# Ogden and Salt Lake City, Utah, and Southwestern Colorado: [specimens] 15735-15882. No. 85 August, 1889

Van Hise, Charles Richard, 1857-1918
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# U. S. GEOLOGICAL SURVEY

## FIELD SECTION BOOK

No. 85.

August, 1889

Ogden and Salt Lake City, Utah, and Southwestern Colorado.

C. R. VanHise

15735–15882

# SURVEY OF THE PRE-CAMBRIAN ROCKS OF THE N.W. STATES.

## INSTRUCTIONS.

1. Ordinarily at least two pages of this book will be devoted to one section. On the left hand page place a map of as much of the section as has *actually been seen*. Denote rivers, lakes, marshes, etc., by the usual topographical signs. Denote the ledges of rock, when no structure is made out, by cross-hatching, making the cross-hatching cover as nearly as possible the areas occupied by the exposures. If the rock is a massive one, but still more or less plainly bedded, use the same sign with a dip arrow and figure attached, showing the amount and inclination of the dip. Denote slaty or other very plainly bedded rocks by lines running in the direction of the strike, with figures and a dip arrow attached as before. In all cases where there is the least doubt about the true bedding directions, indicate it by a query. To each exposure on the face of the map attach the number of the specimen representing it. In mapping the section count each of the spaces between the blue lines as 100 paces, and twenty of these spaces as one mile, or 2,000 paces. Usually the southeast corner will be placed at the bottom of the page, or at the first black line above the bottom of the page, and at the right hand side. If, however, for any reason, it is desirable to show portions of an adjoining section, the southeast corner may be shifted up, or the map may be turned around and the north placed at the left hand side of the page.

2. On the right hand page place the notes descriptive of the exposures. Begin in each case with the number of the specimen, placing the number on the left hand side of the red line, after which give in order on the right of the same red line the position of the ledges as reckoned in paces from the southeast corner of the section, and the dip and strike when observable, for instance: 4025 250 *N.*, 300 *W.*, *Strike*, *N.* 6° *E.*, *Dip*, 50° *E.* Then follow with as full a description of the ledge as possible.

3. The ruling of the left hand page is also arranged so that a smaller scale can be used. Each one of the black lines may represent a section line and the red lines quarter sections and "forties." The scale of the maps may thus be reduced, if desirable, to two inches to the mile (the ordinary town plat scale.)

4. Collect a specimen from each separate ledge of rock, or wherever there is a change of rock on any one ledge. In case of trips made on foot or in canoes, for long distances, neighboring ledges, unquestionably of one kind of rock, need not be sampled, the position and extent of the ledge being marked on the map, with a note that it is of a rock identical with specimen so-and-so. Under the same conditions small sized samples, trimmed to a uniform size of 2 x 2½ x ¾ inches will be allowed, but in all other cases *large sized specimens*, trimmed to a size of 3 x 4 x 1 inches, must be selected, in accordance with § 3, chapter IV, p. 44, Regulations of the U. S. Geological Survey. In all cases collect chips for slicing. All specimens are to have numbers painted on them, in white on a black background, in the field.

5. On the last twenty-five pages of the book give, as may seem desirable, a general account of the examination of the region mapped in the previous pages, correlation of observations, sketches, cross sections, etc., etc.

H85

Wednesday, August 21, 1889.

Trip up Ogden Canyon.

Immediately upon leaving the Quaternary lowlands — upon which is located the city of Ogden — a coarse granitoid
15735 gneiss, 15735, is struck. This gneiss varies in its coarseness and in the degree of the regularity of its lamination. It dips at a high angle to the east. Upon passing up into a higher strata it seems to be somewhat regular in its lamination.
15736 is taken from a middle horizon in the Archaean gneiss.
15737 is from an uppermost horizon, just below the contact of the overlying Cambrian.

The actual junction between the Cambrian and Archaean was at no point found, although the cliff was followed along this line upon the south side nearly to the top. There is always a few feet of debris along the junction line.

The rock found closest to the gneiss
15738 is a sort of a gray novaculite, 15738.

