

BRIGHAM YOUNG UNIVERSITY

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# A Field Geologist/Paleontologist in Western Utah: C.D. Walcott and His Work in the House Range 1903 and 1905

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## INTRODUCTION

The House Range of western Utah, in Millard County, is a remote place, which even today is visited by few persons, other than occasional geologists and trilobite collectors. A century and a half ago, it was an even more remote area for geological studies. In the post-Civil War years, parties from two of the territorial surveys passed through the region and a very few Cambrian fossils were described from "Antelope Springs, Nevada," the Utah-Nevada border was moved in 1866, and in reading the older literature there may be momentary confusion between the "Antelope Springs" of the White Pine District and the "Antelope Spring" of the House Range.

The House Range has little in the way of show of minerals to interest prospectors. There is virtually no water apart from two year-round springs, Antelope on the east side of the range to the north, and Painter on the west to the south. Apart from a traverse through the range during the times of the Territorial surveys, the area remained nearly untouched geologically until 1901 when G.K. Gilbert spent part of a field season there. Loss of maps prevented Gilbert from completing his investigations (Davis, 1927: 241). Nevertheless, the historically-minded could make a strong argument that if structural units have anything resembling a type specimen, the House Range might be as typical of the "Basin and Range" province of western America as one could find.

Immediately following his 1901 field season in Utah, Gilbert joined C.D. Walcott at the Grand Canyon (Pyne, 1980:177). During their time together, Gilbert surely must have spoken of the trilobites that littered the ground in some places in the House Range. The Sevier desert of western Utah—which includes the House Range—is nearly frozen in time; the road system is so little changed that the route Walcott travelled nearly a century ago is relatively easy to trace. The local history of human life in this desert region has been recounted by Kelsey (1997).

Modern studies of the stratigraphy and paleontology of the House Range stem from two brief excursions by Walcott in 1903 and 1905. The range now has been mapped and the stratigraphy carefully worked out; many Cambrian fossils from House Range rocks have been described, but such studies continue to yield valuable data. The area is a classic for North American geology (Hintze and Robison, 1987) and it is appropriate therefore to consider the early work on which later investigations were based.

## WALCOTT IN BRIEF

Walcott was a remarkable man and, in the first edition of "American Men of Science," he was judged by his geologic colleagues to rank just behind T.C. Chamberlin and G.K. Gilbert in his scientific contributions. However, today he is a poorly known figure and a summary sketch of his life did not appear until forty years after his death (Yochelson, 1967); a more detailed biography is now available (Yochelson, 1998). Walcott was born in upstate New York and grew up surrounded by Ordovician rocks. After high school, from which he did not graduate, he supported himself in part as a professional collector of fossils, but made the transition to paleontologist without the benefit of any higher education. Late in 1876 he received his first geological employment as a special assistant to James Hall (Yochelson, 1987).

In July 1879, he was sworn in as employee 20 of the new U.S. Geological Survey as a temporary geological assistant at \$50.00 per month. Walcott was immediately sent to southwestern Utah to measure a section from the Cretaceous-Tertiary boundary downward. After measuring about two miles [3.2 km] vertically through the gently dipping rocks, he reached the mouth of Kanab Creek in the Grand Canyon; the next year Walcott was promoted to a permanent position as Assistant Geologist, and doubled his salary to \$1,200 per year. Next he assisted Arnold Hague in the Eureka, Nevada, mining district where he first collected

from Cambrian rocks of the Great Basin. Two years later, he returned to the Eureka district for more collections (Walcott, 1884) and studied the Cambrian and Precambrian in the eastern Grand Canyon (Walcott, 1894).

For several years thereafter, most of his work was in New York and New England, but he had another season in the Highland Range of Nevada (Walcott, 1888) before he resolved the riddle of the "Taconic System" (Walcott, 1888a). He also corrected his own error and those of other American geologists in the mistaken assumption that the *Olenellus* zone was Middle Cambrian, rather than Early Cambrian in age (Walcott, 1890). For the International Congress of Geologists in Washington, he published a comprehensive summary of the Cambrian as then known throughout North America, including what little was known of the "primordial fauna" of the House Range (Walcott, 1891:155-156); what few Cambrian fossils were known from there had been described by F.B. Meek and C.A. White.

To hurry on, in 1894, Walcott became the third Director of the Geological Survey, resurrecting the organization from the wreckage left by John Wesley Powell in his final years of office. Despite ever increasing administrative duties, Walcott continued research. 1903 was a particularly busy year, for in addition to his running an expanding USGS, the newly formed Reclamation Service was made part of the Geological Survey. Also in that year, President Theodore Roosevelt appointed Walcott as chairman of two committees. Apart from this government service, Walcott was heavily involved with the new Carnegie Institution of Washington (Yochelson, 1994), and was campaigning for the founding of a geophysical laboratory (Yochelson and Yoder, 1994).

By late July 1903 when he headed west, Walcott was ready to look at rocks and fossils, rather than letters and memoranda. He started the season with a Reclamation Service field party in Wyoming and Idaho and finally moved to Salt Lake City. There, he was met by F.B. Weeks, librarian and geologist, and they proceeded to the Park City District in the Wasatch Range for a brief conference with geologist J.M. Boutwell.

The information on Walcott's travels given above is correct, for he kept a pocket diary during most of his life. For more than 40 years, he did not fail to make an entry of a few lines each day. This private document allows one to trace routes of travel and provides some insight that is seldom recorded in typical field notes. The diary entries dealing with the House Range are transcribed as accurately as possible from Walcott's handwriting; spacing of sentences approximates that in the entry and larger spaces commonly separated different sorts of items. There is some uncertainty about his capitalization. Miscellaneous blemishes in

the paper also make for minor uncertainty as to punctuation marks, but the meaning is not confused by inadvertent errors. Walcott was not always consistent in underlining, capitalization, and spelling, but, after all, these entries were only used by him to refresh his memory. One result of tracing the route of Walcott's earlier field work in the White-Inyo Mountains (Yochelson and Nelson, 1994), was to confirm that the distances he gave were accurate. Presumably those mentioned in connection with travel in western Utah were also accurate.

After examining some of Boutwell's sections, the diary records: "At 11 a.m. left with camp outfit. Mr. Weeks, Arthur Brown, Dan Orr—teamster . . . "These persons will be identified in another section. The field party examined various sections to the east and by August 26 they returned to Salt Lake City where they camped on 5th East Street. As Walcott (1904:26) wrote in his official report: "Late in August he made a trip to the western end of the Uinta Mountains, and in September he was engaged in geologic work in the House Range of Utah and the Snake Range of Nevada."

#### WEST IN 1903

The route followed by Walcott in 1903 is shown in Figure 1. The first diary entry germane to his work in western Utah is: August 27—"Up at 5:15. Left Salt Lake City 7:30 with Mr. Weeks in buckboard. Drove west around north end of Achier [Sic-Oquirrh] range & then south. Camped N. of Tooele beside flowing well."

Despite the shortness of this entry, it contains two references to time. Throughout his life, Walcott paid close attention to time, and his diary entries often reflect the start and close of each day and the hours spent on various projects. This concern with time is even more obvious for the entries when he was in Washington, and it grew as he became older and still busier.

August 28—"Left camp 7:30. Stopped at Tooele for a few supplies. Passed Stockton at 11 a.m. Left R.R. track 4. p.m. & camped 5 miles west of Vanderwalkers ranch. The Stockton bar is a most interesting lake deposit."

Consistency in the use of the ampersand and inconsistency in underlying are two characteristics of Walcott's diary. As to his last remark, anyone familiar with Lake Bonneville and the work of G.K. Gilbert (1890:Plate IX) needs no further explanation of the Stockton bar. Today, one reaches the area from Salt Lake City by travelling west on Interstate 80 and then south 20 miles on Utah Highway 36.

August 29—"Left camp 8 a.m. with hay & oats for a week. Crossed Stansbury range over Point Lookout pass. Camped 5:00 p.m. at Simpson spring 27 miles from last nights camp. We have a heavy load on the wagons."



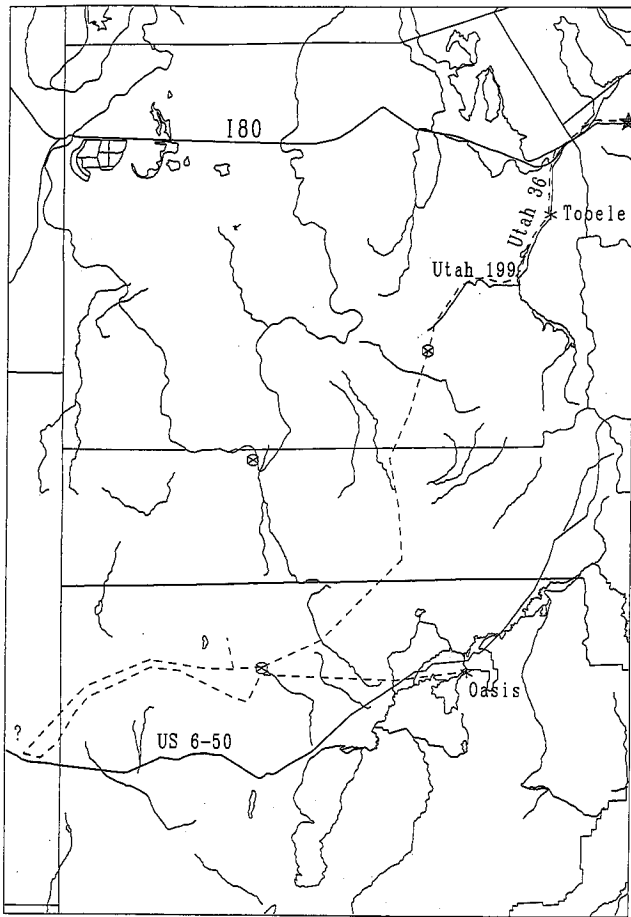


Figure 1. Approximate route taken by Walcott in 1903 from Salt Lake City, indicated by a star, to Oasis, Utah. The Utah-Nevada boundary is to the west, and county boundaries in portions of both states are indicated, along with a few of the present highways. The principal drainage features from the lower portion of Great Salt Lake in the northeast to Sevier Lake to the south are shown; many of the indicated features are ephemeral and are internal drainage within intermontaine basins. The approximate location of Osceola, Nevada, is indicated with a question mark. Three springs are indicated by a crossed circle; Simpson Springs is southwest of Utah 199 and Antelope Spring is north of US 6/50. North of Antelope Spring and midway between these two springs, Fish Springs, at the north end of the Fish Springs Range and visited by Walcott in 1905, is also indicated.

