flat table-like aspect of mesas, the Continental Divide had more the aspect of an evenly convex uplift with rather gentle slopes.

Prior to reaching the Divide, however, the party had passed rocks of apparent igneous origin (p. 74),

exhibiting very strikingly the gradual effect of igneous action upon matter, in proportion to its proximity to the source of heat. Highly scoriaceous rocks protruded here and there through argillaceous rocks, burnt to different degrees of calcination; and a dirty yellowish friable sandstone rock crops out all around from underneath the mass. This is the first scoriaceous or lava rock I have noticed since I left the valley of the Jemez.

Again, as there is no evidence of true igneous activity anywhere in this region, Simpson was seeing the effects of spontaneous combustion in burning coal beds and baking the surrounding rocks into a hard, ceramic-like "clinker." Indeed, early geological surveys noted that "Laramie" (= Fruitland) coal was much burned in the Torreon Wash and neigh-

boring areas (e.g., Gardner, 1909), and clinker deposits are common across much of the Fruitland outcrop in the southern San Juan Basin.

A mile and a half farther on, Simpson again (p. 74)

came to a locality where coal crops out of the soil. Near this locality is a very shallow depression or basin, caused by the washing of the rains. In this basin we found some beautiful specimens of petrified wood—in two instances the trunks of the trees still standing erect and *in situ*. One of these trunks was two feet high by two in diameter, and the other three feet high by two and a half in diameter. In another instance, a trunk of a tree, in its petrified state, had fallen over and split open, the parts lying together as if they had but just been cleft with an axe. Do not these petrifications show that this country was once better timbered than it now is? All the *sylva* we *now* find—except the cottonwood occasionally to be seen on the watercourses—is a scrub growth of cedar and pine.

Simpson's description of this locality will be readily familiar to anyone who has observed the scalloped, highly eroded badlands topography of the Fruitland and overlying Kirtland Formations in the San Juan Basin. The petrified tree stumps (Figs. 5, 6) represent the first record of fossils in Fruitland strata, and such *in situ* stumps are moderately common in some areas, most notably the "Fossil Forest" some 40 mi to the northwest. The Fruitland contains a diverse fossil biota consisting not only of numerous plants, but many dinosaurs and other vertebrates as well (Lucas, 1981).

Simpson's comment that the petrified wood indicates that this region was once better timbered than at present is of course true. However, he was thinking in terms of a few hundred years ago, rather than millions of years, for he compared the present barrenness of this part of New Mexico with similar regions of southern Mexico, which were well forested during the time of the Aztecs. As for the causes of these vegetation changes, Simpson retreated into a curious and uncharacteristic religious explanation—that God cursed the country with barrenness because of the wickedness of the inhabitants, and scattered them "as the ruins everywhere attest that He has done" (p. 75).

After crossing the Continental Divide, the expedition descended its western slope to the headwaters of the "Rio Chaco" (Chaco Wash, one

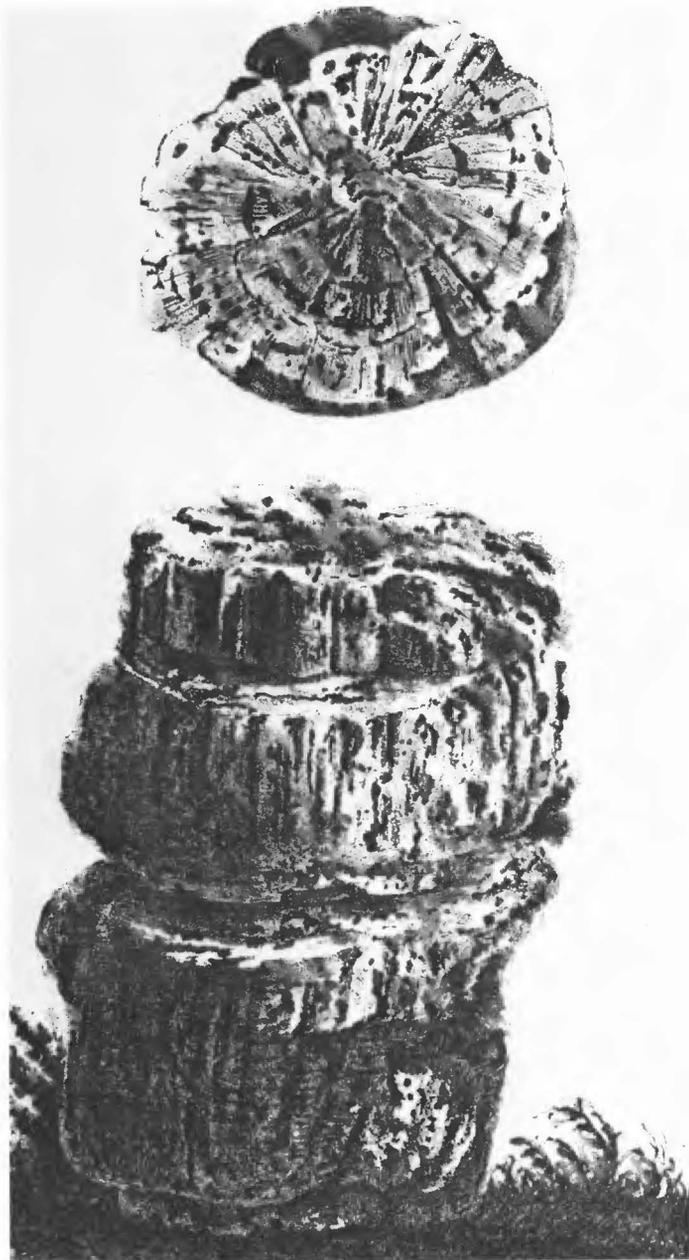


FIGURE 5. "Elevation and Cross Section of a petrified Stump of a tree found standing upright, in place between camps No. 7 and No. 8 [25 and 26 August]" (pl. 18 of Simpson, 1850b).

of the main northern tributaries of Chaco Canyon), and followed it to Pueblo Pintado, where camp was established after a day's march of about 21.5 mi. After dinner, Simpson and the Kern brothers set off "with high expectations" to explore the ruins. From the detail of his description of the architecture and building materials, Simpson must have spent several hours examining Pueblo Pintado, and he returned the following day, 27 August, after the rest of the party had broken camp and headed west through Chaco Canyon. "We would gladly, had time permitted, have remained longer to dig among the rubbish of the past"; Simpson noted (p. 77), "but the troops having already got some miles in advance of us, we were reluctantly obliged to quit." Not mentioned by Simpson, but noted by Love (written comm. 1992), is the fact that several logs were removed from the structure for firewood by the expedition, thus making it difficult to obtain tree-ring dates for Pueblo Pintado.

As the party advanced through Chaco Canyon, it passed by friable sandstone cliffs and occasional stone habitations. Simpson noted bi-

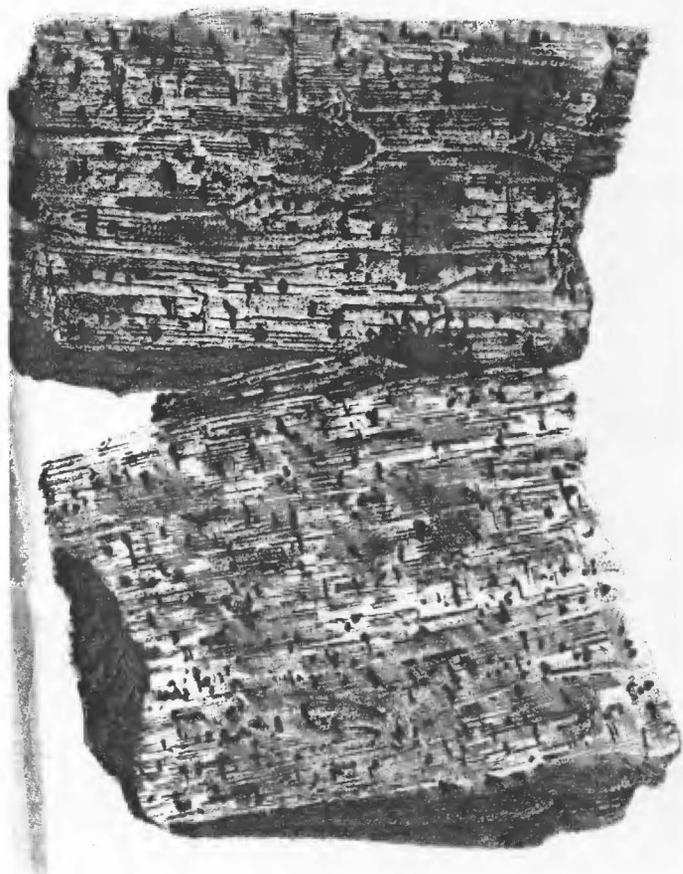


FIGURE 6. "View of a petrified Stump of a tree found lying split open as exhibited in the drawing" (pl. 19 of Simpson, 1850b).

tuminous coal again, "cropping out from sandstone rocks," as they passed through the upper Menefee-lower Cliff House interval. After a march of nearly 15 mi, which put them about 1 to 2 mi east of the present visitor's center for the monument, the party established camp. Nearby (Fig. 7), a

view burst upon us as we turned an angle of the cañon, just before reaching camp. The chief object in the landscape was *Mesa Fachada*, a circular mound, with tableau top, rising abruptly, midway in the cañon, to a height of from three hundred to four hundred feet. The combination of this striking and beautiful object with the clear sky beyond, against which it was relieved, in connexion with the lesser mounds at its base, the serried tents of the command, the busy scene of moving men and animals in the vicinity, and the curling smoke from the camp fires, made up a picture which it has seldom been my lot to witness. (p. 78)

The following day, while the main party moved out of Chaco Canyon, Simpson, with R. H. Kern, an Indian guide and a small mounted escort, struck off on their own to explore more of the ruins in the canyon. Pueblos Una Vida, Hungo Pavie, Chetro Ketl, Bonito, del Arroyo, Peñasco, and two unnamed small ruins (Kin Kletso and Casa Chiquita) were visited and detailed descriptions of several of these ruins—the first for the Chaco Canyon buildings—appear in Simpson's journal. Considering that Simpson spent only a day examining the ruins, his observations were remarkably detailed and comprehensive. He not only described the ruins he visited, but measured their dimensions, speculated on what the complete buildings might have looked like, and what functions certain rooms might have served. He discussed again the likelihood that the Aztecs, moving south toward Mexico, had built them, for (p. 83)

the rooms I have described . . . are evidently, from the similarity of their style and mode of construction, of a common origin; they discover in the materials of which they are composed, as well as the grandeur of their design and superiority of their workmanship, a condition of architectural