High up upon the cliff was found a phase of granitic rock which was

taken to be composed almost wholly
of the debris from the gneiss, and is
15739 therefor supposed to be Cambrian, 15739.
However, it is not certain that this rock
is not crystalline and therefor belongs
to the Archaean rather than the Cambrian.

15740
15741
15741A Pebble. } Three phases of conglomerate
15742 } a little higher up in the Cambrian
The pebbles are almost wholly of
white quartz, although the cementing
material is taken to be of a feldspathic
nature.

15743 is a vitreous quartzite of the Cambrian,
a little higher up.

15744 Cambrian quartzite higher up, containing
brownish cavities which may represent
areas which were once carbonate.

15745 A very vitreous phase of quartzite higher up.

15746 A phase of the quartzite near its top before it
begins to become shaly.

King says that the inclination of
the Archaean gneiss is higher than that
of the Cambrian quartzite, but this was
not found to be the case so far as I
observed the relations in the Ogden
Canyon. The quartzite dipped towards the

east at an angle varying from 60° to 65°, just as stated by King, and the gneiss appeared to me to dip at about the same angle.

Several photographs were taken to illustrate the relations between the Archaean rocks, Cambrian quartzite and Quaternary conglomerate at the place in Ogden Canyon where the three are exposed in close contiguity.

Photo. 741 74. Unconformity between Cambrian quartzite and Quaternary conglomerate. The latter is horizontal and on the left. The Cambrian quartzite dips 63° east. Looking towards the west side of canyon.

Photo. 742 75. The same, higher up. The Archaean gneiss now appears on the left.

Photo. 743 76. The same, still higher up on the opposite side of the canyon; the Archaean gneiss being on the left and the Cambrian quartzite on the right.

Photo. 744 77. Looking down canyon from a high point on its south side. The conglomerate in the foreground is taken to be a tumbled down piece of Cambrian. The major portion of the rocks

shown are Archaean.

Photo. 78. 745 From about the same point as the last, looking across canyon towards the Cambrian quartzites. The photograph was taken to illustrate the bowing which is shown by these layers.

Passing ~~up~~ now up from the Cambrian quartzite it is found to become interstratified with shaly layers, and to run
15747 into a true shale. The shale after a little time becomes more and more carbonaceous, and finally becomes a gray
15748 silicious carbonate which shows by its weathering that it contains a good deal of carbonate of iron.
15749 is taken from one narrow layer of the limestone which is being used to manufacture lime. 15747-48-49 are in King's Ute limestone.

Above this Ute limestone appears a thick bed of quartzite — the Ogden quartz-
15750 15751 15752 ite. Specimens 15750-51-52 represent different phases of this quartzite. The great difficulty of getting other than angular specimens, due to its tendency to break into angular fragments was

noted. The irregular fracturing and weathering of this quartzite, and the angularity of its fracture is also noted by King.

afternoon, Aug. 21, 1889.

15753 Gray limestone
15754 Black, compact limestone.
15755 Quartzite
15756 Gray limestone
15757 Chert nodule which are abundantly found in 5756.
15758 Siliceous slate.

These rocks are taken in order in making a cross-section of the Wasatch limestone. No attempt was made to make a complete section. One or two quartzite layers were noted and numerous other phases. The chert nodules in the gray area in some places are very abundant.

The nature of the Cambrian conglomerate just above the Archaean was carefully re-examined upon our return down the canyon. As far as I could see I found comparatively little evidence

of squeezing, the pebbles showing little or no trace of elongation by pressure. They are usually concentrated into zones and in those zones their greater directions are generally parallel to the bedding; but this is the position in which the pebbles would naturally fall in being deposited in the bed. In proof of the intense squeezing and welding together of pebbles such as described by King, no evidence was found. Many different layers of conglomerates, and thousands of pebbles were closely examined to find, if possible, some granite pebbles, or granitoid gneiss pebbles, in order to show that the conglomerate is later than the granite below. No unmistakable granite pebble was found. The great mass of the pebbles are white quartz; some of them are red quartzite, and fewer are red jasper or agate, or some form of crypto-crystalline quartz. A number of pebbles were, however collected
15759 which most resembled granite, 15759.
I think, however, that they are all sim-

red quartzite. The absence of these granite pebbles does not prove that the granite is not older than the conglomerate; for it may be possible that the granite pebbles were disintegrated more rapidly than the more resistant white quartzes, although it would seem strange that some unmistakable granite pebbles were not found if the granite is older than the conglomerate. The gray character of a good deal of the quartzite suggests that it is strongly feldspathic and is really finely divided granite or gneissoid material.