At this time, the Onaqui Mountains were considered part of the Stansbury Range and the route followed west may have been a little to the north of what is now Utah Highway 199, for that goes through Johnson's Pass. Whichever way they crossed the range, near Dugway they must have turned south along the old Pony Express and stage coach route to reach Simpson's Spring. The comment

about fodder indicates the problem of keeping live stock alive in desert country.

August 30—"Crossed from Simpsons spring west over "River bed" & thro' the hills to the S.W. Made dry camp at 6 p.m. about 6 miles from Joy."

Despite the shortness of this entry, it deserves three comments. On some maps the wide dry "river bed" is indicated and this usage stems back to Gilbert (1890:Plate XXXI) who identified the feature as a former drainage from the Sevier basin into Lake Bonneville.

Joy post office was at a road junction on the east side of the Drum Mountains; its prime reason for being was the Ibex mine, a few miles south. Finally, it is important to note that in 1903, August 30 was a Sunday. Walcott was a Presbyterian who almost never missed church on Sunday in Washington, but in the field he recognized that "Sunday" was determined by weather and condition of animals rather than the calendar. This Sunday was for travel to the outcrops.

August 31—"Left camp shortly after daylight and drove to Joy for water. After an hours rest drove across the slopes into the Whirlwind valley east of the House range & at 6:30 p.m. put up camp at Antelope spring. A long hot drive."

Antelope spring is one of the few places in the House Range where water may be obtained. It is likely that this factor led a party of the Wheeler territorial survey to the adjacent outcrop, which was then named the Wheeler Amphitheater.

September 1—"Put up tents, cleaned up & at 9 a.m. went out on the Cambrian rocks. Collected fossils until 5 p.m. from *Bathyriscus wheeleri* zone. Very warm day."

When a Walcott party was on the move, tents were seldom erected unless the weather was extremely bad. This habit carried over to Walcott's later travels in the Canadian Rockies where the weather was more uncertain than in the desert. Two collections [3s, 3t] were made from the Wheeler Amphitheater region; numbers in brackets are those given to collections and are discussed in the appendix.

September 2—"Mr. Weeks started for Deseret for wagon & feed. With Dan Orr drove thro' Dome pass to the west side of the House range. Examined section & collected a few fossils from the Pioche shale horizon. 7 a.m. to 5:30 p.m."

Quite apart from the necessity of obtaining fodder for the animals, the implication is the four in the party travelled by buckboard and a single wagon, but that for further investigation another wagon might be needed. Rocks of the House Range dip to the east so that older rocks are exposed on the steeper western face. Presumably the extra wagon would be used to carry additional water and animal feed when they explored that area. Collections [3u, 3v] were made on the west side of the House Range.



Figure 2. "South end of Great Salt Lake desert from the southwest of Simpson Range, Utah." This photograph and those following were taken in 1903 and were originally 6 1/2" x 8 1/2", unless otherwise noted. The caption accompanying the photograph is quoted and number refers to the C. D. Walcott albums in the USGS Denver photographic library. This was taken August 29th or 30th. No. 694.

Dome Canyon is south of Antelope Spring and north of Marjum Pass. The name, however, has disappeared and the current term is the more dramatic "Death Canyon." (One reviewer noted seeing a road map of about 1960 date which still used "Dome Canyon"). The round trip from Antelope Spring was about 15 miles, which would have allowed a little time for collecting.

September 3—"With Dan Orr drove south to Marjum pass. Collected a lot of Middle Cambrian fossils. 7 a.m. to 6 p.m. Hot in sun & 86° in shade."

Walcott was recording a characteristic desert climate, very hot during the day and cool at night, like that he encountered a few years earlier in the Inyo Mountains of California (Yochelson and Nelson, 1994). This was a longer trip than the previous day. Collections [3w, 11r, 11s] were made.

Some maps use the names Granite Pass and Granite Canyon for Marjum, but this seems not to have displaced the older name, as is the case with Dome and Death Canyon; perhaps "Granite" is too prosaic a term for this country. (One reviewer noted that are granite outcrops about a mile south of the pass).

September 4—"Work section east of camp 3 miles. Found *Olenoides nevadensis* fauna above *Bathuriscus* [sic] fauna. 7 a.m.-4. p.m. Showers at 4. p.m. Very warm."

Collections [3x, 3y] were made.

September 5—"Out all day collecting Cambrian fossils. Many good things turned up. 7 a.m.-5 p.m."

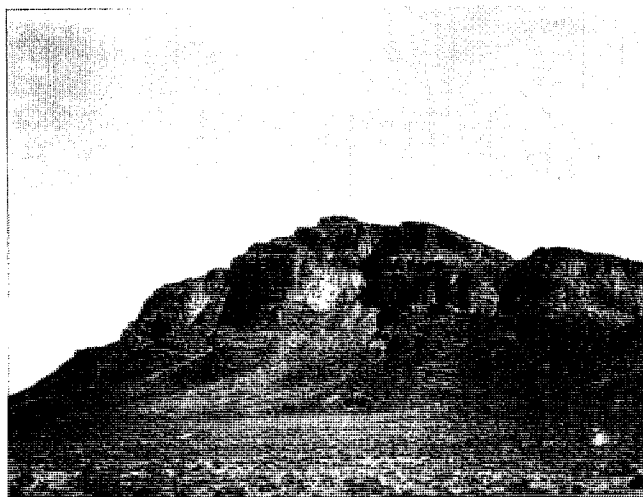


Figure 3. "West front of House Range, Utah," near mouth of Dome Canyon, 1903, 4" x 5". If this were taken on September 11 when Walcott and Weeks were out on horseback, that would explain why the smaller camera was used.

Collections [3g, 11y] were made. Just what the "good things" were is not obvious, but knowing Walcott's interest these likely were well preserved trilobites.

September 6—"Writing letters in a.m. After lunch went with Mr. Weeks to look over the *Asaphiscus wheeleri* locality."

This was a true Sunday and probably badly needed as a day of rest by the men and the stock. Even so, some scouting for future collecting spots was in order.

September 7—"Left camp 6 am with Mr. W. & studied section to top of range. Could not find any trace of a fauna above the Cambrian *Olenoides* fauna. 6 a.m. to 6 p.m."

September 8—"Measured section of *Bathyriscus* shale & *Olenoides* limestones 2920 feet. A great thickness for two faunas to range thro'. Collecting a little en route. Mr. Weeks & Dan collecting from the upper zones. 7:30-5:30 p.m."

No collections were noted from this date. It is likely the rocks may have been sampled to determine the local range of fossils, but the material obtained was not well enough preserved to retain.

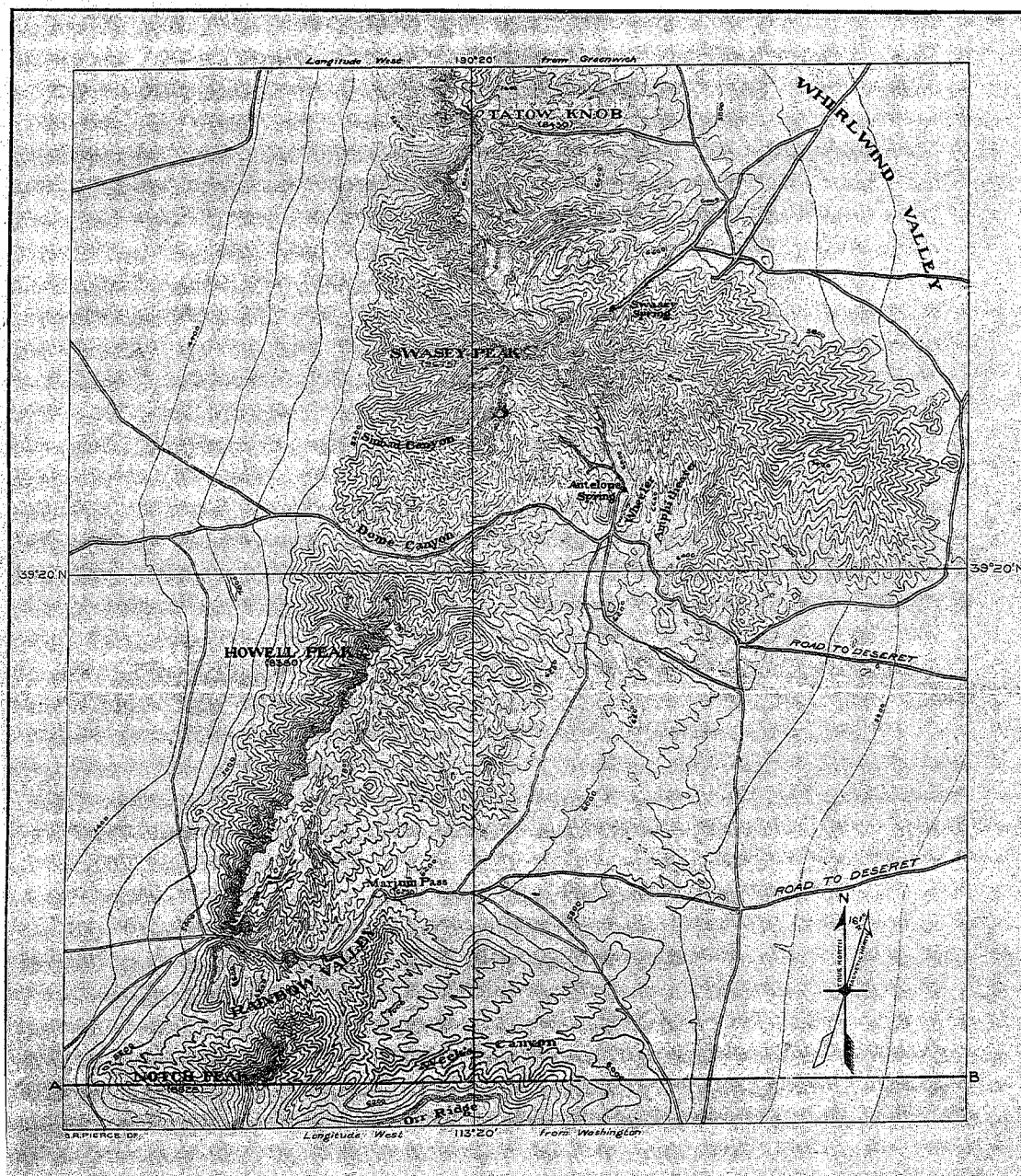
September 9—"Packed up. Drove with Mr. Weeks over to Dome canyon. Made small collections in shales 1500 feet below 'Bathyriscus shales.'"