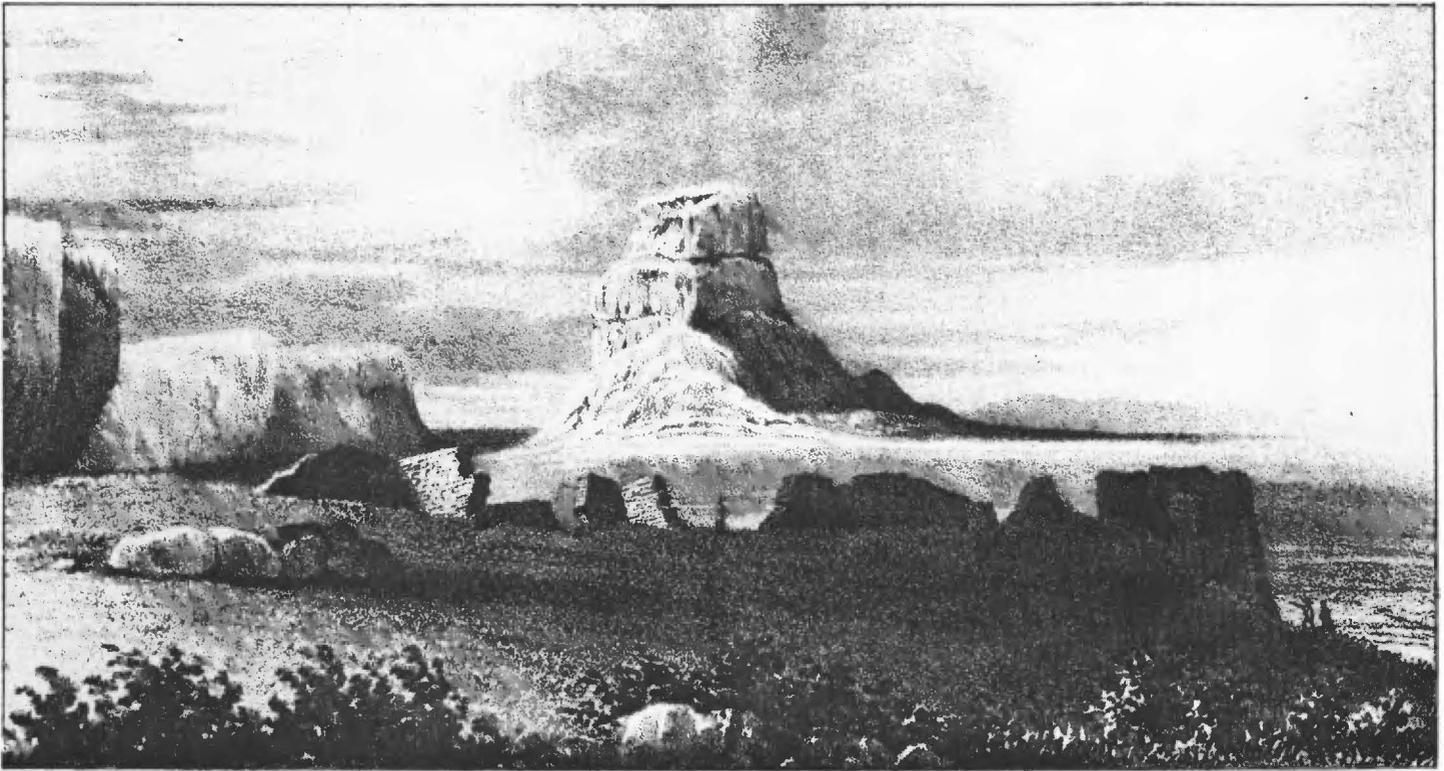


FIGURE 7. "Ruins of the Pueblo Una Vida, with the Mesa Fachada in the distance" (pl. 28 of Simpson, 1850b).

excellence beyond the power of the Indians or New Mexicans of the present day to exhibit . . .

Simpson's record of Chaco Canyon's ruins remained a primary source of information on them for nearly half a century; few other Americans visited them during that time. Members of two military expeditions chasing Navajos left their names on the rocks near Chetro Keti in 1858, and Oscar Loew, geologist for the Wheeler Survey visited them briefly in 1874 (Loew, 1875). Three years later, the photographer W. H. Jackson spent five days examining the ruins. Although producing no photographs, he described the ruins and related surficial geological features in detail (Jackson, 1878). Jackson was the first person in the Southwest to apply geological observations to the interpretation of archaeological materials in context, and discovered a buried arroyo containing pottery adjacent to some of the large Chaco pueblos (Jackson, 1878; Love, written comm. 1992).

Jackson also measured a fairly wide and deep (16 ft) channel of the arroyo in Chaco Canyon. As indicated in the discussion of the Rio Puerco, Bryan (1928, 1954) believed that incision of the arroyo reported by Jackson had occurred since Simpson's visit 28 years earlier, because Simpson made no mention of a steep-walled gully or arroyo in the canyon. However, this is dubious evidence, because Simpson's journal does not include every detail of what he saw along his route. (There is no mention, for example, of Mt. Taylor as he was traveling along its base.) Awed by the canyon and intent on studying the ruins within it, Simpson could easily have neglected to note or record the dimensions of the arroyo channel.

Because of its remoteness, serious archaeological excavations and studies of the Chaco Canyon ruins did not commence until 1896, when the Hyde Exploring Expedition began four years of excavations focusing on Pueblo Bonito.

Simpson and his small group set off in the early evening and covered 15 mi, mostly in darkness, but did not find the camp of the main party. However, he could say, with some satisfaction, that the "whole distance travelled today was about twenty-three miles; and, considering the amount of labor we accomplished at the ruins, we look upon our day's

work as being considerable" (p. 86). Their camp was in the vicinity of the present La Vida Mission.

#### Chaco Canyon to Canyon de Chelly

The following morning, 29 August, they lingered for awhile near camp, in the valley of the Rio Chaco, believing they were ahead of the main party. Simpson (p. 86) again observed exposures of the Menefee Formation.

I examined the geological structure of the rocks forming the enclosing walls of the cañon. Beginning at the base and proceeding upwards, I found, first, a bed of impure bituminous coal five feet thick; next, a stratum of argillaceous earth twelve feet thick; next, two feet of argillaceous rock of a reddish ferruginous aspect, presenting evidences of induration by heat; and last, forming the crowning rock of the whole, an amorphous yellow sandstone, interstratified with gray argillaceous shale, of about two feet in thickness. Upon the *talus* of the escarpment I picked up also some fragments of selenite. The formation just described has characterized the country generally ever since we left the *Rio Puerco*.

Simpson, although untrained as a geologist, was correct; the expedition had continuously been within exposures of the Mesaverde Group since the Rio Puerco. His description of the sequence of strata at this locality represents a perfectly good stratigraphic section for the time.

With no sign of the expedition by late morning, Simpson's group continued northwest up the valley of the Rio Chaco for 6.5 mi before encountering another exposure of the Menefee that he thought worthy of description (p. 87):

. . . we came to a hemispherical mound, fifteen feet high, and of about fifty feet base. At the base, coal crops out. Immediately above is a blue rock, apparently argillo-calcareous, two feet thick, blackened as if by fire. Above this, and forming the chief covering, is a grayish-white pulverulent mass, intermingled with fragments of red argillaceous rock, also showing marks of heat; and immediately at the apex, or summit, are fragments of the same kind of rock, highly scoriaceous. Is it not reasonable to presume that here has been a slight upheave from below, attended with fusion—indeed, a volcano on a small scale?

These exposures were described much later by Shaler (1907, p. 403, No. 68), who noted that "nearly all the coal beds exposed here have been burned at their outcrops." It is not surprising that Simpson mistook the evidence of heat for volcanic activity. Simpson's party left the valley of the Rio Chaco about 3.5 mi farther on, near its junction with Denazin Wash, and struck southwestward across "a barren waste of broken hills and arid plains" (p. 87). Then it crossed an extensive area of badlands in the Menefee Formation (p. 87):

... we got in the midst of a most singular profusion and confusion of deep, rugged ravines, and high sandstone rocks, of almost every shape and character imaginable. Here were at once to be seen domes, pillars, turrets, pinnacles, spires, castles, vases, tables, pitched roofs, and a number of other objects of a well-defined figurative character. . . . The base of these formations is an argillaceous friable rock.

To the party's relief, the camp of the main expedition came into view, and after a total march of 29 mi for the day, Simpson and his men rejoined it. The troops were camped in the Tumecha (now Chuska) Valley, near Badger Springs, the present site of the Naschitti trading post on US-666, about 8 mi east of the Chuska Mountains. While Simpson was exploring the Chaco Canyon ruins, the main expedition had headed nearly due west. The short notes kept by E. M. Kern while Simpson was away note petrified wood along the route, which would have come from the Menefee Formation.

The expedition headed northwest up the Chuska Valley on 30 August, with the peaks of the "Ojo Calientes" (Fig. 8) presenting "a most splendid view" (p. 88) ahead. They appeared, Simpson noted, "very much like ships under full sail—two of them looking very rakish, and the other more upright, as if moved by a gentle breeze" (p. 89). These peaks, now named Bennett Peak and Ford Butte, rise along US-666 about 7 mi north of Newcomb. They are small volcanic necks composed entirely of tuff breccia (Williams, 1936), with associated radiating dikes, intruded through surrounding Cretaceous exposures of the Menefee Formation (Beaumont and O'Sullivan, 1955). The troops passed through the lushest cornfields Simpson had seen in New Mexico, and found the water of the Rio Tumecha to be sufficient and good. Although deep in

Navajo country, this was the first day that members of the tribe appeared in large numbers. A council with several of the chiefs was arranged by Colonel Washington for the following day, and camp was established along Tuntsa Wash near the site of the present Two Grey Hills trading post.

At noon on 31 August the council was held, and Simpson reported the discussion nearly verbatim. Colonel Washington, through Calhoun, the Indian agent, asserted American protection over the Navajos, the right to establish forts and draw boundaries in their territory, and required that the Navajos turn over stolen livestock and Mexican captives. The response of the Navajos to these demands, as recorded by Simpson, ranged from "they are willing," to "it is all right" and "they are very glad." What the Navajos *really* thought went unrecorded. At the end of the conference, a minor altercation involving a stolen horse the tribe refused to return escalated; American troops fired on a group of Navajos, killing Narbona, an 80-year-old chief, and six others. Simpson commented that these people were "tricky and unreliable, and probably never will be chastened into perfect subjugation *until troops are stationed immediately among them*" (p. 91), and lamented the loss of several pack mules that had wandered off during the fight.