On the lower horizons of the quartzite and conglomerate, upon the north side of the river, specimens 15760-61-62 were taken because of the resemblance which they bear to a true gneiss. One of them, however, distinctly shows the rounded character of contained pebbles, and its position in the quartzite and conglomerate would be evidence that it is a fragmental rock even if this were not the case.

15760
15761
15762

15763 A peculiar quartzite in which the con-

stituent white quartz grains have been larger than usual and of uniform size. The dip of the gneiss was again examined inorder to ascertain if there was any difference in the inclination of its dip and that of the quartzites. While the granitoid gneiss, as is common with such rocks, has wide variations within short distances, in the dip of its schistose structure it cannot be said, so far as I could see, to differ markedly in its dip from that of the overlying Cambrian quartzite. The relations seen suggested to me that the pressure of upturning parallel to the bedding had perhaps produced the schistosity in the granite or gneiss.

15764 Granitoid gneiss, selected as a particularly fresh phase of this rock from near the contact.

Thursday, August 22, 1889.

Trip up Weber Canyon.

The rock first seen in Weber Canyon
15765 is a coarse hornblendic gneiss, at the foot of the canyon. Its strike is N. 40° E. magnetic and its dip 40° southeast.

Photo. 746/79. View of the banded and contorted gneiss at the entrance of Weber Canyon, from the south side, looking north. Time 10:30 A.M.

The granite while evenly laminated has coarse layers of nearly pure feldspar, both white and pink, some of which are 18 inches or more across
15766 shows a portion of one of the pink feldspar layers.

Photo. 747/80. A land slide in the Wasatch as a freight train is passing by. Weber Canyon a few miles above Uintah.

Photo. 748/81. Another view of the same; clearing up the wreck.

Farther up the canyon the granitoid gneiss becomes coarser and more contorted.
15767 From this place specimen 15767 was taken, which however on account of its small size does not show the peculiar banding and contortions, and the irregular way

in which nests of feldspar are contained in the granite. Coarse grains of nearly pure feldspar are also seen to cut across the schistose structure of the granitoid gneiss.

Photo. 82.[749] Was here taken, looking northwest down the canyon road.

Photo. 83.[750] Gives the detail of a small portion of the same.

This same granite becomes black and hornblendic, mingled with veins and nests of white feldspar.

15768 shows this black phase.

15769 One of the white feldspar veins cutting it.

A little farther on the granite is cut by a very large vein two feet wide of

15770 feldspar and quartz.

Photos. 84[751] and 85[752] were here taken, showing the structure of the granitoid gneiss and the relations of the granite veins which cut them. Looking northeast. Time 1:15 P.M.

Photo. 86.[753] Looking down the canyon which shows the large exposure of Archaean gneiss; from a little farther up the river than the one taken by the wagon bridge. This place is about

a mile from the east side of the Archaean
15771 area. At the latter point 15771 coarse granitoid gneiss was taken.

Photo. 754 87 On the return trip a view of the black banded gneiss cut by white feldspar, from which 15768-69 were obtained, was taken.

Upon the return trip, about half way through the Archaean core the strike was taken and was found to be N 45° to 50° W, and the dip about 20° W, although the coarse foliation makes both determinations somewhat uncertain.

Photo. 755 88. Looking out of Steber Canyon from 1½ to 2 miles up. Time 1:30 P. M.

Photo. 89. Looking north up a side gulch of Steber Canyon, from point a little farther on.