As with the preceding day, there is no indication of the fossils being retained.

September 10—"Broke camp and moved thro' Dome canyon pass to west side of House range well towards north end. A long tedious day owing to extreme heat & heavy roads in White valley. Dry camp on wash slope."

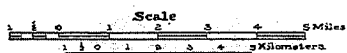
SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL. 53, PL. 13



## HOUSE RANGE, MILLARD COUNTY, UTAH

### CENTRAL PORTION



Contour interval 200 ft.  
Datum is mean sea level

Contours below A-B have been added to Map to show approximate relations of Notch Peak and Orr Ridge to the rest of the range

TOPOGRAPHY BY W. D. JOHNSON, 1901

Figure 4. Reproduction of plate 13 from Walcott (1908a). Joy post office is to the east of the map area, and the White, or Tule, Valley is unmarked west of the House Range.

There were no well-travelled roads, even by the standards of that part of the world, leading to the northern part of the range.

September 11—With Mr. Weeks out on horseback examining section of N.W. end of House range. Collected a few Cambrian fossils from *Pty. [coparia] Kingii* zone."

During Walcott's time it was common to capitalize patronyms in Latin names of fossils, so his use of an upper case "K" is not surprising. What is surprising is the mention of horses. The wagon and the buckboard were pulled by mules and there are no horses in evidence when Walcott took a picture of the outfit. It may be that Mr. Weeks brought the animals back from Delta. Collection [1z] was made.

September 12—"A long hard days drive. Twelve (12) miles over very bad & rough road to opposite Dome canyon, thence 20 miles across White valley and over divide [sic] of Confusion range, passing Tule spg. Hot midday, south gale followed by cold norther at 3 p.m. Dry camp below pass."

For some reason Walcott consistently misspelled "divide" in his diary from his earliest usage of the term to his last. White valley of his usage is now Tule Valley on most maps; it is even more desolate than Whirlwind Valley, east of the House Range.

The rocks in the Confusion Range are late Paleozoic, significantly younger than those of the House Range; almost certainly the route was through Cowboy Pass on a secondary road north of the present U.S. Highway 6-50.

September 13—"Crossed to Snake range *via* Knoll spg. Camped on stage road about 12 miles E. of Osceola, Nevada. Snow squalls at night."

This was another Sunday on the move. Osceola has vanished, but according to one reviewer it was a mining town southwest of Sacramento Pass on the west side of the Snake Range, about 16 miles north-northwest of Baker, Nevada.

September 14—"Drove to summit of divide above Osceola & then back four miles & camped at noon. Out on East side of ridge N. of Osceola p.m. with Mr. Weeks. Found Middle Cambrian—Cold at night."

In connection with the Middle Cambrian collection [10w] Walcott noted: "The section in the Snake Range is of the same type as that of the House Range but varies in detail. The massive bedded, siliceous limestones of the Middle Cambrian of the House Range are represented in the Snake Range by thin-bedded, blue limestones with beds of gray siliceous limestones 100 to 200 feet thick interbedded. Owing to plication it was not practicable to measure the thickness of the section. The Upper Cambrian beds are much like those of the Middle Cambrian."

Regional investigations of the Cambrian and more detailed interpretations of faunas and sediments have pro-

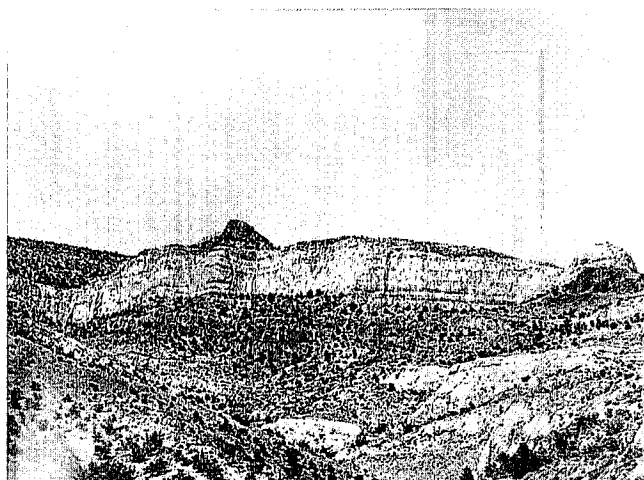


Figure 5. "Cambrian limestone cliff, Death Canyon, House Range, Utah." Whether Walcott later used Death Canyon or someone later changed the caption is unknown, but the latter is far more likely. This view of the north side of Dome Canyon was published as plate 16 of Walcott, 1908a. Swasey Peak, composed of dark Swasey Limestone, is to the left. It overlies the prominent wide band of Dome Limestone; The Dome, from which the Canyon was named is to the far right. The Howell formation forms the slope below the prominent cliff. To the right foreground is an outcrop of Dome Limestone downfaulted. No. 689.

duced a picture of shelf deposits changing to slope deposits to the west (Taylor and Cook, 1975; Taylor, 1976). Although those studies were based on outcrops still further west, Walcott's observation that the massive limestones of the House Range were represented in the Snake Range by thinner bed is in keeping with the regional changes.

September 15—"Examined section N.W. of camp. Collected a few upper Cambrian fossils. Section too much broken up to work out unless a good base map is available. On way in had a scrape with saddle horse by saddle slipping. He also knocked Mr. Weeks down."

As on the previous day, a single collection of fossils [10x] was made, this time from the Upper Cambrian. "The fossils occur in thick layers of gray limestone interbedded in thin-bedded blue limestone. The latter frequently form solid masses 100 feet or more in thickness when compressed."

September 16—"Out taking photographs a.m. Fixing up odds & ends about camp p.m. & writing letters."

From the general tone, this Wednesday must have been declared "Sunday." Some photographs were taken earlier at other localities in the House Range but this is the first record of that activity and indicates that a fair amount of time was devoted to photography.



Figure 6. "Under the west face of House Range, north of Dome Pass, near the end of a long, hot march." Since this is north of Dome Pass, the best guess is that it was taken on September 12 during the trip to the Snake Range. The party may have paused for a rest and Walcott could not let the opportunity pass for such a dramatic picture. All the animals in harness are mules. It is likely that Mr. Weeks was driving the buckboard, which carries hay bundles at the back. Dan Orr would have been driving the wagon and Arthur Brown is near the water barrel on the side of the wagon. The dog is unidentified and is not mentioned in the diary, but probably was a key member of Orr's camp outfit. No. 692a.

September 17—"Left camp at 6:30 a.m. & moved outfit to camp near divide in Confusion range."

September 18—"Moved over into White valley. Filled water barrels at Baker's spring on the east side of the Confusion range. Crossed White valley & camped at lower end of Marjum canyon in the House range."

Tule Spring and South Tule Spring occur near the center of the valley, but the water is not satisfactory. At least one water barrel, and commonly more, was carried on each side of a wagon in this harsh land.

September 19—"Visited granite area of Sawtooth Mts. & obtained water. Went up Marjum canyon to just below divide at head of pass. Collected a few good Middle Cambrian fossils at *Asaphiscus wheeleri* zone."

The reference to Sawtooth Mountains is enigmatic. One may guess that because the granite of the area weathered more irregularly than the sedimentary rocks, Walcott saw fit to use a different name. Collections [10y, 10z, and 11n] were made.

September 20—"Out all day with Mr. Weeks on the ridge S.W. of camp. Dan went for water to Antelope Springs

[sic]. Very much disappointed in not finding many good Cambrian fossils. Superb exposures of the rocks."

Walcott's use of "Dan" is unusual and probably indicated a high regard for the man's ability as a packer. Almost without exception, persons were Mr. or Dr. Even though Walcott had spent three field seasons in the Inyo Mountains and then more field time in Montana with Fred B. Weeks, he was still "Mr. Weeks" in the diary entries.

September 21—"Moved camp via Antelope spgs. to a point in the desert about 15 miles west of Deseret Utah. Collected a lot of Middle Cambrian fossils on ridge about 4 miles S. of Antelope spgs."

Collection [11o] was made. This was a better way to end the field season than the poor luck of the previous day; there is a bit of a flourish on the final "s" of Walcott's entry. Deseret was the main point of civilization, but now Delta, a few miles to the northeast, is the largest town in the region.

September 22—"We drove to Oasis on the San Pedro, Los Angeles & Salt Lake R. R. Packed up and cleaned up. The wagons went north in chg of Dan Orr and Arthur Brown—Regret to leave camp life as there is much to be done in the Cambrian & and I like the life."

These are the words of a born field man, not a born administrator. Notwithstanding that, at 2:15 the next morning, Walcott and Weeks took the train to Ogden and ultimately to Washington to return to the cares of the Director's office and the library, respectively.

## THE HOUSE RANGE IN 1905

Early in June, 1905, Walcott left Washington with his wife, Helena, three of his four children, and Arthur Brown in tow. After field work in Montana, they travelled to the west coast where Walcott conducted business for the Reclamation Service, and then the director had more business in Idaho.

Walcott's family returned to Washington, and on August 30, he and Arthur Brown arrived in Salt Lake City. Brown immediately went to the camp of F.B. Weeks. Weeks and Lancaster D. Burling, a young geologist, had been studying the Cambrian in the Wasatch Range. These three men are identified in more detail in the following section of this paper. While Walcott and F.W. Newell, the second-in-command of the Reclamation Service, spoke to the governor, senators, and newspapermen, the two geologists and Arthur Brown organized for the trip west.