The party moved a little more than 4 mi before camping in the Chuska foothills. Simpson took the opportunity to summarize briefly the topographical features and the geology of the area so far traversed. Concerning the fertility of the land, he somewhat disdainfully noted (p. 92) that the entire country, with minor exceptions, "is one extended, naked, barren waste."

Ascent of the Chuska Mountains commenced on 1 September, as the expedition headed southwest, taking precautions against Indian attack. The route was steep and rocky, and progress was difficult. Crossing an arroyo, Simpson noted in its banks "bituminous coal, apparently of excellent quality . . . in beds of from two to three feet in thickness, with argillaceous shale intervening" (p. 93)—an outcrop of the Menefee Formation. Landslide debris from high exposures of the Tertiary Chuska Sandstone mantles the eastern slopes of the Chuska Mountains in this area, covering Menefee outcrops and contributing to the difficulty of

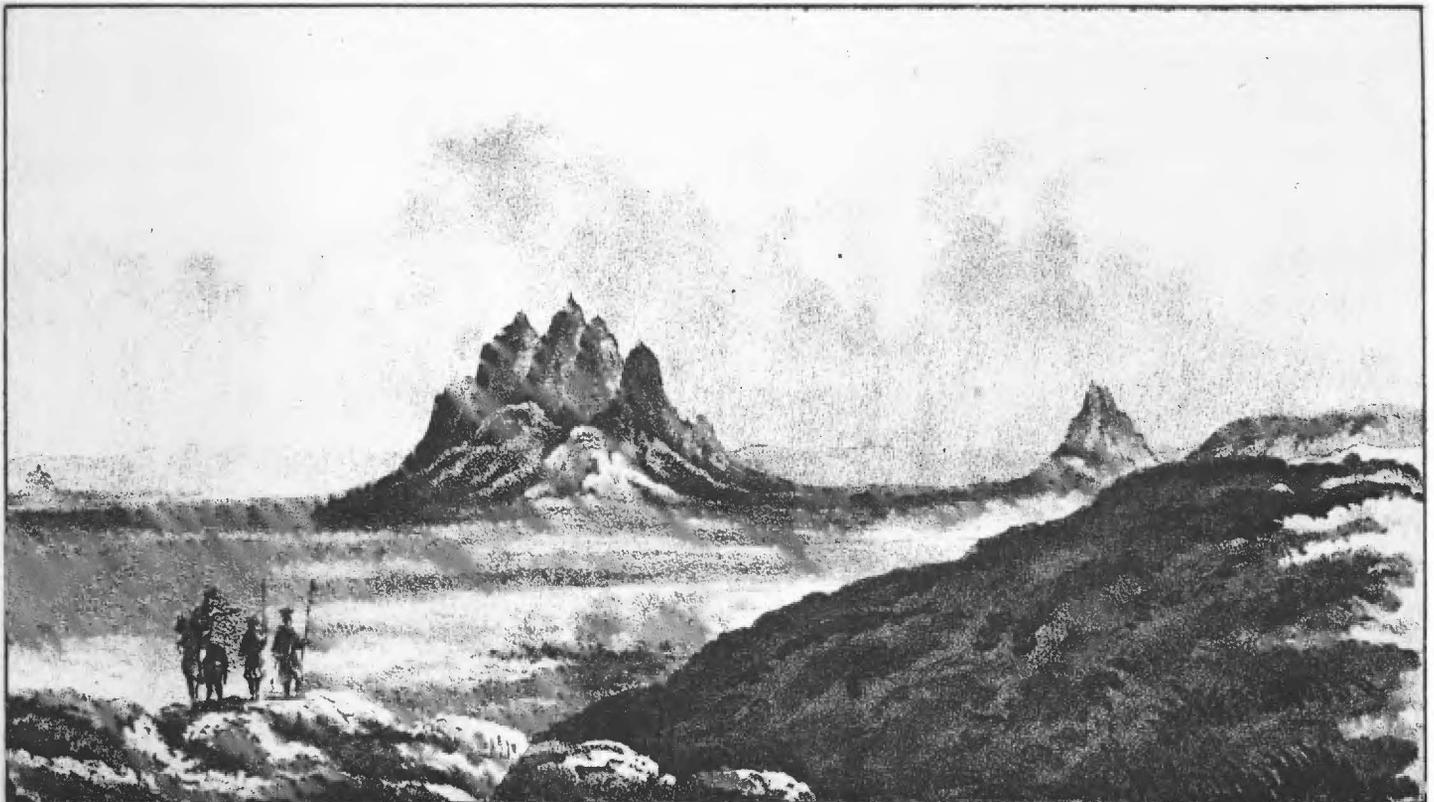


FIGURE 8. "Peaks of Los Ojos Calientes" (pl. 43 of Simpson, 1850b), as seen on 30 August.

travel. Watson and Wright (1963) called this landslide area one of the largest and most continuous areas of mass movement in the United States. They recognized three levels of debris, each representing a separate period of sliding. The highest produced a topography of ridges and troughs parallel to the main escarpment, composed of gigantic masses of detached sandstone up to 100 ft high and wide, and 1000 ft long. This mass movement is not now active, but occurred during the cooler, moister conditions of the Pleistocene. Blocks became detached from Chuska Sandstone exposures along joints, and moved down-slope without tilting, over water-saturated underlying sediments and porous sandstone exposures.

The party camped this day after proceeding a laborious 10 mi. The following day, it ascended the final distance to the crest of the Chuskas, covering a total of but 6 mi. The pass (Fig. 9) was extraordinarily formidable (p. 94):

On the north side is a wall of trap, capped with sandstone, running perpendicularly up from the bottom of the defile to a height of about six hundred feet; and, in addition to this, there are two others, but further removed. On the left side is another height, running up from the defile, with an accessible slope, to a height of probably about three hundred feet.

The width of the pass at this pint is probably not more than fifty feet, and barely furnishes a passage-way . . . for the artillery.

Simpson named the pass for Colonel Washington, the name it bears today. In recent years the Navajos have advocated changing its name to Narbona Pass, and it is likely this change will be made in the near future (Love, written comm. 1992). The sandstone noted is the Chuska Sandstone, the tan to white, fine- to medium-grained, crossbedded, eolian unit of Eocene or early Oligocene age that caps much of the area of the Chuska Mountains. It is typically 800–1000 ft thick, and forms steep cliffs along the upper heights of the range (Wright, 1956; Smith et al., 1985).

The “trap” is part of a large, local mid-Tertiary outpouring of basalt and tuff associated with a caldera some 2 mi in diameter and 700 ft in depth, through which Washington Pass has been eroded. According to Appledorn and Wright (1957), who studied this volcanic field, pyroclastic rocks were first emitted by explosive eruptions, followed by voluminous eruptions of lava, which filled the depression and extended beyond it, attaining a maximum thickness of more than 300 ft. These volcanic eruptions covered the local erosional topography developed on the surface of the Chuska Sandstone. Three main basalt flows, all greenish-gray trachybasalts, have been identified. Dikes and three small columnar plugs of dense black minette (feldspathic basalt) intruded the basalt and pyroclastic debris. Simpson’s mention of “a wall of trap, capped with sandstone” is difficult to explain, as no later observer has reported sandstone overlying the basalt flows.

Simpson took the opportunity here to correct an earlier report from a fanciful book written by a private on the Doniphan expedition (McNitt, 1964), referring to the Chuskas as “the grandest of mountains, consisting of large masses of granite piled upon granite, and penetrating into the region of clouds and permanent snows” (p. 95). He dryly noted that he saw neither granite nor snow. Simpson did observe (p. 95) that “a very pretty stone, between the jasper and chalcedony, has been found strewed over the ground at this and our last encampment.” He was not the first to notice these “pretty stones,” which are white to salmon-pink chalcedony derived from veins and nodules in the volcanics of the Washington Pass area. It is of excellent quality for stone implements and was used extensively by Anasazi as well as older Indian cultures. Evidence of ancient quarrying for this chalcedony is abundant in the Washington Pass area (Loose, 1977).

On 3 September, the expedition followed the canyon of the Rio Negro (now Crystal Creek) down the east slope of the Chuska Mountains, and camped at Sienequilla Chiquita, west of the present community of

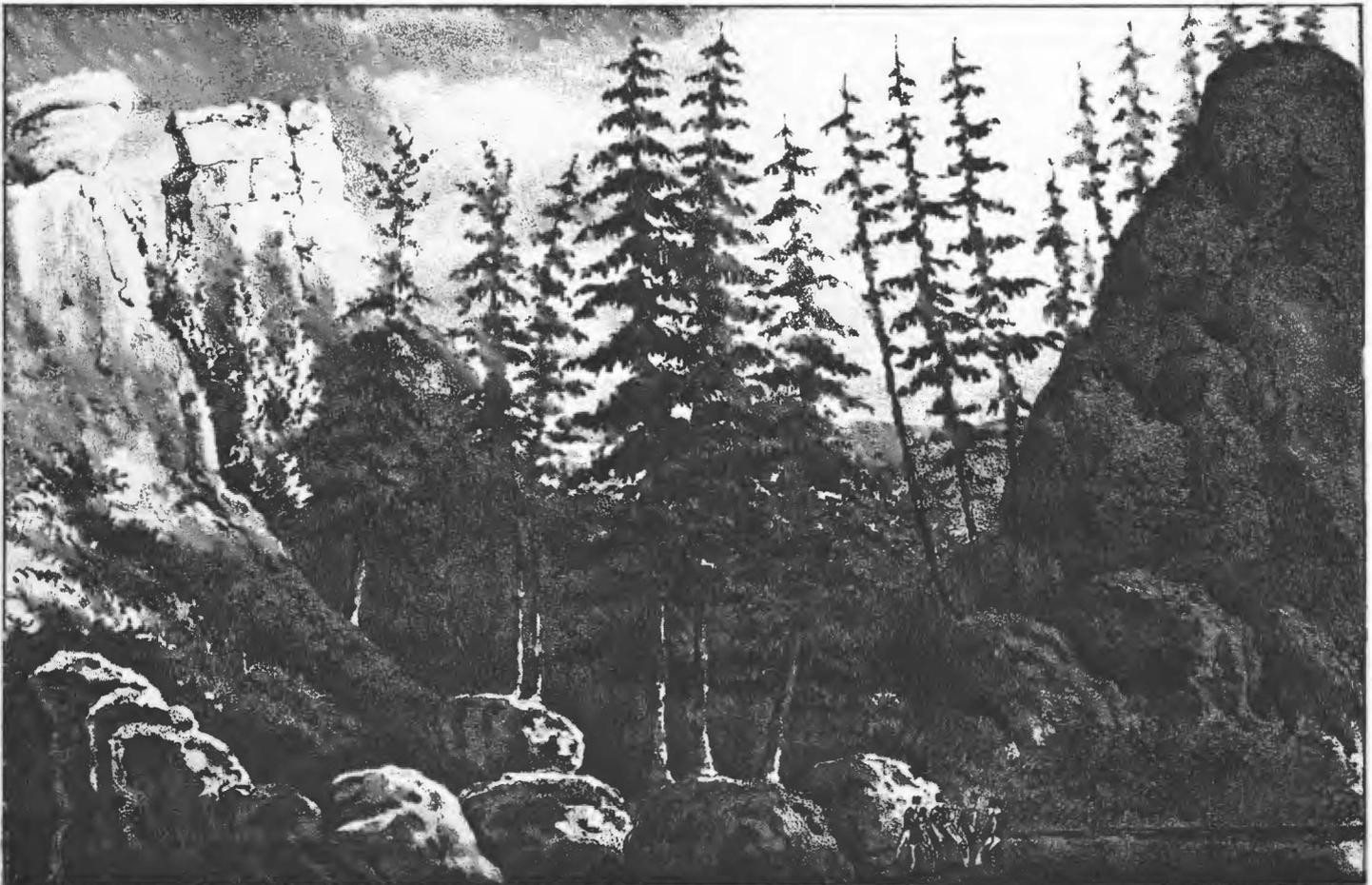


FIGURE 9. “Pass Washington, Tune-cha [sic] Mountains” (pl. 45 of Simpson, 1850b).