From about 3/4 mile up Steber Canyon from its lower part the strike of the evenly banded granitoid gneiss is about east and west magnetic — that is, parallel to the sides of the canyon — and its dip is here to the south about 45°. King mentions the regularity of the

banding of the granite and granitoid gneiss in each particular area, showing that the dip is always to the west. The observations at the mouth of Weber Canyon unmistakably put the dip to the south and southeast, although farther up the canyon a dip in the reverse direction was noted. These facts might suggest that the river itself was along the line of an anticlinal in the gneiss.

Photo. 90.[756] Looking back at the mouth of Weber Canyon from the plains below.

Photo. 91.[757] The same from farther out on the plain; about ½ mile away from the gap. Time 2:15 P. M.

Photo. 92.[758] The Wasatch between Uintah and Ogden, from about a mile away; looking east.

Photo 93.[759] Ogden, Utah, at the right; the Wasatch beyond Ogden; on the left the Great Salt Lake; looking north.

Friday August 23, 1889.

Trip up Big Cottonwood Canyon.

15772 represents the first exposure found at the mouth of Big Cottonwood Canyon.

The next rock exposed along the road

15773 is a peculiar black slate, the strike of which is N. 23° E. magnetic, and the dip 85° S.

The relations of this black slaty rock to the surrounding rocks were difficult to make out. It appeared, however, to be in well defined layers, the sides of which are parallel to the slaty cleavage. The red rock with which it is associated, where the black slate is well exposed, is high up on a cliff; but a little farther on this red rock comes down to the river and it is there a quartzite.

15774 represents the red phase.

15775-76 two other phases of quartzite interlaminated with the first.

Continuing up the canyon the black slates and quartzites continue to be interlaminated for a long distance.

15777 A particularly fresh phase of the black slate. Following the black slate is

15778 a coarse vitreous quartzite.

For quite a distance up the canyon the layers of slate and quartzite, as represented by these specimens and those previously obtained, alternate in sharply contrasting layers. The thickness of the individual layers of both slate and quartzite vary greatly. In one locality the slate seems to preponderate over the quartzite, but usually the reverse is the case. In passing up the canyon the slates become less and less numerous, and finally the rock is wholly quartzite. This rock continues for a long way.

15779-80 represent two phases of the quartzite about 4½ or 5 miles up the canyon.

15781 Coarse brown sandstone, or semi-quartzite, about 5 miles up canyon. This coarse conglomeratic phase of rock runs in

15782. a short distance to purple quartzite.

The white quartzite again reappeared and continued until near the top of the member. Then was found

15783 a thin layer of slate. All of the previous specimens are taken from King's Cambrian. Upon the top of this

appears the Ute limestone the lower horizons of which is very siliceous
15784 and is represented by # 15784.
15785-86 Typical specimens of the white and gray varieties of the Ute limestone, a little farther along than the last.

Driving along we soon come to a
15787 gray crystalline rock, the nature of which is uncertain, but is probably the Ogden quartzite. Passing this we immediately
15788 come to a gray limestone which is supposed to be the Wasatch.

Driving along a little farther the
15789-90 limestone is white, 15789-90.
15791 Gray cherty limestone high up in the Wasatch member.

Saturday, August 24, 1889.

Trip from the head of the Big Cottonwood to the Little Cottonwood, and down Little Cottonwood Canyon.

In starting south from the little lake where the hotel is near the head of Little Cottonwood Canyon, limestone was found in contact with granite.

The limestone was in an unusual degree metamorphosed, and with difficulty the point was determined where the limestone ended and the granite began.

15792 } were taken in order along the base
15793 } from the place where the white marble was
15794 } exposed, to a place where there is unmis-
15795 } takable granite. The nature of the rocks
15796 } between 15792-15797 is uncertain without
15797 } microscopic study.

In passing up towards the top of the divide between the Little Cottonwood and Big Cottonwood, marble and limestone was found on the road in most places and granite on the left, the road sometimes being over one and sometimes over the other.

15798 Two phases of granite well up towards the
15799 top of the divide. The two phases are mingled in the most intimate fashion, fragments of 15798 being contained in 15799.