September 1—"Left Salt Lake City at 7:45 a.m. with Mr. F.B. Weeks & Arthur Brown. By railroad to St. John where Dan Orr met us with wagon and buckboard. Packed up & crossed to west side of Stansbury Range thro' Johnson's pass. Camp by small ranch on roadside."



Figure 7. "Granite Peak from the west, south of Marjum Pass, House Range, Utah." This is Notch Peak under a different name, the highest part of the stratigraphic section; it was published as plate 14 in Walcott, 1908a. Probably this was taken on September 18th or 19th when the party was returning from the Snake Range. No. 685.

St. John Station is about 15 miles [24 km] south of Tooele and the rail line is now part of the Union Pacific system. The route followed is essentially that of Utah highway 199 toward Dugway, Utah. It is a reasonable surmise that Walcott and Weeks rode in the buckboard, with Arthur Brown and Dan Orr in the wagon. Presumably young Burling had been sent ahead on August 31 with the buckboard; when the party assembled, he may have rated a place in the buckboard for part of the trip so that Walcott could instruct him as to the local geology. Whether Orr came from the Wasatch or from the Orr Ranch is not clear.

September 2—"Left camp 6:30 a.m. Stopped at Orr ranch 7 miles to get running gear for our heavy wagon. Left there & drove 25 miles out into the desert towards the Fish Spring [sic] range. Took water & made dry camp in scrub greasewood—pleasant day."

Much more than 25 miles per day by wagon is commonly considered a hard day, yet distances of more than 30 miles were recorded on several occasions. This is perhaps an indication of a hard surface without sand, and relatively gentle slopes on the terrane which superficially appears flat. The party may well have been following the old "Pony Express" route through this area.

September 3—"Crossing the desert all day. At night camped at the Thomas ranch at the east foot of Fish Spring [sic] range. Large warm springs rise near the level of the desert & make ponds & tules over a wide area."

This was another Sunday where travel was a necessity; one does not linger in the desert. The wide damp area noted

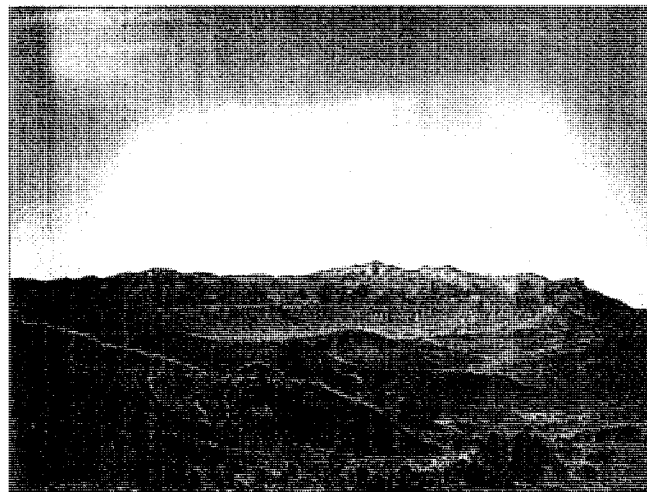


Figure 8. "House Range, south of Marjum Pass, Utah." This was published as plate 15, figure 1 of Walcott, 1908a. That caption indicates that the rounded hills in the foreground are eroded in the Wheeler Shale. The Marjum Limestone forms the long, nearly horizontal prominent band. It is overlain by the Weeks, Orr, and Notch Peak formations, with Notch Peak itself as the highest point on the skyline. No. 686. (The rectangular block in the sky results from silver tarnish on the negative.)

now constitutes Fish Springs National Wildlife Refuge at the north end of the Fish Springs Range.

September 4—"Left camp at 7:15 a.m. with Mr. Weeks & Mr. Burling. Drove about 12 miles along the east front of Fish Spring [sic] range. Examined sections as far as Sand pass. Found rocks much altered so decided to go to Antelope Spring in the House range & work from there as the strata are in continuous section and not much altered."

From the word "drove" it is clear that this was a trip by buckboard. The House Range lies south-southeast of the Fish Springs Range, but there is no direct route in that direction. Walcott (1916:185) mentioned two collections [15j, 15t] from the Fish Springs Range.

September 5—"Long days drive via Joy for water. Reached Antelope spgs 8 p.m. with camp outfit."

The Wheeler Amphitheater east of the spring is one of the remarkably fine fossil collecting localities in the world. Complete specimens of the trilobite *Elrathia kingi* (Meek) littered the ground, though ninety years of collecting have removed most of them. They are so abundant in the matrix that they are mined commercially for sale.

September 6—"Collecting fossils & making reconnaissance of lower part of section in Dome canyon, about 3 miles west of camp. Out with Weeks & Burling."

The use of last names without title was most unusual. The last line was added later and possibly Walcott was



rushed in the evening. Collection [30b] was made over several days from this area and is credited mainly to L.D. Burling; collection [30c] was limited to this day, as was [30d]. Collection [31w] carries no information but may have been made on this day.

September 7—"Off at 7 a.m. Began study & measurement of Middle Cambrian section carried it up 1005 feet. Showers P.M. Cool morning. Dan Orr started for Oasis for grain & hay."

Oasis is a mile [1.6 km] east of Deseret and a few miles southwest of Delta, Utah; during this time, Delta was just becoming a new town, according to one reviewer. The trip east to pick up fodder for the animal was about 40 miles in each direction and a reasonable surmise is that Orr was gone 2 1/2-3 days. Collection [30e] was made this day.

September 8—"Completed section up to horizon of Antelope shales. Left camp 6:40 a.m. & returned at 6. p.m. All tired & turned in early."

Rules of nomenclature for rocks were first distributed to Geological Survey employees in 1902, making capitalizing of "formation" or a lithologic descriptor a formality, but it took some years for this notion to become general practice. Walcott's term "Antelope shale" did not become formalized in the literature. Collection [30f] has no date but may have been made this day. Collections [31s] and [3v] have no data.

September 9—"Measured section of Antelope shale & rocks above to summit of fossiliferous shaly lm. beneath cliff E. of Antelope spgs. We collected a lot of Cambrian fossils." Collection [30y] was made this day; collection [30z] has no data, but may also been made this day.

September 10—"With Mr. Weeks drove 5 miles to look at rocks near where the Joy & Deseret road unite on way to Antelope Springs. Returned 4 p.m. and cleaned up. Wrote letters & read a little."

The junction exists today, one track going north to Whirlwind Valley and the other, east. The trip was hardly a day of rest, but this was not a strenuous Sunday. Presumably young Mr. Burling rested in camp, for if he collected from the section, Walcott probably would have recorded it.

September 11—"Left camp 7:30 a.m. & drove to Marjum pass. Measured section of cliffs & at night camped about 3 miles S. of Marjum pass near spring in granite. A fine day for work."

While the three geologists investigated the rocks, Arthur Brown and Dan Orr broke camp, moved, and resettled. The original location of U. S. Highway 6/50 was through Marjum Pass; it was relocated south of Notch Peak and skirts the southern end of the House Range.

September 12—"Worked on section of Cambrian rocks & collecting fossils all day. Measured up 1100 feet of the section. Mr. Weeks & Mr. Burling collecting fossils on the line of section."

Walcott's last sentence is the epitome of biostratigraphy. There are no dates given, but collections [30h-30m, 30t and 30q] are from the Marjum Pass area, and may have been made during these few days.

September 13—"Continued work on section about 2000 feet above camp. Continued up to summit of ridge where erosion has cut section off. Very sorry as I wished to take section up to the Ordovician. Will try to the west."

September 14—"Working on portion of section from Marjum pass section south. Reached bottom of Weeks canyon. We collected a lot of Middle Cambrian fossils. Out from 6:50 a.m. to 6:20 p.m. Clear warm day."

This was a long day in the field. Collections [30n, 30n', and 30o] were made.

September 15—"Completed section by 10 a.m. and collected fossils for the remainder of the day. Burling & Weeks collected all day & obtained some good Middle Cambrian fossils."

Walcott published his measured sections as relatively thick units with few details of lithologic changes, but later investigations in several different areas in which he worked have verified that his measurements were fairly accurate.

September 16—"Left camp 6:20 a.m. on horseback with Weeks & Burling. We crossed the granite area south of Marjum canyon & measured the Upper Cambrian limestone of Luke Peak 1510 ft. Returned to camp 6:45 p.m. After dinner wrote up field notes. Fine weather."

The reference to horseback is again a puzzling one, for where the horses came from is a mystery. It is unlikely that the buckboard team, if the team was horses in 1905 unlike the mules of 1903, was pressed into service. Even so, a buckboard would be pulled by two horses, not three. It is more likely that Dan Orr brought the horses from Oasis. Least likely is that the horses were in camp throughout the field season, for that would have required the providing of even more fodder and water for the animals. Why the horses were useful is no mystery, for they allowed the geologists to cover more ground and would have been particularly helpful toward getting partway up the slope to the top of Notch Peak.

September 17—"Moved camp back to Antelope sprgs. A cold, cloudy, windy day."

This was yet another Sunday with no rest.

September 18—"With Weeks & Burling collecting Middle Cambrian fossils all day from Marjum limestone east of Antelope Springs. The fauna is very interesting & need careful study."

September 19—"Moved camp from Antelope Springs to Oasis. 40 miles to railway. A cool beautiful day."

This is an exceptionally long trip by wagon and was aided by the gradual slope eastward as they left the House Range.

September 20—"Left Oasis on 12:35 a.m. train Salt Lake 6:30 a.m. . . ." It would be another two weeks on Reclamation Service and Geological Survey business before Walcott returned home. He was satisfied with the accomplishments of the short field season. "A detailed section of the Cambrian rocks of the House Range, Utah, was completed and large collections of fossil were made" (Walcott, 1906:11).

### THE ASSISTANTS

Fred B. Weeks was a stalwart member of the U.S. Geological Survey, though his name is hardly a household work. He was a librarian first and foremost, but equally able as a field geologist. For some reason he is first listed on the official rolls only in 1900, yet during 1894, 1896, and 1897 he assisted Walcott in the Inyo Mountains. A few years later he spent time in the area with Walter Weed, the far better known mining geologist. Weeks is responsible for the *Bibliography of North American Geology*. In 1899, he volunteered or was volunteered to compile a card catalogue of formation names in the United States. This eventually became the *Lexicon of Geologic Names in the United States* and is the intellectual forebear of international efforts to standardize formation names. A few years after Walcott resigned as Director of the Geological Survey, he also left to work for U.S. Smelting Corporation in Utah and died in 1942.