Crystal and within a mile or two of the New Mexico–Arizona border. Simpson recorded no geological observations during the 12-mi march, but was impressed with the remarkable scenery, the rich soil, and profusion of vegetation, including 90 different varieties of flowers.

The expedition headed to the northwest on 4 September, and covered 13.4 mi.

For the first half of the distance, the *Sierra Rayada* was immediately on our left; and throughout the whole of it, the *Sierra de Sienuilla* was immediately on our right. These mountains are of a basaltic trap character, in some instances resembling very much the palisades on the Hudson river. This trap is apparently the effect of protrusion, rather than of overflow, and is more irregular in its outlines than that I have already noticed as characterizing the country west of the Rio de Jemez.

At about six miles from our last camp, immediately on the right of the road, I observed a well-marked dike of trap rock, its course being north of east, and it leaning slightly towards the north. It exhibits itself in an outcrop of detached blades, some of them being from thirty to forty feet above the plain, and about three feet thick. The soil from which it projects is of a reddish argillaceous character. This outcrop, it is obvious, must have been the effect of protrusion from below, and at a time when there were rocks against it to prevent an overflow; and these adjacent formations must since have been either decomposed or have sunk. (p. 97)

This route crossed the valley of what is now called Whiskey Creek, which flows westward into Canyon de Chelly. Sierra Rayada is now known as Sonsela Buttes, and the Sierra Sienuilla is a prominent southwestern extension of the Chuska Mountains. Both Sonsela Buttes rise from an eroded surface of Triassic Chinle Group sediments (the reddish soil noted by Simpson). East Sonsela Butte is composed of Chuska Sandstone, capped by at least three basalt flows, whereas West Sonsela Butte is a dome-shaped, circular mass of basalt overlying a pyroclast-filled crater about a mile in diameter. A small volcanic neck between the two buttes may mark the source of some of the basalts (Appledorn and Wright, 1957).

Simpson's comparison of Sierra Sienuilla to the Palisades of the Hudson River is apt; the name Palisades is still applied to this feature

(Williams, 1936; Appledorn and Wright, 1957). This large volcanic mass was erupted into a valley system eroded into the underlying Chuska Sandstone, and rises some 1800 ft above the level of Whiskey Creek. The south wall, which impressed Simpson, is a vertical cliff more than a mile long, composed of massive columnar basalt more than 400 ft high. The stratigraphic position, composition, and structure of the basalts of the Sonsela Buttes and the Palisades are quite similar to the Washington Pass volcanics, very likely indicating a genetic relationship (Williams, 1936).

Several small volcanic necks with associated dikes are present near Sonsela Buttes, including a conspicuous one in the valley between these buttes and the Palisades that was probably the "well-marked dike of trap rock" (Fig. 10) that attracted Simpson's attention. His explanation of the dike, as an eroded intrusive feature, is essentially correct. McNitt (1964) put the day's camp on Tsaille Creek, which runs into the Canyon del Muerto, north of Canyon de Chelly. However, the distance traveled this day and the topographic features reported by Simpson, as well as features described the following day, suggest that the expedition may have camped nearer to Wheatfields Creek, a few miles to the south. Wheatfields Creek is a tributary that flows southwestward into Canyon de Chelly.

The following morning, Colonel Washington, Simpson, the Kern brothers and several others rode 5 mi to the southwest to obtain a view of the head of Canyon de Chelly. McNitt (1964) placed them at the head of Canyon del Muerto, but the sketch of this location (Fig. 11) includes a tall, isolated pillar that is probably Spider Rock, which would have been easily visible from the north side of Canyon de Chelly.

On reaching the cañon, we found it to more than meet our expectations—so deep did it appear, so precipitous its rocks, and so beautiful and regular the stratification. Its probable depth I estimate at about eight hundred feet.

As far as time would permit an examination, for a depth of about three hundred feet—I could descend no further, on account of the wall becoming vertical—the formation appeared to be sandstone, horizontally stratified with drift conglomerate. At this depth I found protruding from the wall,



FIGURE 10. "Trap dyke" (pl. 47 of Simpson, 1850b), seen on 4 September.

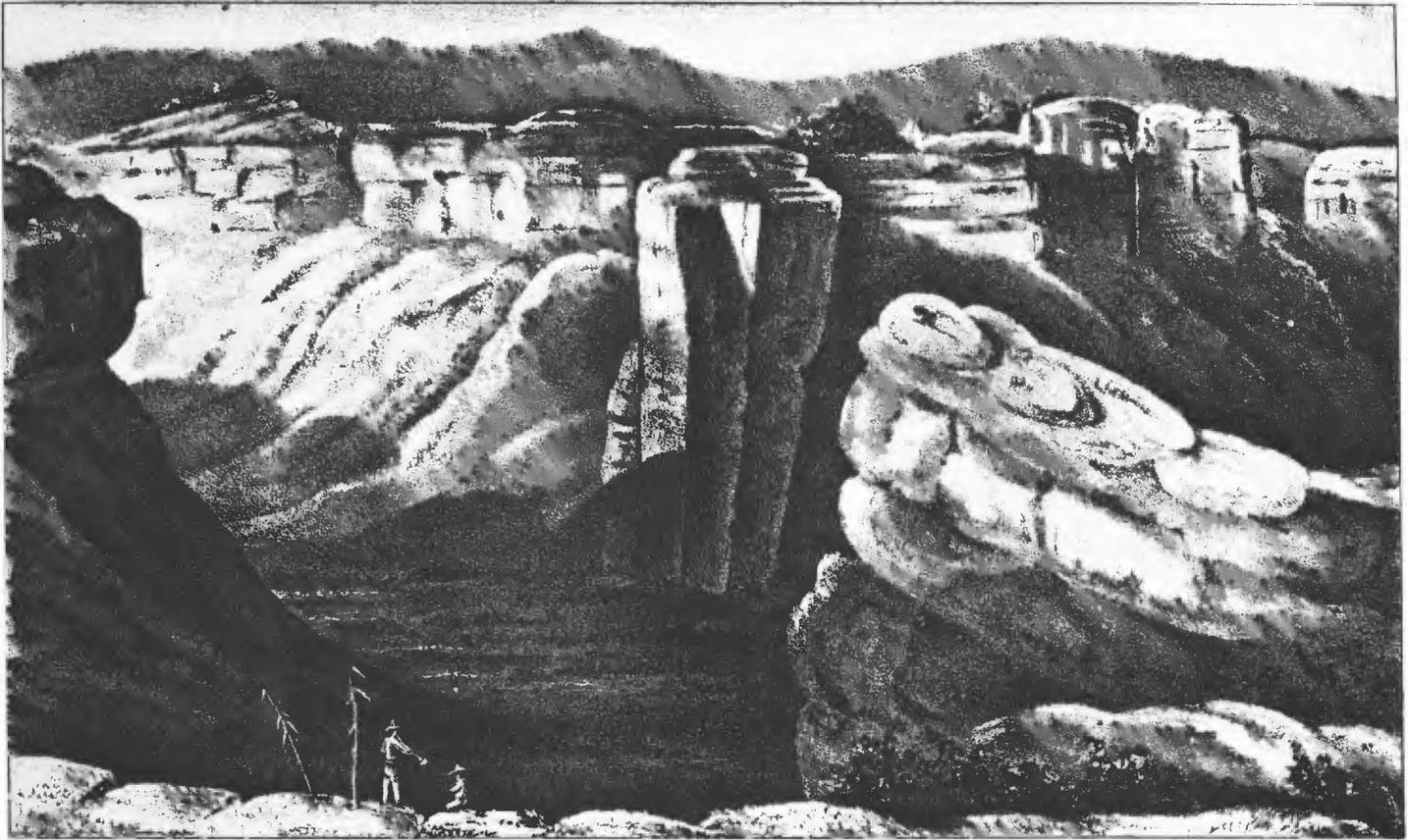


FIGURE 11. "View of the Cañon of Chelly near its head" (pl. 48 of Simpson, 1850b), as seen on 5 September.

its end only sticking out, a petrified tree of about a foot in diameter, a fragment of which I broke off as a specimen. How did this tree get there? I also picked up at this point, upon the shelf on which I was standing, a species of iron ore, probably red hematite. (p. 98)

Canyon de Chelly and Canyon del Muerto are deep gorges incised by streams flowing westward off the Chuska Mountains as the Defiance uplift, a north-south-trending anticlinal structure, rose during the Tertiary (Baars, 1983). These streams gradually cut through the surficial sandstones and shales of the upper Chinle Group, and eroded deeply into the underlying Triassic Shinarump Formation and thicker Permian DeChelly Sandstone, which form the walls of these canyons. Canyon de Chelly became the ultimate destination of Washington's expedition because it was reported to be the stronghold of the Navajos. Since the unsuccessful meeting several days previously east of the Chuskas, numerous Navajos had approached the party indicating a desire for peace, but, in Simpson's words (p. 98) ". . . they want peace; but the official persons, the chiefs, not presenting themselves to obtain it, the colonel commanding is determined to push on to the Chelly, the heart of their country, and dictate the terms there."