A little farther on limestone is found

on the right hand side of the road intensely metamorphosed

15800
15801
15802 represent 3 phases of this limestone taken within 50 feet of each other. The exposure is practically continuous between them and phases intermediate between those taken were seen.

In passing up towards the top of the divide a series of photographs were taken.

✓ Photo. 760/101. Looking north down into the valley of Silver Lake.

✓ Photos. 761/102 and 762/103. Looking south towards the top of the divide at the upper lakes; from point well up. The rocks in the foreground are granite.

✓ Photo. 763/104. Looking northwest down to the head waters of the Cottonwood. The rock on the left is the limestone.

15803 White marble
15804 Granite } were taken a little farther up the divide, the two being near each other and practically in contact. Here is the beginning of the main granite area.

Photo. 764 108. Looking north into Cottonwood Canyon from the top of the divide between the two Cottonwoods. The white rock capping the mountain is limestone; the remainder of the rock is granite.

The mass of the granite here contains so much white feldspar as to make its exposures at a distance almost as white as the limestone. This massive granite contains within it many rounded black bowlder-like areas which vary in size from those a fraction of an inch to those two or three feet in diameter. These larger ones run up into irregular large masses. Were one not familiar with these peculiar segregations of granite, they would undoubtedly be mistaken for rolled bowlders of a different material.

15805 is mostly from one of the black bowlder-like forms, although it has a scale of the ordinary white granite.

15806 contains two of the small black nodules.

The larger bowlder-like forms are here 6 feet or more in diameter, and the larger of these run into irregular masses included in the granite. The relations here combined with the relations shown by specimens 15 798-99 seem to me to indicate conclusively that the black parts are but segregations ~~of the~~ masses of a different rock which have been caught in the white granite and have been partly absorbed.

✓ Photos. 765 105 and 766 106. Represent two exposures of this granite containing the black bowlder-like forms. The larger of these is about six inches in diameter.

✓ Photo. 767 107 is an exposure of the same a little farther on.

✓ Photo. 768 109. Looking down into the head of Little Cottonwood Canyon, southwest from the top of the same divide.

✓ Photos 769 110, 770 111 and 771 112. Looking down the same canyon in the same direction, from

points respectively farther on in the canyon. 111 and 112 show the village of Alta.

15807 Gray limestone at Alta, taken to be near the base of the Wasatch limestone

15808 Quartzite just below Alta, probably Ogden quartzite.

15809 Slate, a little farther down. Either Ogden or Cambrian.

15810 Marble a little farther down. Taken to be the Ute limestone.

15811-12 Slate and conglomerate still lower down. almost certainly the Upper Cambrian. This conglomerate was found to contain numerous fragments of granite and quartzite as well as pebbles from the peculiar black areas found in the granite before described. These pebbles and bowlders are of very various sizes, some of the latter being a foot or more in diameter. The presence of these granite fragments

seems to be conclusive proof that the granite was in position and yielded bowlder fragments at the time of the formation of the Upper Cambrian.

a little farther on the Cambrian is
15 813-14 represented by quartzite.

✓ Photo. 772 113. Looking down canyon, standing a little below the village of Alta. The 3 layers of rock on the right represent, first, slate, 15809, lower Ogden?; 15810, marble, Ute limestone?; 15811-12-13-14 Cambrian slate, conglomerate and quartzite.

Photo 773 113A. A nearer view of the same

✓ Photo. 774 114. Looking up side of canyon — that is, north — towards the Ute limestone. This view is that contained in the middle part of 113. The white and gray layers are seen to alternate.

Although I did not pass up the side of the cliff, the transition from the limestone to the slate seemed to be a gradual one.

Photo 775 and 776 115 and 116. Represent the unconformity between the Archaean granite and the Cambrian slate, conglomerate and quartzite on the north side of the canyon. The camera is pointed up in 116. The granite is below, the Cambrian quartzite and conglomerate above.

Photo. 777 117. represents the same thing from a point farther down in the canyon, looking back up the canyon; that is, northeast.