If Weeks is poorly known, Arthur Brown is completely unknown. Classified by the U.S. Bureau of the Census as a mulatto, he was born in Virginia, and apparently was employed as a railway porter and, later, a White House waiter before obtaining a position with the U.S. Geological Survey in 1891 or 1892 as a watchman. He worked his way up through the organization to janitor, assistant messenger, and messenger. In 1895, Walcott took him to Montana as camp cook. He was phenomenal in this capacity and equally good in keeping a camp running smoothly. Early in the 1905 season when plans were still fluid, Weeks wrote Walcott: "I have two very good camp men; my cook is the best one I have ever had with the exception of Arthur . . ."

In 1907, when Walcott became fourth Secretary of the Smithsonian Institution, Arthur Brown followed him. From 1908 through 1925, he was in camp every season, commonly organizing the outfit before Walcott arrived and packing it up for the winter when field work ended. In the winters he acted as butler at formal dinners and during the days in the Smithsonian "Castle" when not delivering messages, sawed the Burgess Shale fossils into trim blocks. At the time of Walcott's death, he was paid \$87.00 per month and a year later, he simply vanished from the

Washington scene. He was, without question, Walcott's strong right hand.

Lancaster D. Burling joined the U.S. Geological Survey in 1905 after receiving a Master's degree from the University of Wisconsin. In 1906, he worked with Walcott in the Wasatch Range. Like Arthur Brown, he transferred to the Smithsonian Institution in 1907 and became Walcott's research assistant. He was with Walcott during the first five field seasons in the southern Canadian Rockies. The trilobite genus *Burlingia* was named for him by Walcott. He then worked for the Geological Survey of Canada before transferring to oil company exploration. Following the Second World War, he returned briefly to the Geological Survey of Canada. Because he outlived many of his contemporaries, dying in 1975, and because he was employed by a variety of organizations, obituaries of his life were not written.

Packers and camp hands come and go and there are no records of temporary employees. Dan Orr obviously had worked for the Geological Survey in 1903 in the Wasatch. The Orr ranch was in western Utah and how Dan Orr became a packer for the USGS is not clear. He had familiarity with that part of the state and this trip got his outfit closer to home at government expense. The letter from Weeks quoted above implies that Orr was not in camp with him in 1905, for otherwise he would have been mentioned.

One of Walcott's collections is specifically noted as having been made by Daniel Orr. On September 5, 1903, Walcott was collecting three miles east of Antelope Spring [11y], and Orr went 3/4 mile to the south [3g]. According to legend, that evening he brought a magnificent specimen into camp. Orr told Walcott that the night before he had thought about where the trilobite ought to be and had then gone to the spot and picked it up. No matter what the rationale behind the find, the genus *Orria* marks his discovery.

### THE FIELD WORK

The first impression one gains from the diary entries is how little time Walcott actually had to examine, measure, and collect the outcrops, relative to the time involved in travelling to the area. The second impression is the difference in style between the first and second seasons. The 1903 trip was reconnaissance and when Walcott was satisfied that the House Range was the area to be examined in detail, the 1905 season was concentrated; he examined the Fish Springs Range, more or less in passing, to satisfy himself that the House Range was indeed worth the investment of time and effort.

Where Walcott could travel was limited by available roads and by water supply. Given those limitations, he picked good places to measure and collect. The exposures



are excellent, as might be expected in a desert climate; where Walcott did not obtain his fossils from measured sections, it was easy enough to place these specimens in their correct stratigraphic units.

Walcott gave no indication of his field methods, but it is a reasonable surmise that he used a "Jacob's staff" for it is ideal as a quick method of measuring rock thickness. A Jacob's staff is a pole of known length that has an inclinometer mounted on top. The inclinometer is set to the dip of the beds, and one measures thickness in cumulative pole lengths by sighting straight ahead. Walcott (1889) was apparently the first American geologist to use, or at least describe, this handy and simple field tool.

Walcott also made good use of assistance. During his measuring, he determined the places where collections might be made. While he continued upward, Weeks and later Burling would either pick up specimens on the surface or break rock to obtain fossils.

### THE PHOTOGRAPHS

As noted, on only one day in 1903 did Walcott record taking photographs. Several pictures of Wheeler Peak in Nevada are in his portfolios and these were probably taken at that time. The photographic library of the U.S. Geological Survey lists 19 pictures taken by Walcott in the House Range. From their geographic spread, they must have been photographed throughout that trip. Walcott (1908a) published five views of the Range from a variety of positions; only four of these photographs are among those credited to him in the archives records.

During the 1903 season he had at least two cameras with him. Several pictures are 4" x 5" but most are 6 1/2" x 8 1/2". A significant number are panoramas, presumably used to trace the strata along the front of the range. There is no listing for any 1905 Walcott photographs nor any indication in his diary that he used a camera that season.

The photographic library in the Denver Federal Center is a treasure trove, and, like every such depository, it contains a few mysteries. Nine pictures are listed as taken by F.B. Weeks in 1900 in the House Range; a dozen are listed as taken by him in 1903. However, apart from this listing there is no evidence whatsoever that Weeks or any other U.S. Geological Survey member was in the House Range in 1900. It is far more likely that all these pictures were taken by Walcott in 1903.

Some photographic sessions in other parts of the west, which Walcott recorded in his diary in 1901 and 1903, are not represented by pictures in the archives. The first few years after the turn of the century brought both expansion and stress to the Geological Survey. Certain of the more routine jobs, such as proper cataloguing of negatives, may have been delayed. When Walcott's transfer to the Smith-

sonian in 1907 is added as an element, it is understandable that some documentation was lost or confused.

### THE FOSSIL COLLECTIONS

Walcott's collections were originally in the U.S. National Museum building, now the Arts and Industries Building, to the east of the Smithsonian "Castle." Later they were moved to the Natural History Building, across the Mall, and in the 1960s these were transferred to the then new east wing of that building. The 1990s saw wholesale shuffling of specimens as most material was moved to storage in Silver Hill, Maryland, in anticipation of major construction.

It is impossible to estimate the size of Walcott's House Range collections. Not only have the moves posed difficulties, but type specimens were separated from the bulk of the material. The remainder of collections are divided into biological groups with, for example, Walcott's brachiopods being in one part of the building and the trilobites in another. Some of these major biologic groups are then arranged alphabetically, and others are arranged systematically. Reassembling a former collection is a daunting task, verging on impossible.

On the basis of other Walcott collections and what is known of the abundance of fossils in the House Range, it is likely that the wagon carried a significant load when it left the House Range. The fauna of the Cambrian rocks consists primarily of trilobites and, less common, brachiopods. Most other groups of fossils are uncommon to rare. Even a Walcott could not exhaust the fossil treasures of the House Range and he did not reach every place where fossils were abundant (Beckwith, 1931).

Dr. L. Babcock has made a particularly interesting observation on soft-bodied fossils. "How could Walcott have missed the exceptionally preserved fossils such as *Morania*, *Margaretia*, and *Yuknessia*, all of which are common in the Wheeler Formation? Didn't Walcott open even minor quarries, or did he just pick up loose material on the surface? If he just picked up loose material, he would have been much more apt to collect the trilobites with extra calcification on them than to collect the black spots on weathered calcareous shale. It is ironic that Walcott apparently worked a Burgess Shale-type locality before discovering the Burgess Shale, but he does not seem to have recognized the significance of the Wheeler site" (written communication, 1997).

The diary entries give no indication of any quarrying undertaken during either season. From those parts of the fossil collections which can be studied, it is evident that, as Dr. Babcock surmises, many loose fossils were collected. With so much to do in so little time, and with many trilobites at hand, it is understandable that Walcott did not concentrate on dark patches on the rock; had he seen an obvious, well-preserved soft-bodied fossil loose on the

surface, he surely would have collected it. In the final analysis, although "Burgess Shale" type fossils do occur in the House Range, a great deal of quarrying of the shale is required to obtain them.

Walcott kept a continuous numbered log of collections as he obtained material over the years. This was eventually typed from his notes—which seemingly no longer exist—and is now in the Department of Paleobiology, National Museum of Natural History. Later, each collection was assigned a permanent locality number in the U.S. National Museum register; they were added by hand to the typed sheets. These numbers are given in brackets [ ] and where possible are keyed to the diary entries.

Many of Walcott's Cambrian localities in final form are compiled in his monumental *Monograph* 51 (Walcott, 1912). However, only those localities that yielded brachiopods are included in that work; thus, some of the collections from the House Range are not in that work. Although there has been much careful modern collection and restudy of the fauna of the House Range, these collecting localities further document his daily movements and supplement the diary entries. Because these details are of little interest to the general reader, they are given in an appendix.

## THE MAJOR SUBDIVISIONS

For the Cambrian System, a tripartite division has been in use for more than a century. There has been discussion of the criteria to be used for defining these major elements (Robison, 1976 and later literature). The base of Cambrian was fixed by international agreement in 1992. However, despite deliberations and field work specifically aimed at this issue, there is not yet such a decision defining the upper boundary of the system, let alone the stratigraphic positions or even the names of Cambrian subdivisions.

Walcott (1891a) developed the concept of linear belts of outcrop, the Lower Cambrian rocks being limited to the margin of North America, Middle Cambrian being somewhat less restricted, and Upper Cambrian widespread. Early in his career, he incorrectly identified trilobites from the Wasatch Range as Early Cambrian in age. Much later, Walcott (1912:189) corrected this error; one presumes that careful examination of the associated brachiopods that were part of his monographic study caused him to reexamine the basis for his original age determination.

Walcott collected in Dome Canyon on September 2, 1903. On the typed locality numbers, 245 is indicated as being from the upper zone of the Lower Cambrian. This collection languished in Washington. Sixty-nine years after it was made, on the basis of new collections from near the mouth of Marjum Canyon Robison and Hintze (1972) determined that the House Range contains the oldest

Cambrian metazoans known to date from Utah.