After reconnoitering the canyon, Washington's small reconnaissance party returned to camp, and the expedition headed northwest. Simpson noted of the canyon that he "had not the time necessary to make the full examination which I would have liked. I saw, however, enough to assure me that this cañon is not more worthy of the attention of the lover of nature than it is of the mineralogist and geologist" (p. 99). Soon after breaking camp, the expedition

. . . passed on our right a cylindrical mass of trap rock protruding from the summit of the mountain ridge, the outcrop being probably as much as one hundred and fifty feet high. This singular landmark was seen yesterday before reaching camp. Two and a half miles further can be seen, also, immediately on the right of the road, a dike of trap rock ranging very nearly east and west, its eastern terminus of the form of a semi-conical abutment, about five hundred feet in protrusion from the plain below. A portion of this dike is perfectly columnar in its details. (p. 99)

Although McNitt (1964, p. 81) wondered why Simpson failed to mention Tsaile Peak, a prominent igneous landmark on the western side of the Chuskas, the "cylindrical mass of trap rock" mentioned above can only be this feature. The east-west-trending dike of columnar trap is Black Pinnacle, an elongated neck of platy and columnar intrusive rocks composed mainly of alkali feldspar, diopside and biotite (Williams, 1936). Black Pinnacle is between Wheatfields and Tsaile Creeks, close to the route of the expedition. Camp was established, probably on Tsaile Creek (McNitt placed it at the head of Sheep Dip Creek, a few miles to the northwest), after a total march of 7.4 mi.

On 6 September, the troops departed early and marched a distance of more than 26 mi across a rolling landscape cut by numerous rocky arroyos, which impeded the progress of the artillery. Their route generally paralleled the north rim of Canyon del Muerto, and brought them at the end of the day to the common mouth of Canyons de Chelly and del Muerto, near the present town of Chinle. As they approached, Simpson witnessed numerous "huts of the enemy, one after another, springing up into smoke and flame, and their owners scampering off in flight" (p. 100). McNitt (1964) suspected that Washington had ordered the hogans burned, rather than the Navajos setting them on fire. Cornfields in the vicinity supplied forage for the animals, and "fine roasting ears" for the men's dinner.

On 7 September, Washington met with Mariano Martinez, one of the primary Navajo chiefs, who agreed to organize a conference in a day or two. The following day, Simpson and an escort of 60 troops headed east to begin exploration of the canyon. The party moved slowly, examining side canyons as they progressed gradually up the main one. Simpson marveled at the "stupendous appearance" of the vertical rock walls, noted caves and springs and some small cliff dwellings. About 4 mi from the canyon's mouth, he reported (p. 103)

The width of the cañon at this point is probably from two to three hundred yards wide, the bottom continuing sandy and level. And, what appears to be singular, the sides of the lateral walls are not only as vertical as natural

walls can well be conceived to be, but they are perfectly free from a talus of debris, the usual concomitant of rocks of this description. Does this not point to a crack or natural fissure as having given origin to the cañon, rather than to aqueous agents, which, at least at the present period, show an utter inadequacy as a producing cause?

Here, Simpson's inadequate understanding of the vast time scales of geology led him to misinterpret the origin of the canyon. A sudden event, the opening of a fissure, seemed more reasonable than supposing that the slow erosive activity of a small stream over a long span of time could have both cut the canyon and broken down and disseminated the talus from its walls.

Eventually, about 7 mi from the mouth, the party reached "some considerable ruins" on the north side of the canyon, about 50 ft above the floor (Fig. 12). Simpson briefly described these ruins, now called White House ruins, which are the largest cliff dwellings in Canyon de Chelly. The party continued up the canyon for two more miles before heading back toward camp:

Proceeding still further up the cañon, the walls, which yet preserve their red sandstone character, but which have increased in the magnificence of their proportions, at intervals present *facades* hundreds of feet in length, and three or four hundred in height, and they are beautifully smooth and vertical. These walls look as if they had been erected by the hand of art—the blocks of stone composing them not infrequently discovering a length

in the wall of hundreds of feet, and a thickness of as much as ten feet, and laid with as much precision, and showing as handsome and well-pointed and regular horizontal joints, as can be seen in the custom-house of the city of New York. (p. 104)

Simpson and his companions were the first Americans to explore Canyon de Chelly. To Simpson (p. 105):

The mystery of the Cañon of Chelly is now, in all probability, solved. This cañon is, indeed, a wonderful exhibition of nature, and will always command the admiration of its votaries, as it will the attention of geologists. But the hitherto-entertained notion that it contained a high insulated plateau fort near its mouth, to which the Navajos resorted in times of danger, is exploded.

Simpson discussed the surprising contrast between the Navajos' present pole, brush and mud lodges, and the well-designed and constructed pueblo dwellings at Chaco Canyon and Canyon de Chelly. He considered the possibility that the Navajos had once inhabited the pueblos, but questioned how they could have "retrograded in civilization" to their present migratory state. He proposed two hypotheses to account for this: either the Navajos descended from a stock of Indians that split off from the stock that later produced the pueblo-builders, or (p. 106), "in the process of time, the cultivable and pastoral portion of the country becoming more and more reduced in area, and scattered in locality, the people of necessity became correspondingly scattered and locomotive, and thus gradually adopted the habitation most suitable for such a state of things—the lodge they now inhabit." Both are logical explanations in view of what was known at the time, and both touch upon factors that actually did influence the development of Southwestern Indian populations.

#### Canyon de Chelly to Zuni Pueblo

On 9 September, a treaty was signed with the Navajos, by which they put themselves under the jurisdiction and "paternal control" of the U.S. government, and agreed to return all stolen property and captives. "Added to this . . ." Simpson noted (p. 107), "the troops have been enabled to penetrate into the very heart of their country, and thus a geographical knowledge has been obtained which cannot but be of the highest value in any future military demonstration it may be necessary to make." This same day news was brought to Colonel Washington of an Apache attack on Zuni Pueblo, with loss of life. Probably this was a ruse by the Navajos to hasten the departure of the Americans (McNitt, 1964).

Washington decided to march to Zuni as quickly as possible, and the following morning the troops left the entrance to Canyon de Chelly and headed southeast. Most of the 20.5 mi covered on 10 September were across the dissected uplands southeast of the canyon, from which Simpson observed (p. 109) "a protrusion of trap rock, looking for all the world like the square tower of a church, with windows" to the northeast (probably Tsaile Peak). About 18 mi into the day's march, the expedition ascended what Simpson called the Sierra de Laguna, part of the Defiance Plateau, and camped on its summit. The geology of the next several days' route in Arizona was mapped by Cooley et al. (1969).

The following day they continued to the southeast, detouring for water into the head of Monument Canyon, the southernmost major tributary canyon of Canyon de Chelly. Their route took them southwest of Buell Park, near the present community of Sawmill, and then nearly due south to the head of Cañoncito Bonito (now Bonito Canyon), just west of the present site of Fort Defiance. Simpson noted a mesa escarpment about 300–400 ft high to the east, marking the eastern edge of the Defiance Plateau, and a sandstone prominence resembling a statue or vase (probably an erosional feature of the DeChelly Sandstone) near the head of Bonito Canyon. Total distance traveled this day was 24.8 mi. Fort Defiance was established two years later, during another ineffectual Navajo campaign (McNitt, 1964).

On 12 September, the expedition threaded its way through Bonito Canyon, which is incised mainly through the Permian Supai Formation and DeChelly Sandstone (Read and Wanek, 1961), and Precambrian quartzite.

This cañon, which is about a quarter of a mile in length, is, on account of its high enclosing walls, and the well-defined character of their strati-

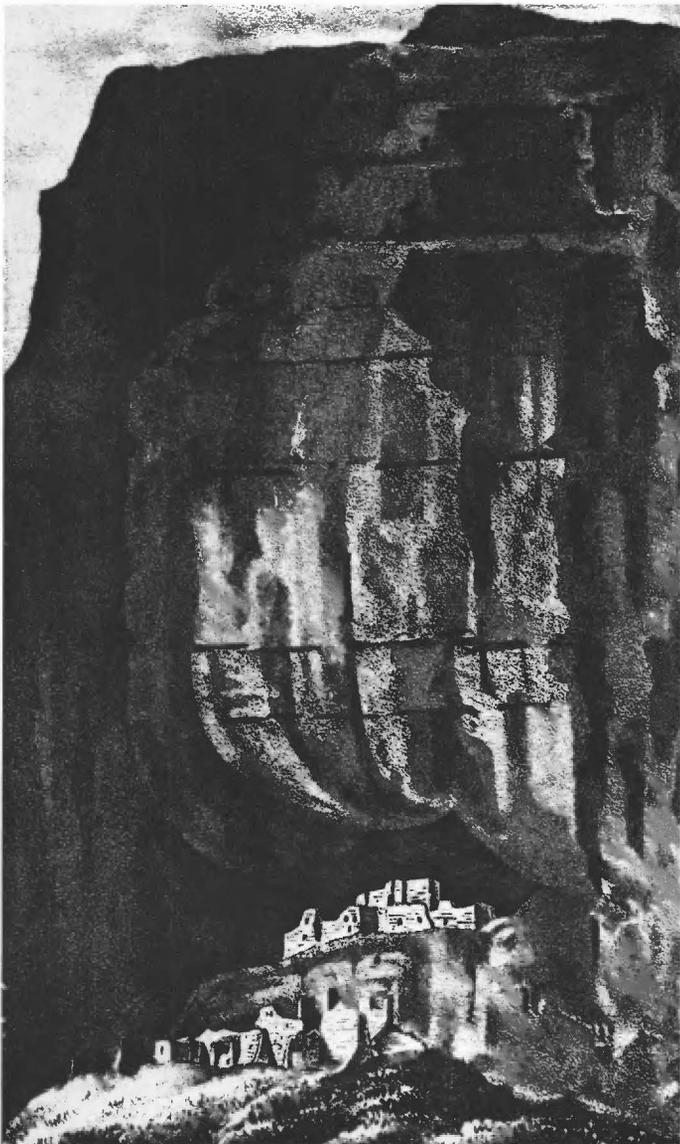


FIGURE 12. "Ruins of an old pueblo in the Cañon of Chelly—Sept. 8th" (pl. 53 of Simpson, 1850b); the earliest depiction of the White House ruins.

fication, beautiful. The walls, which are nearly vertical, are probably from three to four hundred feet high. Their formation is a red friable sandstone—the stratification, which discloses a dip of about ten degrees towards the east, as also the line of cleavage, being very distinctly marked. The width of the cañon is about one hundred feet, a small stream finding its way through its bottom. This cañon differs from that of Chelly, in the face of its walls not being so smooth, in not presenting as large unstratified masses, and in having a *talus of debris* at the foot of the walls. (p. 110)

Just after leaving Bonito Canyon, Simpson noted (p. 110–111):

... down the valley, in a more southerly direction, a trap dike of a striking character presented itself, a short distance to our front. This dike [*sic*], on examination, I found to present a most interesting exhibition of igneous action and vertical protrusion. Its height above the plain is some three or four hundred feet; its breadth, one hundred and fifty; and its length, about two hundred yards. Its strike is nearly due east. Here can be seen, in the same formation, rocks that have once been perfectly fused, and then cooled under pressure, the effect being to make them more dense; rocks that have been fused, and then cooled under the pressure only of the atmosphere, the effect being to make them scoriaceous; and rocks that look as if they had not been fused, but merely baked.

This prominent neck, Black Rock (Fig. 13), rises in isolated splendor from the alluvium of the Black Creek Valley. It is the southernmost of the many Tertiary intrusions in the Chuska Mountains–Defiance Plateau area, and because of its proximity to Fort Defiance, one of the most often mentioned in early accounts. Newberry (1861), for example, included Black Rock in a geologic section of the region, together with a general account of the geology of the Fort Defiance area, although he did not describe it. Black Rock consists of homogeneous feldspathic basalt, mostly covered by a coarse-grained tuff breccia that includes clasts of igneous and sedimentary rocks up to 15 inches in diameter (Gregory, 1917). Simpson was perceptive in noticing the variation in igneous rock types that compose Black Rock, although he exaggerated its height a bit; it is closer to 250 ft high than to 300–400 ft high.

The party continued southward through the Black Creek Valley. Twelve miles south of the previous night's camp (a few miles southwest of the present site of Window Rock), Simpson observed (p. 111)

some very singular whitish abutment rocks, probably of sandstone . . . on the left, jutting out from among rocks of a sandstone character and red color. The difference in the complexion and shape of the former of these rocks indicates a superior hardness, in the formation of which there are prominences. Four miles further, just to the right of the road, appears a beautiful exhibition of horizontal stratification, terminating in one of a bent, semicircular character—the strata (red stone) in the last case being concentric, like the coatings of an onion. . .

Black Creek Valley is eroded into soft, upper Chinle Group sediments; the westernmost of the prominent, narrow hogbacks that mark the east margin of the Defiance Plateau lay to the left of the party as it proceeded south. This hogback is held up by the tan to white massive sandstones of the Jurassic Entrada and Cow Springs Formations, which have eroded into a variety of unusual features, such as the “window” at Window Rock. Camp for the day was established after a march of 23 mi, and was located about 2 mi north of the Canyon of Black Creek.

About noon on 13 September, after a heavy rain, the troops continued their march south, passing the mouth of the Canyon of Black Creek, coming in from the southwest. The “red sandstone rocks, beautifully stratified in curves” observed by Simpson (p. 112) within the canyon, refers to the DeChelly Sandstone and its conspicuous crossbeds. In the lower levels of the canyon, red sandstones and shales of the underlying Pennsylvanian-Permian Supai Formation are exposed. Simpson also noted the first occurrence of limestone boulders since the Jemez area, and a curiously eroded sandstone knob shaped like a tankard with the profile of William Penn. Only a few miles were made this day, and camp was in a broad valley about 2 mi north of present Lupton, Arizona. The campsite was picturesque and peaceful (p. 112):

Our encampment to-night appears peculiarly beautiful. The heavens are deeply blue; the stars shine resplendently bright; the bivouac fires mark well the form and extent of the camp; and peacefully ascending can be seen the blue smoke—the whole forming, in combination with the general cheerfulness which pervades all nature, both animate and inanimate, a most pleasing picture.

On 14 September, progress continued to the southeast, and the march of 12.1 mi brought the expedition once again into the present confines

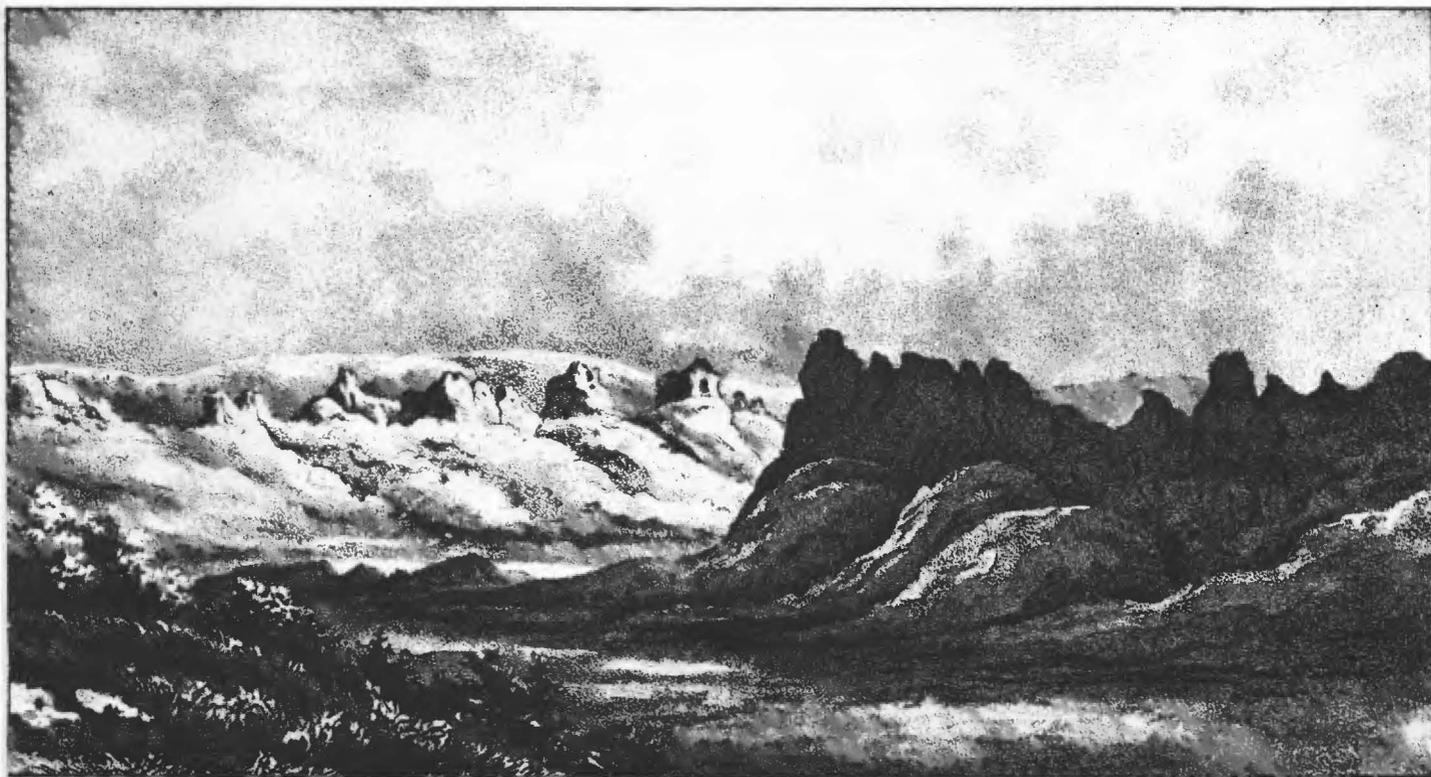


FIGURE 13. “Trap dike and sand stone formations” (pl. 57 of Simpson, 1850b), seen on 12 September. The “trap dike” is Black Rock, just south of Bonito Canyon.

of New Mexico. Early in the day they "crossed an arroyo, coming in from the north, and coursing through a valley half a mile wide, this valley being skirted on either side by mesa heights of red sandstone" (p. 112). This is the Rio Puerco of the West, through which now runs I-40, and the prominent mesas noted by Simpson are easily visible to modern travelers along the interstate just west of the New Mexico-Arizona state line. These mesas are chiefly carved from upper Chinle Group sandstones overlain by thick, massive beds of the Jurassic Entrada (or Zuni) Sandstone, to the east, but are mainly Triassic units to the west. The party continued down a tributary of the Rio Puerco for several miles south of Lupton, before emerging from the valley and moving over a succession of hills and arroyos to Whitewater Creek, where they stopped for the day.

The following day, the expedition headed south-southeast and passed to the west of "a couple of *mesa* mounds, with a very singular-looking pinnacle standing isolated between them" (p. 113), a few miles before reaching the Zuni River, about 3 mi from Zuni Pueblo. These mounds are the Zuni Buttes, which rise from upper Chinle Group strata and are composed of Jurassic sandstones, capped by the Cretaceous Dakota Sandstone. The party was met with enthusiasm by residents and dignitaries from the pueblo, and learned that the story of an Apache attack told to them at Canyon de Chelly, was false. After the long days of marching, and the tensions of traveling as strangers and enemies through Navajo country, their arrival at friendly Zuni Pueblo must have been a pleasant relief.

Simpson included a fairly detailed description of Zuni Pueblo in his journal, and was impressed, writing that it "is by far the best-built and neatest-looking pueblo I have yet seen" (p. 114), and the inhabitants "seem further advanced in the arts of civilization than any Indians I have seen" (p. 115). McNitt (1964, p. 114) noted that "Zuni Pueblo remains today substantially the same village that welcomed Colonel Washington's command" (see also Love, 1989, for details of Zuni Pueblo history and architecture). The Zuni River near the pueblo, at the time the expedition visited, was about 6 ft wide and a few inches deep, in a channel 150 yards wide.

### Zuni Pueblo to Santa Fe

On the morning of 16 September the expedition left camp just east of the pueblo and headed eastward up the valley of the Rio Pescado, approximately along the present route of NM-53. Simpson noted (p. 117), 1.5 mi from camp, mesas on either side of the river capped with basalt,

... a beautiful exhibition of lava, which had been fixed in its wavy, undulating state by sudden refrigeration. This locality is the commencement, eastward, of the evidences of a basaltic, if not of a comparatively recent volcanic outflow, and on that account was regarded by me with considerable interest.

Simpson was seeing here the northwestern extent of the Zuni-Bandera volcanic field, which covers more than 1000 mi<sup>2</sup> of land southeast of the pueblo, and extends all the way to the Grants area. The basalt in this area is the result of relatively recent volcanic activity; a radiometric age of 700,000 ± 550,000 years was obtained from a sample near Black Rock, just east of the expedition's camp the previous night (Laughlin et al., 1979). This lava flowed westward down the Zuni-Pescado River valley from sources to the east. Simpson referred (p. 118) to a previous report by the Doniphan expedition of "immense beds of vitreous deposit [*sic*] and blackened scoriae, presenting the appearance of an immense molten lake in the valleys, and other volcanic remains, with chasms and apertures opening down through this stratum of lava to an unknown depth" near ruins east of Zuni. Simpson observed that he had seen nothing that would fit that apparently wildly exaggerated description. After a march of 13.7 mi, the party camped at *Los Ojos del Pescado*, or Pescado Springs, about 4 mi southwest of the present community of Ramah.