None of the 1903 collections made by Walcott were identified by him as Upper Cambrian. In 1905 he measured a section about 3 1/2 miles south of Marjum Pass and collected Upper Cambrian fossils. Except that the Orr Formation is given as Upper Cambrian, there is no statement as to the position of the Upper/Middle Cambrian boundary. However, on the basis of later restudy of certain trilobites, Walcott (1916:161) later transferred the Weeks Formation to the Upper Cambrian. Currently, "The position of the . . . boundary falls within an unfossiliferous interval from 50 to 85 m above the base of the Weeks [Formation]" (Hintze and Robison, 1975:887). Walcott (1908a:173) also indicated that Ordovician limestone was conformable above the Notch Peak Formation.

When Walcott (1908:171) published his detailed section, he used Georgian as the series term for Lower Cambrian; he noted that the Pioche Shale could be correlated to the Mount Whyte Formation of Canada. He used Acadian as the term for Middle Cambrian; the only confident correlation he made was to the Spence Shale in southern Idaho, and to the Stephen Formation of Canada. For the Upper Cambrian, or Saratogan, Walcott judged that he could correlate the Notch Peak with the St. Charles Formation of Montana and the Sherbrooke Formation of Canada.

## THE STRATIGRAPHY

Walcott published nothing as a direct result of either the 1903 or 1905 trips. His manifold other activities explain this lack of publication. Walcott was involved in trying to correlate the Precambrian of Montana, completing the monograph on Cambrian brachiopods, and keeping the activities of the Reclamation Service from becoming entangled in politics. During this interval he also was still serving as Secretary of the Carnegie Institution of Washington, quite apart from his full-time position as director of the U.S. Geological Survey.

In January 1907, Walcott was appointed fourth Secretary of the Smithsonian Institution, but, until April, he still ran the Geological Survey and laid the groundwork for the formation of the Bureau of Mines before he resigned. That summer he had his first field season in the southern Canadian Rockies where he saw rocks with familiar fossils. To make sense of that area and others in the United States that he had visited over the years, his first step was a preliminary paper that proposed a number of new formations; this included several pages on the House Range stratigraphy (Walcott, 1908:9–12).

Walcott recognized the Prospect Mountain Formation (now Quartzite) and Pioche Formation as Lower Cambrian, with type sections in Nevada. The latter is now divided

Ord.			Feet	Me- ters	
			250	76	Thin-bedded limestone
Upper Cambrian	Notch Peak lime- stone		1490	451	Massive bedded, arenaceous limestone with a few thin beds
	Orr limestones and shale		375	114	Thin bedded limestones with two bands of arenaceous shale
			84	26	
			206	63	
			235	72	
			925	282	
Middle Cambrian	Weeks limestone		1390	424	Thin bedded and shaly lime- stones
	Marjum limestone		1102	336	Thin bedded limestones
	Wheeler shales		570	174	Calcareous shales
	Swasey limestone		152	46	Arenaceous limestone above, with thin bedded limestone below
			188	57	
	Dome limestone		355	108	Massive bedded, arenaceous limestone.
	Howell limestone		435	133	Thick and thin bedded limestone
	Spence shale		< 20	6	Argillaceous shale
	Langston (?) limestone		205	62	Bluish gray arenaceous limestone
	Pioche shale		125	38	Arenaceous shale
Lower Cambrian	Prospect Mountain sandstones		1375	419	Brown quartzitic sandstone

FIG. 6.—House Range Section.

Figure 9. "House Range Section." The stratigraphic column published by Walcott, 1908a, p. 174.

into two members, the upper of which is dated as early Middle Cambrian (Hintze and Robison, 1975:882–883). Above the Pioche in ascending order, Walcott named six new stratigraphic units in the House Range: Howell, Dome, Swasey Peak, Wheeler, Marjum, and Weeks; the Dome was referred to as a limestone and the other units were referred to as formations. Overlying the Weeks he named the Upper Cambrian Orr Formation and overlying it, the Notch Peak Formation.

In compliance with the new rules for stratigraphic nomenclature promulgated for usage by the U.S. Geological Survey in 1902, Walcott gave a type locality, derivation of the name, and a scant summary of lithologic characterization, thickness, and general age. It now became standard geologic practice to name formations after geographic features where they crop out. In an area of sparse names, a geologist would name a feature and then name the formation after that feature. The names of Dan Orr and F.B. Weeks are in a sense immortalized in the rocks. A social commentary on the times is that Arthur Brown's effort were not similarly noted.

Later that same year, Walcott (1908a:173–185) published in considerably more detail, giving measured sections and faunal lists for each of the formations. Presumably on the basis of later examination of the fossils in the laboratory, Walcott tentatively recognized two lower Middle Cambrian formations he had named from the northeastern Utah-southern Idaho region. However, this was an error; for he had missed a fault that repeated a younger unit (Hintze and Robison, 1975:884).

The same material, with a few changes in names of fossils, was republished four years later (Walcott, 1912, 153–158) with essentially no change and with the fossils keyed to the collection numbers. The Notch Peak was referred to as limestone and the Dome was referred to as the Dome Canyon limestone. The Spence shale member of the Ute limestone of 1908 became member 1h of the Howell formation.

The essence of stratigraphy is elucidating ever-finer subdivisions of the rocks and more detailed collection of fossils to improve correlation. The Middle Cambrian stratigraphy of the House Range has been rigorously studied by Hintze and Robison (1975). They recognized eight Middle Cambrian formations; four of Walcott's formations were left essentially unchanged and the other two were restricted to allow for their new Chisholm and Whirlwind formations. They note that all but two of the formations are mappable units in adjacent mountain ranges.

Walcott did subdivide his thick formations, though the subdivisions were not described in great detail; some of these constitute the members recognized today. In the uppermost Middle Cambrian Weeks Formation, as he then designated it, Walcott (1908) recorded 1390 feet, whereas

Hintze and Robison (1975:882) noted 1,200 feet. It is likely that some of the beds at the top were reassigned by them to the overlying Orr Formation. Walcott's total Middle Cambrian section was 4,417 feet, whereas Hintze and Robison's total column is about 250 feet thicker, about a 6% difference. Considering that Walcott's was the first effort in the area, and considering the number of days in which the section measuring was done, Walcott's stratigraphic work has fared well though time.

So much for lithostratigraphy. No formal biostratigraphy of the House Range was developed as such by Walcott, though his faunal lists for the fossiliferous units of his formations provide the basic information for such an exercise. It is evident from the description of his localities that he recognized several zones. He used some zones in his investigations of stratigraphy in western Canada, but never proposed any formal zonation within the subdivisions of the Cambrian.

In the United States, the first 75 years of the U.S. Geological Survey were probably the heyday of biostratigraphy based on megafossils. After Walcott left the Geological Survey, study of Cambrian faunas languished in that organization. A few years after Burling departed from the National Museum, C.E. Resser joined the staff, in effect as Walcott's assistant. Efforts on Cambrian paleontology of the Great Basin were nominally in his hands. The only joint paper Walcott published was with Resser, and this was the only work Resser published until after Walcott's death in 1927. Thereafter, Resser published changes in nomenclature, proposed new species and genera, and in various ways "improved" on Walcott's studies, including some of the House Range material. The result, however, was to muddle matters. His series of papers "Contributions to nomenclature . . ." are still referred to as "Contributions to confusion . . ." by some paleontologists.

Later, Charles Deiss began to make some sense out of Great Basin stratigraphy, despite the Resser mess, and, following the Second World War, a more detailed biostratigraphy of the Cambrian emerged. Still later, Robison (1976) recognized the need for three zonal schemes in the Middle Cambrian of the Great Basin. That for the restricted-shelf was based on polymeroid (non-agnostoid) trilobites. That for the open-shelf had two zonal schemes; one of two broad zones of polymeroids, and the other a more detailed zonation based on agnostoids. The presence of agnostoids were noted by Walcott in the House Range, but they were essentially unstudied by him, perhaps because of their small size and less easily observed characters. Many of the agnostoid species evolved rapidly and have wide geographic distribution, presumably because they had a pelagic mode of life (Robison, 1972); accordingly, these forms are among the best guide fossils for global correlation of Cambrian strata (Robison, 1982:132).

## THE PUBLICATIONS ON FOSSILS

As noted, nothing on the House Range stratigraphy was published by Walcott until 1908; after 1906, he never returned to field work in the Great Basin. Walcott's appointment as Secretary of the Smithsonian Institution gave him the advantage of publishing in *Smithsonian Miscellaneous Collections*. Never one to miss an opportunity, he filled five entire volumes of that series. However, there is no paper devoted to fossils of the House Range as such; rather various elements of that fauna are included as minor parts of other studies.

By 1905, according to his diary, a manuscript had been submitted for Cambrian brachiopods; if so, the House Range material must have been among the last to be integrated into that work. For the trilobites, most of his effort was concentrated in Canada, although he also had several seasons in Montana. Although no research program was ever formally outlined by him, in general from 1907 onward, Walcott systematically worked his way up the stratigraphic column in the southern Canadian Rockies from Precambrian to Devonian.

Walcott had no significant fossils from Lower Cambrian rocks of the House Range. His principal efforts on Upper Cambrian trilobites of the House Range came more than a decade after his second foray into that area.

The genus *Millardia* (Walcott, 1916:163), named for Millard County, was described with its type species from the House Range. Walcott assigned a new species to his new genus *Norwoodia* (Walcott, 1916:162). He revised an older genus, *Acrocephalides*, and added a new species (Walcott, 1916:180). He also revised *Lonchocephalus*, and added two new species (Walcott, 1916:194-195). One new species of *Crepicephalus* was noted as ranging through the Weeks Formation into the Orr Formation (Walcott, 1916:207). For the Orr Formation, from the Fish Springs Range but not the House Range, he extended the stratigraphic range of a species he had described from the Middle Cambrian of the Eureka District (Walcott, 1916:184). Finally, a new species was assigned to a genus that Walcott had described from North China; "This species is referred to the Upper Cambrian, but it may belong to a lower Ozarkian fauna that has not yet been well determined and probably will not be until the various faunal horizons of the lower Pogonip Formation have been studied in the field" (Walcott, 1916:227). Clearly Walcott was planning more study of Great Basin faunas for further refinements in biostratigraphy.