The following morning, Simpson met Mr. Lewis, a trader with the Navajos, who offered to guide him to a rock with "half an acre" of inscriptions, and ruins upon its summit. Permission to leave the expedition to examine them was obtained, and Simpson, R. H. Kern,

another assistant and Lewis set off on a route slightly to the south of the main expedition. They passed (p. 119-120)

... fantastic white and red sandstone rocks, some of them looking like steamboats, and others presenting very much the appearance of facades of heavy Egyptian architecture. This distance traversed, we came to a quadrangular [*sic*] mass of sandstone rock, of a pearly whitish aspect, from two hundred to two hundred and fifty feet in height, and strikingly peculiar on account of its massive character and the Egyptian style of its natural buttresses and domes.

The men skirted the north side of the rock, rounded its eastern terminus, and came upon the inscriptions on the south side (Fig. 14) at about noon. Simpson and Kern immediately set about making copies of all the inscriptions they could find, a task that occupied them the remainder of the day and several hours the following morning. They ceased their efforts near sunset and ascended to the top of the rock to examine the ruins, which Simpson carefully described.

Inscription Rock, or El Morro, is a gigantic erosional headland of the Jurassic Zuni Sandstone, capped with more resistant beds of Cretaceous Dakota Sandstone. Simpson was the first to make a record of the inscriptions at El Morro, and included copies and transcripts of many of them in his journal. They have since been studied by numerous historians, and some corrections and additions to Simpson's record have been made. The earliest dated name is that of Oñate, in 1605, but prior Indian petroglyphs testify to El Morro's significance as a landmark before the coming of Europeans. The site was established as a national monument in 1906. Additional information concerning the history of El Morro and the record that centuries of travelers left there may be found in Lohr (1959) and Slater (1961), among many others. Upon departing, Simpson and Kern added their names to the record (p. 123): "Lt. J.H. Simpson, U.S.A., and R.H. Kern, artist, visited and copied these inscriptions, September 17, 1849."

The small party began the day's travel eastward about 8 a.m., picked up the trail of the main expedition along a well-traveled road, and soon began to ascend the "Sierra de Zuni." Massive limestone outcrops (San Andres Limestone, of Permian age) were noted along both sides of the route. With little difficulty they surmounted the "summit of the pass of the *sierra*," and crossed Oso Ridge. From this vantage point (p. 127):

... bearing north of east some thirty miles off, we caught sight, for the first time, of one of the finest mountain peaks I have seen in this country. This peak I have, in honor of the President of the United States, called *Mount Taylor*. Erecting itself high above the plain below, an object of vision at a remote distance, standing within the domain which has been so recently the theatre of his sagacity and prowess, it exists, not inappropriately, an ever-enduring monument to his patriotism and integrity.

In a footnote, Simpson remarked that Mount Taylor could be seen from Fort Marcy in Santa Fe, a distance of 100 mi.

Simpson's party continued to the *Cañon de Gallo*, now known as Zuni Canyon, the main incision through the northeastern side of the southern Zuni Mountains. They then emerged into the "broad, beautiful, and fertile valley of the *Ojo de Gallo*," and found the main expedition camped at Ojo del Gallo, a spring between the present village of San Rafael and the town of Grants. Simpson described the geology of this area as follows (p. 127-128), beginning about 4 mi west of the entrance to Zuni Canyon:

... immediately on the right side of the road, for the first time, some unseemly piles of blackened scoriaceous volcanic rocks make their appearance. Three miles further, in a kind of a basin, we met another series of piles of lava debris, covering an area of at least one hundred acres. These piles look like so many irregular heaps of stone coal. A mile further brought us to the entrance of the *Cañon de Gallo*, down which the route continued its course. This cañon, which is a rather narrow one, and walled on either side by sandstone rocks some three hundred feet high, is quite interesting, both as an object of vision and because of the blackened volcanic scoriaceous rocks which crop out from its bottom. Did this cañon exist before the development of these volcanic rocks, or was it the result of that development? Is it not possible that the incandescent mass below, and the gases generated by the heat, in connexion with the ruptures of the superincumbent sedimentary strata which such a condition of things would be like to produce—I say, is it not possible that such a combination of

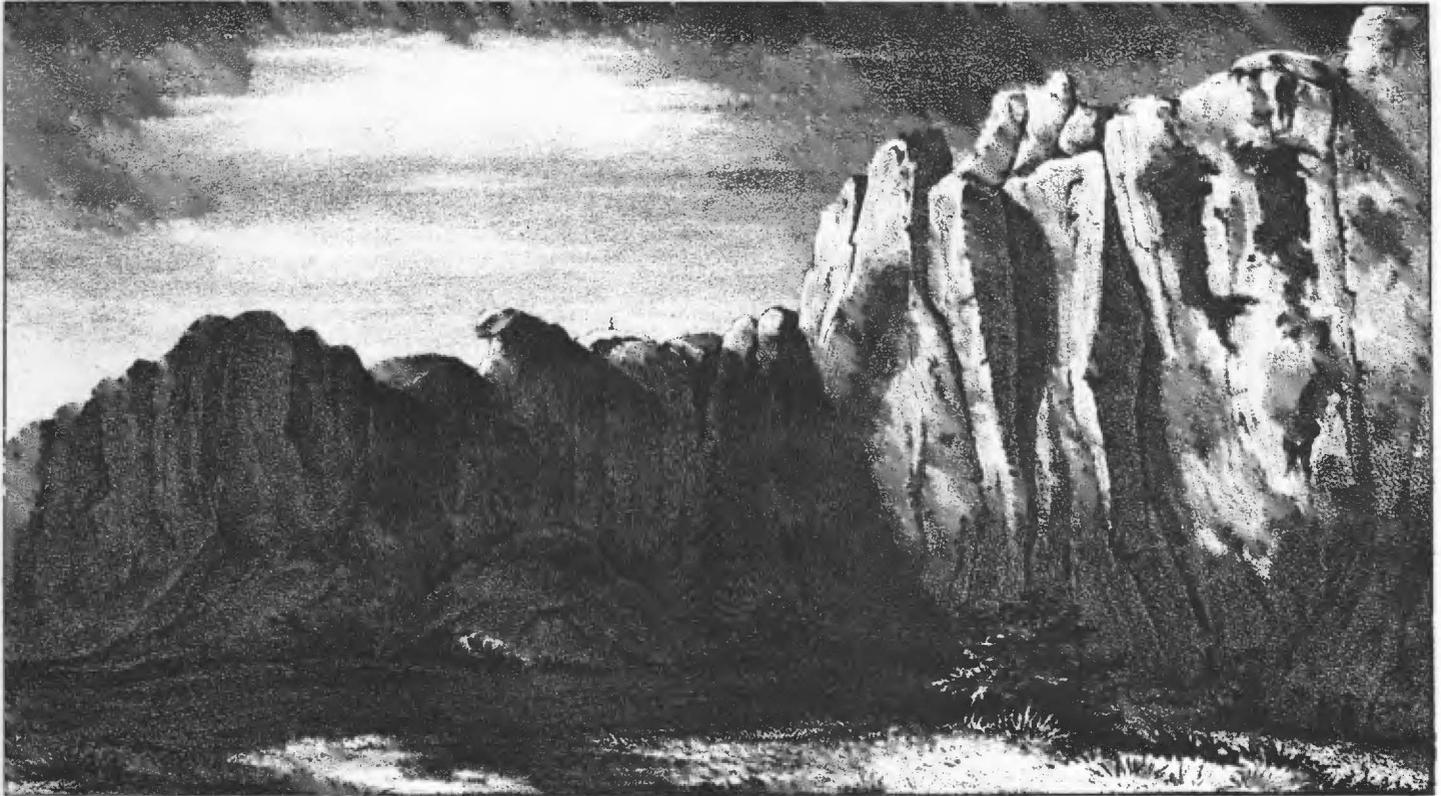


FIGURE 14. "South face of Inscription Rock" (pl. 61 of Simpson, 1850b), observed on 17 September.

circumstances could have given rise first to the cañon, and then to the volcanic matter cropping from its bottom?

Detailed geologic maps of this area were published by Thaden et al. (1967) and Maxwell (1986), and White (1989) discussed the geology and hydrology of Ojo del Gallo. The basalt near the mouth of, and within Zuni Canyon erupted less than a million years ago from a vent in the Precambrian core of the mountains near Paxton Springs. The lava flowed northeastward some 17 mi through the canyon. The walls of Zuni Canyon display the Permian Yeso Formation and Glorieta Sandstone, beneath limestones of the San Andres Formation, which form much of the northeastern slopes of the Zuni Mountains. Simpson hypothesized that volcanism somehow split the sedimentary sequence open to form the canyon; this reflects a mindset more comfortable with short spans of time and catastrophic geologic processes. One must remember that uniformitarianism, with its underlying assumption of very long periods of geologic time, was only gradually becoming accepted in the 1830s and 1840s, with the publications of Lyell's books popularizing Hutton's ideas. Thus, the transition in geological thought from catastrophism to uniformitarianism was just beginning about the time Simpson was receiving his training in the natural sciences at West Point. Despite his misconception that the volcanic rocks were genetically related to the formation of the canyon, Simpson's conclusion that the canyon must have existed before the emplacement of the basalt on its floor was correct.

On 19 September, the expedition proceeded eastward from Ojo del Gallo, passing around the north margin of the Grants malpais basalt field and entering within a few miles the valley of the Rio San Jose. The route from here to Albuquerque is nearly coincident with the route of I-40; several road logs in previous guidebooks (Hawley, Crumpler and Wells, 1982; Hawley, 1982; Maxwell et al., 1989) provide detailed description of the geology along the route traversed by the Washington expedition.

Simpson noted the rich soil of the Gallo Spring area, and related it to the volcanic rocks (p. 128):

A great deal of scoriaceous matter, in black angular fragments, lies scattered over the surface of this valley in piles and ridges; and it is doubtless owing to this source that its soil is so fertile; for wherever this igneous product is observable, there have I noticed the soil in proximity to it to be of like character.

He also inspected the surficial details of the malpais field (p. 128–129):

Just before entering the valley of the San Jose . . . are hundreds of acres of volcanic rock, a great deal of it exhibiting, with marked distinctness, the undulations of the wave in its oscillatory motion. I endeavored, by the curvature of these waves, to find, by a normal or rather an applicable radius, the crater or source of the outflow, but it resulted in nothing satisfactory. I ascended an adjoining hill to overlook the whole field, and found the lava to exist in ridges ranging generally north and south . . . This seems to point to a swelling or intumescence of the fluid mass, longitudinally—a partial overflow—and a fixedness of condition, caused by refrigeration, before it could spread laterally to any considerable extent, and subsequently a tumbling in at the sides, from disintegrating causes, and the want of subjacent support.

This large basalt field includes several overlapping flows, all less than a million years old, from several different vents or cones to the south and west of I-40. The most recent, McCarty's flow, extends from the main field several miles to the east along the Rio San Jose valley, and may have erupted as recently as 1000 years ago (Maxwell, 1982). Simpson's inability to spot the crater or source of the Grants malpais basalt is not surprising; the McCarty's flow originated from a small cinder cone 25 mi to the south.

The expedition continued down the valley of the Rio San Jose, Simpson noting the termination of the lava flows near the present location of McCarty's. He referred briefly to sedimentary mesas on the north capped by basalt, and mesas to the south capped by sandstone, but surprisingly made no mention of Mount Taylor, which was constantly and dramatically visible to the north. The sedimentary strata in these mesas are intertonguing units of the Upper Cretaceous Mancos Shale and Dakota Sandstone. After a march of 28.9 miles, the expedition established camp near Laguna Pueblo.

During the morning of 20 September, Simpson toured Laguna and briefly described it, although most of the population was away gathering piñon nuts. He noted that "selenite as usual, answers the purpose of window-lights" (p. 131). About 11 a.m. the expedition proceeded through the pueblo and continued its journey eastward, passing another basalt flow after 2 mi. This is the Laguna flow, in the valley of the Rio San Jose, which has been dated at about 380,000 years (Lipman and Mehnert, 1980). Farther on, the expedition passed the ruins of the deserted Mexican village of Rito, and camped about 15 mi east of Laguna, near the base of Mesa Gigante. Simpson observed gypsum cropping out for several miles along the route to the north, beneath a sandstone, a reference to the Jurassic Todilto Formation and overlying Jurassic sandstones referred to the Summerville or Wanakah Formations, which are well exposed on the sides of mesas in this area.

The following morning, awakened by the howling of wolves near camp, the party mounted up for the final day's march into Albuquerque. Aside from noting the Santa Fe Mountains, Rio Grande, and (unnamed) mountains in back of Albuquerque coming in to view as they rode eastward, Simpson recorded few geological observations. The Rio Puerco was dry when they crossed it, and he noted no difficulty in the crossing, suggesting that its channel was not much incised into its floodplain. Topographic maps from the 1880s likewise show a small, shallow channel. A major dam failure upstream, near Mesa Prieta, in the 1890s, which released a flood pool 1.5 mi long, was probably the main cause of the incision of this part of the Rio Puerco (Love, written comm. 1992). Today, around the present route of I-40, the banks are steep and as much as 40 ft high. Camp for the day was established in a field north of Atrisco, on the west side of the Rio Grande opposite Albuquerque.

The expedition officially disbanded on 22 September, with the different commands each making their own way from Albuquerque to Santa Fe. Colonel Washington and Simpson spent much of the day in Albuquerque, then rode through Alameda, Sandia Pueblo and Bernalillo before stopping for the night in Algodones. The following day they proceeded along mesas composed of horizontally stratified sandstone (Santa Fe Group) and capped with basalt, passed through San Felipe Pueblo and crossed the dry bed of the Galisteo River. Some "fine specimens of trap dike" (p. 136) were noted north of the river. In mid-afternoon, on 23 September, they rode into Santa Fe, "much to the gratification of the whole party" (p. 136).

Although Simpson recorded sights that excited him or caused him to become almost poetic in his descriptions, his overall opinion of New Mexico was not high. The territory possessed little of the fertility and beauty he was accustomed to in the eastern United States. Even the geology he observed suffered, in his view, in comparison with the East. In his summary of the expedition (p. 136–137), these opinions are stated very forcefully:

The idea I pertinaciously adhered to when in the States, before ever having seen this country, was, that, besides partaking of the bold characteristics of the primary formations, rocks confusedly piled upon rocks, deep glens, an occasional cascade, green fertile valleys—the usual accompaniments of such characteristics with us in the States—it was also, like the country of the States, generally fertile, and covered with verdure. But never did I have, nor do I believe anybody can have, a full appreciation of the almost universal barrenness which pervades this country, until they come out, as I did, to "search the land" and behold with their own eyes its general nakedness. The primary mountains present none of that wild, rocky, diversified, pleasing aspect which they do in the United States, but, on the contrary, are usually of a rounded form, covered by a dull, lifeless-colored soil, and generally destitute of any other silva than pine and cedar, most frequently of a sparse and dwarfish character. The sedimentary rocks, which, contrary to my preconceived notions, are the prevalent formations of the country, have a crude, half-made-up appearance, sometimes of a dull buff color, sometimes white, sometimes red, and sometimes these alternating, and, being almost universally bare of vegetation, except that of a sparse dwarfish, sickening-colored aspect, cannot be regarded as a general thing—at least, not until familiarity reconciles you to the sight—without a sensation of loathing. The face of the country, for the same reason—the general absence of all verdure, and the dead, dull, yellow aspect of its soil—has a tendency to create the same disagreeable sensation.

## EPILOGUE

A short time after returning to Santa Fe, on 29 September, Simpson was ordered to return to Cebolleta, near Laguna, to select a site for an army fort to guard the southwestern approaches to the populated central part of New Mexico. The reconnaissance occupied him for about two weeks. A small fort was constructed in August 1850, but was abandoned about a year later, with the garrisoning of Fort Defiance (McNitt, 1964). Navajo raids continued unabated. Another punitive expedition to Canyon de Chelly was mounted in 1851, with little effect. Only in the 1860s were the Navajos decisively defeated and concentrated for a time on a reservation near Fort Sumner before being allowed to return to their homeland. Thus, the main objective of the Washington expedition, to subdue the Navajos and bring them under American jurisdiction, failed miserably. The scientific, historical and cultural discoveries made by Simpson, on the other hand, formed an important contribution to human knowledge and an outstanding early record of conditions in New Mexico at the midpoint of the 19th century. It is ironic, and perhaps fitting, that Simpson's scholarly work represents by far the most important result of that expedition, which otherwise would be remembered only as one of many inconsequential and unsuccessful military operations.

Simpson spent the first three months of 1850 writing his report in Santa Fe, finishing on 13 April. The Kern brothers catalogued geological and botanical specimens, finished drawings of landscapes, buildings, people and Indian artifacts, and completed the map of the region traversed. The geographic information was later incorporated into the Parke-Kern map of New Mexico (1851), the most detailed and accurate map of the territory at the time.

While engaged in his writing, and for some months afterward, Simpson was intermittently in the field, in the Ocate–Wagon Mound–Cimarron River area, scouting possible locations for a fort near the Santa Fe Trail. Fort Union was built near a site he recommended. He also requested a transfer back to the East; he had not seen his young wife in more than a year. The request was denied, but later, in August 1850, he developed a throat ailment and was given a leave of absence to return home. His report, published in Washington that year, was so popular that the first government printing of several thousand copies was soon exhausted, and Simpson arranged for a second edition to be privately published in 1852 (McNitt, 1964).

In 1851 Simpson was ordered to Minnesota to survey and supervise the construction of wagon roads, a task that occupied him for five years. After two years on a coastal survey, he went to Utah in 1858, and explored a new wagon road from Salt Lake City, across Nevada, to California, ending up for a brief time in San Francisco. In the summer of 1859 he explored parts of Utah, Wyoming and Colorado, then came east to complete his reports. Simpson explored and mapped more of the West than any other officer in the Army's Corps of Topographical Engineers (Goetzmann, 1959; McNitt, 1964), but after 1859 he did not venture west of the Mississippi River again. Service in the Civil War, in which he attained the rank of Brigadier General, a term as chief engineer in the Interior Department, and further river and harbor surveys, mainly in the South, occupied his efforts until he retired. He died in his bed at home in 1883.

Simpson's geological observations along the southern part of his route, from Albuquerque to the Zuni Pueblo area, were verified and extended four years later by the geologist Jules Marcou, traveling with the Whipple expedition to California. Marcou (1858; see also Whipple, 1856; Blake, 1856) was able to determine accurately the ages of the Carboniferous through Cretaceous units Simpson reported, and make some preliminary suggestions concerning structure and geological history. Newberry (1861), returning east through New Mexico in 1858, after the Ives expedition to the Grand Canyon had disbanded in Fort Defiance, also reported upon the geology, including structure diagrams, stratigraphic sections, and descriptions of some fossils collected in the Fort Defiance, Zuni Mountains and Laguna areas. Early studies culminated in Dutton's (1885) magnificent report on the geology of the Mount Taylor–Zuni Plateau region. However, no serious geological studies were made of the area along the northern part of Simpson's

route, across what Loew had called "the Nacimiento Desert," until the early part of the 20th century.

Today, we have a rich and diverse literature dealing with almost every aspect of San Juan Basin geology, as well as the history and archaeology of its former and present inhabitants. The many striking features of San Juan Basin geology, such as the classic Cretaceous transgressive-regressive cycles, the remarkable record of volcanic activity, the extraordinary Cretaceous-early Tertiary vertebrate fossil record, and the extensive, coal, oil and gas deposits, are well known and familiar to every geologist acquainted with this region. Yet, our present abundance of knowledge, derived from the efforts of many generations of geologists, does not diminish the importance of the contributions of those, like Simpson, who were seeing the basin for the first time and attempting to understand its geology. It is the record of their observations, made in conditions far more difficult than those faced by modern geologists, that attracted the attention of scientists to northeastern New Mexico, and pointed out areas worthy of future study. Simpson wasn't always correct and some of his interpretations seem naive today. Judged by the standards of his time, and the military nature of the expedition he accompanied, however, his journal stands as an unusually detailed and accurate early record of geological observation and interpretation in the southwestern United States. By reading Simpson's journal, we can share in his efforts to make sense out of what he was seeing, and participate in the intellectual excitement of being the first to attempt to understand something of the geology of this vast, fascinating area.

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Cuestas to the west of N.M. Highway 44 along Cuchilla Arroyo northwest of San Ysidro are capped by limestone and gypsum of Todilto Formation underlain by Entrada Sandstone above Chinle Group red beds. Photograph taken the morning of 11 April 1992. Copyright © Paul L. Sealey, 1992.