Much of what Walcott wrote regarding the Middle Cambrian House Range trilobites is in another 1916 publication, also entitled "Cambrian trilobites." In it, an undescribed species questionably assigned to *Bathyriscus* was described from the Marjum Formation (Walcott, 1916a:

348), as was a new species of his new subgenus *Poliella* (Walcott, 1916a:354). *Orria* Walcott (1916a:379) comes from the Marjum Formation along with *Marjumia* Walcott (1916a:401), with one new species in the former and two in the latter. Three new species questionably assigned to *Asaphiscus* and one unnamed form were described from the Weeks Formation (1916a:385, 388, 389, 391). Walcott re-described *Ogyia productus* Hall and Whitfield, a species in the literature from the time of the territorial surveys, and found it to be widespread, including occurrences in the Howell Limestone (Walcott, 1916a:371). Finally, Walcott (1916a:374) named a new subgenus *Housia* which included only the type species from the Orr Formation.

Following the end of the First World War, Walcott concentrated more on lithostratigraphy of the Upper Cambrian and overlying rocks in Canada. He did add a little more to the Upper Cambrian of the House Range. One publication (Walcott, 1924) is simply a series of skeleton descriptions of new genera, which appears to be the first and only time Walcott rushed a paper into print to get his names for new taxa into the literature. *Elrathia* appears here for the first time, and *Housia* was raised from a subgenus to full generic rank. His more definitive effort came the following year in which *E. kingii* (Meek) was re-described and illustrated by photographs for the first time from the Wheeler Amphitheater (Walcott, 1925:87). The same publication indicated that additional species from Canada were to be placed in *Housia*, but nothing was added to the original species description. In both publications, genera are listed in alphabetical order.

As a point of historical interest, *Housia* from the Orr Formation was referred to the Upper Cambrian. Walcott was one of the few geologists to follow E.O. Ulrich in using the "Ozarkian" and "Canadian" Systems (Weiss and Yochelson, 1995: 43). So far as can be determined, this attempt at further refinement of the geologic column did not affect Walcott's thinking until several years after Ulrich's proposal. Had Walcott written more on the younger fossils, the Notch Peak might have been assigned to the Ozarkian. However, the late Late Cambrian age assigned in 1908 remained unchanged in the literature and remains unchanged today.

Walcott at one time entertained the concept of a monographic treatment of the trilobites, like that of the brachiopods, but there were simply too many trilobites, and each season in Canada brought more. His answer was a series of papers, four of which contained the House Range specimens. Other papers included material from elsewhere in the Great Basin, and eastern North America, as Walcott tried to build up the biostratigraphic framework.

Apart from the brachiopods and some of the trilobites he collected, Walcott described one other group of fossils from the House Range. Walcott's collecting in the Middle

Cambrian Burgess Shale of Canada yielded a remarkable sponge faunule and a few other forms and occurrences from western North America were included when these fossils were monographed. The genus *Sentinella* Walcott was based on a single species, known from two fragments, one from Canada and one from the Wheeler Formation (Walcott, 1920:290). *Choia utahensis* Walcott (1920:205), one of five new species in his new genus is from the Marjum "limestone," a minor change from Walcott's original use of formation. However, in the new genus *Kiwetinkia*, *K. spiralis* Walcott is listed as being from the Marjum Formation.

So far as is known, no other House Range fossils were described by Walcott. In closing, it may be worthwhile to mention that two projects distracted him from a more detailed Cambrian biostratigraphy. First, he had the opportunity to be the first geologist to describe the stratigraphy of Mount Robson, the highest peak in the Canadian Rockies. Second, he discovered the Middle Cambrian Burgess Shale biota and spent years of his time collecting and describing it (Yochelson, 1996); surely that is an acceptable reason for not describing all the fossils of the House Range.

### SUMMARY

In a very short time in the field, Walcott laid a solid foundation for future studies. He developed a reasonably good lithostratigraphic section for the House Range. Although he originally considered the Weeks Formation to be Middle Cambrian, on the basis of new information from western Canada, he moved it to the Upper Cambrian. His descriptions of fossils have stood up fairly well, though he was far from exhausting the diversity of the fauna. The section in the House Range is so rich and the fossils so varied that it has become one of the prime reference sections for the Middle Cambrian of the world.

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### REFERENCES CITED

- Beckwith, F.A., 1931, A field of small fossils in western Utah. *Utah Historical Quarterly*, 4 (1):25-29.
- Davis, W.M., 1927, Biographical Memoir—Grove Karl Gilbert 1843-1918, National Academy of Sciences, 21 (fifth memoir):303 p.
- Gilbert, G.K., 1890, Lake Bonneville, U.S. Geological Survey, Monograph 1.
- Hintze, L.F., and Robison, R.A., 1975, Middle Cambrian stratigraphy of the House, Wah Wah, and adjacent ranges in western Utah, *Geological Society of America, Bulletin*, 86:881-891.
- Hintze, L.F., and Robison, R.A., 1987, The House Range, western Utah: Cambrian mecca, *Geological Society of America, Centennial Field Guide*, volume 2, Rocky Mountain Section; 257-260.
- Kelsey, M.R., 1997, Hiking, climbing & exploring western Utah's Jack Watson's Ibex country. Kelsey Publishing, Provo, Utah, 272 p.
- Pyne, S.J., 1980, Grove Karl Gilbert: a great engine of research, University of Texas Press, Austin, 304 p.
- Robison, R.A., 1972, Mode of life of agnostid trilobites, 24th International Geological Congress, section 7:33-40.
- Robison, R.A., 1976, Middle Cambrian biostratigraphy of the Great Basin, *Brigham Young University Geology Studies*, 23 (2):99-109.
- Robison, R.A., 1982, Some Middle Cambrian agnostoid trilobites from western North America, *Journal of Paleontology*, 56:132-160.
- Robison, R.A., and Hintze, L.F., 1972, An Early Cambrian trilobite faunule from Utah, *Brigham Young University Geology Studies*, 19 (1):3-13.
- Taylor, M.E., 1976, Indigenous and redeposited trilobites from the Late Cambrian basinal environments of central Nevada, *Journal of Paleontology*, 50:668-700.
- Taylor, M.E., and Cook, H.E., 1976, Continental shelf and slope facies in the Upper Cambrian and Lower Ordovician of Nevada, *Brigham Young University Geology Studies*, 23 (2):181-214.
- Taylor, M.E., and Robison, R.A., 1976, Trilobites in Utah folklore, *Brigham Young University Geology Studies*, 23 (2):1-5.
- Walcott, C.D., 1884, Paleontology of the Eureka District, U.S. Geological Survey Monograph 8,
- Walcott, C.D., 1888, Cambrian fossils from Mount Stephens, Northwest Territory of Canada, *American Journal of Science*, 35:229-242.
- Walcott, C.D., 1888a, The Taconic System of Emmons, and the use of the name Taconic in geologic nomenclatures, *American Journal of Science*, 35:229-242, 307-327, 394-401.
- Walcott, C.D., 1889, A simple method of measuring the thickness of inclined strata, *Proceedings of the United States National Museum for 1888*, 11:447-448.
- Walcott, C.D., 1890, The Fauna of the Lower Cambrian or *Olenellus* zone, Tenth Annual Report of the Director of the United States Geological Survey to the Secretary of the Interior, 1888-1889, Part 1:509-774.
- Walcott, C.D., 1891, Correlation Papers—Cambrian, U.S. Geological Survey, Bulletin 81.
- Walcott, C.D., 1891a, The North American continent during Cambrian times, Report of the Director of the United States Geological Survey to the Secretary of the Interior, 1890-1891, Part 1:523-568.
- Walcott, C.D., 1894, Pre-Cambrian igneous rocks of the Unkar Terrane, Grand Canyon of the Colorado, Arizona; with notes on the petrographic character of the lavas by J.P. Iddings, Fourteenth Annual Report of the Director of the United States Geological Survey to the Secretary of the Interior, 1894-1895, Part 2:497-519.
- Walcott, C.D., 1904, Twenty-fifth Annual Report of the Director of the United States Geological Survey to the Secretary of the Interior, 1903-1904:1-388.

- Walcott, C.D., 1906, Twenty-seventh Annual Report of the Director of the United States Geological Survey to the Secretary of the Interior, 1905–1906:1–104.
- Walcott, C.D., 1908, Nomenclature of some Cambrian Cordilleran formations, Smithsonian Miscellaneous Collections, 53:1–11.
- Walcott, C.D., 1908a, Cambrian sections of the Cordilleran area, Smithsonian Miscellaneous Collections, 53:167–230.
- Walcott, C.D., 1912, Cambrian Brachiopoda, U.S. Geological Survey Monograph 51.
- Walcott, C.D., 1916, Cambrian trilobites, Smithsonian Miscellaneous Publications, 64 (3):137–258, plus unnumbered index.
- Walcott, C.D., 1916a, Cambrian trilobites, Smithsonian Miscellaneous Collections, 64(5):303–456, plus unnumbered index.
- Walcott, C.D., 1920, Middle Cambrian Spongiae, Smithsonian Miscellaneous Collections, 67 (6):261–364.
- Walcott, C.D., 1924, Cambrian and Lower Ozarkian Trilobites, Smithsonian Miscellaneous Collections, 75 (2):53–60.
- Walcott, C.D., 1925, Cambrian and Ozarkian Trilobites, Smithsonian Miscellaneous Collections, 75 (3):59–146.
- Weiss, M.P., and Yochelson, E.L., 1995, Ozarkian and Canadian Systems: gone and nearly forgotten: 41–44; In Copper, J.D., Drosser, M.L., and Finney, S.C., eds., Ordovician Odyssey; short papers for the Seventh International Symposium on the Ordovician System. The Pacific Section, Society for Sedimentary Geology (SEPM), 498 p.
- Yochelson, E.L., 1967, Charles Doolittle Walcott 1850–1927, National Academy of Sciences, Biographical Memoirs, 39:471–540.
- Yochelson, E.L., 1987, Walcott in Albany: James Hall's "Special Assistant," Earth Sciences History, 7:86–94.
- Yochelson, E.L., 1994, Andrew Carnegie and Charles Doolittle Walcott: The origin and early years of the Carnegie Institution of Washington: 1–19, in Good, G.A., ed., The Earth, the Heavens, and the Carnegie Institution of Washington, American Geophysical Union, History of Geophysics, volume 5.
- Yochelson, E.L., 1996, Discovery, collection, and description of the Middle Cambrian Burgess Shale biota by Charles Doolittle Walcott, Proceedings of the American Philosophical Society, 140:469–545.
- Yochelson, E.L., 1998, Charles Doolittle Walcott, Kent State University Press. 584 p.
- Yochelson, E.L., and Nelson, C.A., 1994, Walcott and Early Cambrian of eastern California: Geology in the White-Inyo area, 1894–1897: 15–37, in Hall, C.A., Jr., and Widawski, B., eds., The Crooked Creek guidebook, University of California, White Mountain Research Station.
- Yochelson, E.L., and Yoder, H.E., 1994, Founding the Geophysical Laboratory, 1901–1905: A scientific bonanza from perception and persistence, Geological Society of America, Bulletin, 106:336–350.

## APPENDIX-REGISTER OF FOSSIL LOCALITIES

The locality registers of the National Museum of Natural History have a curious history, an admixture of Geological Survey and Museum activities. For the lower Paleozoic, fossils which bear locality numbers on circular green labels refer to the first register, and these are keyed to Walcott's localities. This Paleozoic register was originally divided among Walcott, G.H. Girty and E.O. Ulrich; Girty soon abandoned its use. Apparently at first, letters were added to indicate collections in sequence through a section. For some reason, the amount of numbers was limited

and in later years letters simply indicated different localities. Ulrich in particular added superscript and subscript letters and marks, making his part of this locality register increasingly bizarre.

Geographic locality information that helps trace Walcott's route has been included below. For most localities, a "Formation" or "Zone" was included, and these were Walcott's biostratigraphic units; except for No. 245 (Lower Cambrian), and 262–262g (Upper Cambrian), all were listed as Middle Cambrian; this has been omitted. Faunal lists that were given have also been omitted. Generic and specific names are as used by Walcott. There may have been minor modifications by the typist(s) as indicated by varying use of underlining, capitalization, and spelling.

From the reference to a 1905 collection in the last 1903 collection listed in the previous section, it is evident that the locality data were "worked over" after they were first written by Walcott. Several of the faunal lists contain handwritten additions or deletions. Some provisional formation names such as Luke, Pass, and Antelope, vanished before publication.

### Collecting localities for 1903

For numbers 244, 244a, 253, 253a, and 253b, F.B. Weeks and C.D.W., in that order, are listed as collectors. For all others, except 249, which is specifically credited to Dan Orr, C.D.W. is listed as collector.

No. 244 [3s]. West side amphitheater of Antelope Springs, . . . about one mile north of the locality where most of the trilobites collected near Antelope Springs have been obtained. Essentially the same species occur at both places. The species of *Actinotreta* occur near the summit of the shales. *Ptychoparia kingii* occurs most abundantly 100 feet below the summit. *Asaphiscus wheeleri* ranges throughout the 200 feet of shale exposed, also *Acrothele subsidua*. . . *Asaphiscus wheeleri* zone.

No. 244a [3t]. About one mile south where the cone-in-cone structure occurs on many of the trilobites. In this locality *Ptychoparia Kingii* and *Asaphiscus wheeleri* are most abundant at 230 to 350 feet from the base. Many hundred entire trilobites have been taken from the slopes of clay resulting from decomposition of argillaceous shales. . . *Asaphiscus wheeleri* zone (same as 244).

No. 245 [3u]. Dome Canyon, 6 miles west of Antelope Springs, Utah. Cruziana and annelid trails. This is a zone of *Olenellus gilberti* in the Highland and Snake ranges of Nevada.

No. 246. [3v]. Dome Canyon, 5 1/2 miles west of Antelope Springs, Utah. From a band of greenish and drab argillaceous shale about 200 feet up in the limestone above the Lower Cambrian shaly sandstones. . . *Zacanthoides typicalis* zone. . . According to the section estimated by

Mr. G.K. Gilbert, there are several massive beds of limestone between this shale and the shales carrying the *Asaphiscus wheeleri* fauna, the total thickness of which is 1,600 feet.

No. 247 [3w]. "G" of G.K. Gilbert 1901. 4 miles east of Marjum Pass, on north slope of the low ridge, south side of Rainbow Valley.

No. 247a [11r]. *Asaphiscus wheeleri* fauna in low mounds of shales and shaly blue limestone. {Note—a sketch under 247 shows a low mound in front of a cliff marked "a" with the beds dipping gently into the cliff.}

No. 247b [11p]. *Ogygopsis* ? fauna about 200 feet above *A. wheeleri* fauna. Shales barren of fossils between, except an occasional head of *Ptychoparia*-like *Kingi*. {Note—on the sketch a "b" is marked on the first major unit relatively low on the cliff face.}

No. 248 [3x]. 2 1/2 miles east of Antelope Springs, . . . *Olenoides Nevadensis* ? zone.

No. 248a [3y]. 50 to 75 feet below No. 248. . . . Very few traces of *Olenoides*? at this horizon. It is the *Ogygopsis* zone.

No. 249 [11v]. 3 miles east of Antelope Springs. . . . *Olenoides* zone. Fauna occurs in shaly limestones. Carries some species similar to those of locality No. 248.

No. 249a [3g]. 3/4 miles south of No. 249.

No. 250 [1z]. North end of House Range, southeast of Sand Pass, on west face of ridge. Shales reddish above and buff and drab below. . . . *Asaphiscus wheeleri* fauna.

No. 253 [10y]. South side of Marjum Pass at Divide, House range (south end). Same horizon occurs at Antelope Springs. . . . *Asaphiscus wheeleri* zone.

No. 253a [10z]. South side of Marjum Pass, at Divide. . . . *Agnostus* characterizes this zone and ranges through about 200 feet of shaly limestone. It is the zone of *Ogygopsis* south of Antelope Springs. *Agnostus* occurs in immense numbers up to the top of the section, about 2,500 feet above the base of the *Bathyriscus wheeleri* zone.

No. 254b [11n]. Same as 253a. 200 feet higher up in the section. This is about the upper zone from which trilobites were obtained south of Marjum Pass. *Agnostus* occurs in great numbers.

No. 254 [11o]. About 3 miles southeast of Antelope Springs, on spur of House Range, near union of Deseret and Swazy [sic] spring road, Utah. . . . Next horizon about Loc. 261.

The first two collections listed are from the world-famous Wheeler Amphitheater. More Middle Cambrian trilobites have been obtained from this locality than any other in the world. It was well known to the native Americans of the area (Taylor and Robison, 1976) and must have been visited by local settlers long before Walcott arrived.

## The localities for 1905

A reasonable surmise is that larger collections were obtained in 1905 than in 1903. First, there was less travel. Second, there was concentration on collecting from measured sections. Third, another geologist was present to assist. The first collection is credited to the efforts of Burling. Only two other collections bear the name of collectors and these are "F.B. Weeks, L.D. Burling and C.D. W." Although Walcott was party chief, quite apart from his position as director, he apparently listed collectors in the order in which they contributed to that effort. The implication is that Walcott measured the sections, and while going up the section he indicted the layers to be sampled in detail.

No. 258 [30b]. Head of Dome Canyon on hill just below pass, 3 miles west of Antelope Springs. Base of {blank} limestone of section and capping limestone of ridges west and southwest of upper Antelope Spring amphitheatre [sic] 1035 feet up from base of Middle Cambrian and below Antelope shales. . . . *Fossils*: Occur in lower 50 feet none found above.

No. 258a [30c]. Same as 258. In shale and thin interbedded limestones (Pass shale).

No. 258b [30d]. Same as 258. In gray limestone beneath "Pass" shale but not the same layer as 258. Top of *Ptychoparia*. 258a and 258b same fauna, about 50 foot range.

No. 258c [31w]. {numbers written on same page, without data}

No. 259 [30e]. West side of Dome Canyon, about 1 1/2 miles from its mouth . . . Limestone just beneath or in horizon of 246. About 205 feet above Lower Cambrian.

No. 260 [30f]. On ridge on east side of Dome Canyon about 1 1/2 miles from mouth. . . . Bluish thin bedded limestone about 330 feet above Lower Cambrian.

No. 260a [31s]. {numbers written on same page, without data}

No. 260b [31v]. {numbers written on same page, without data}

No. 261 [30q]. East side of amphitheatre east of Antelope Springs, Utah. Horizon {crossed out} feet above Antelope formation . . .

No. 261a [30z]. {numbers written on same page, without data}

No. 262 [30 h]. About 3 1/2 miles south of Marjum Pass . . . Upper Cambrian in lower portion of 2a of Orr formation. House Range section 1905.

No. 262a [30i]. Same fauna as 262; 275 feet higher in 2a.

No. 262b [30j]. Same locality as 262; near base of 2e of section.

No. 262c [30k]. Same locality as 262; near top of 1e of Orr formation.



No. 262d [30l]. Same locality as 262; in 1b of Orr formation. Same fauna as 262c.

No. 262e [30m]. Same locality as 262; in 1e of Luke limestone. . . . 120–150 feet above base. {Thickness has been added by hand.}

No. 262f [31t]. Just above 262c {all data written in}.

No. 262g [31q]. Base of 1a of Luke limestone, west slope of Luke Peak {all data written in}.

No. 263 [30n & 30n']. Two miles south of Marjum Pass, . . . on north slope of large canyon. . . . About 570 feet above base of Weeks shale. This fauna ranges through about 100 feet.

No. 263a [30o]. Two miles south of Marjum Pass, . . . on north slope of large canyon. . . . 690 feet above base of

shaly limestone. Fauna much like 263 but has *Asaphiscus* . . .

It is difficult to determine just how many collections were made in 1905. Those written in by hand may have been separated after the group returned to Washington, though this seems unlikely. Number 263a is the last sheet in the typed compendium even though collections were made after September 15.

The Cambrian brachiopod monograph (Walcott, 1912: 153–156) listed 40 collections from 21 localities in the House Range. It is not known how many of the other collections did not contain brachiopods and therefore were excluded from that study.