This unconformity is one of the most beautiful that I have ever seen. The granite is heavily bedded and dipping at a high angle down the canyon, while the layers of the fragmental rocks resting upon them dip up the canyon at a low angle. This makes the dips of the two kinds of rocks almost perpendicular to each other.

✓ Photo. 778 118. Looking down the canyon from a point a little farther on. The most prominent granite mountain

seen is the same as that which is the most important thing in the picture in photographs 109-110-111-112.

✓ Photo. 779 119. A mountain rill, looking across canyon from some distance up the north side — that is, nearly south. This rill is in granite.

Photo 780 119A. another view of the same

The unconformity between the granite and the Cambrian quartzite, which was so beautifully seen just below the village of Alta, shows again far up the side of the canyon at some 3 or 4 miles below.

✓ Here Photo. 781 120 was taken. The granite below, the Cambrian quartzite above; looking nearly north.

✓ Photo. 787 121. The same granite mountain as in 118, looking diagonally across the canyon.

Photo 783 121A. The same a little farther on.

✓ Photo. 784 122. Looking out the Little Cottonwood Canyon. The first place

where one has a chance to see in the valley from the tramway; 4 or 5 miles up the canyon.

Phots. 785 123. Looking directly across the canyon — that is, south — at the mountain which has appeared in 118-109-110-111.

Photographs 114 - 123 inclusive are all taken from a tramway which runs along the north side of the canyon at a varying distance from its foot. Usually from 100 to 2 or 3 hundred feet up the side of the canyon.

15815 As soon as the main mass of the Little Cottonwood granite was struck, 15815 was taken. This granite is precisely like the granite found in going up the divide from Silver Lake. It is coarse and white, and contains, as did that, the numerous black bowlder-like forms. This identity of appearance, and particularly of the fact that these bowlders are so numerously contained in both masses, leave little doubt in my mind

that whatever the genesis of the granite, the Little Cottonwood mass and the Clayton Peak mass are of one and the same origin.

15816 is another specimen of the coarse granite taken at Ltasatch village, where quarrying is going on and the granite therefore particularly fresh.

So far as I could see, although I did not climb up the side of the cliff, the granite in structure is practically the same all the way down the canyon. It appears to be very heavily bedded in the cliff, but in the gigantic bowlders which have fallen down the side, show scarcely any trace of bedding. It, however, cleaves more readily in one direction than another, making it an easy stone to quarry, and this ready cleavage in one direction is supposed to conform to the apparent heavy bedding as seen on the wall. I could see no evidence of any change from a granite to a gneiss.

Upon nearing the foot of the canyon the granite somewhat abruptly terminates, and instead of the white granite we have a series of dark schistose rocks. These rest upon and over the granite in apparent unconformity. The point was, however, high up on the cliff and time did not permit a close examination.

Photos 786 and 787 124 and 125. Two views to show the relations of the schists and the granite at this point; looking northwest up and back in the canyon.

15817, 15818, 15819 } Three specimens taken from the talus slope and supposed to represent the schistose rocks at the foot of the canyon.

15820 was taken from a huge bowlder near the bottom of the canyon, and instead of representing these schistose rocks may possibly be from the Cambrian quartzite.

Photo. 788 126. Looking back — that is, east — towards the mouth of the Little Cottonwood, from the plain about a mile away from the mouth of the canyon.

Monday, August 26, 1889.
Trip up Mill Canyon.

15821 Coarse gneiss, readily cleavable. The first exposure of rock found in passing up Mill Creek, 8 miles north of Salt Lake City.

15822 Coarse grained quartz and feldspar from north side of canyon. This is taken to be a local thing, as the ordinary gneiss before seen at several points occurs on just the opposite side of the creek.

15823 Gneiss, about ½ mile farther up the creek.

15824 Coarse interlaminated gneiss and granite a little farther up the creek. The specimen shows the irregular way in which the gneiss is cut by the granite.

15825 Coarse micaceous gneiss still farther up the creek

A gneiss of this kind has been seen

interlaminated with the more evenly laminated and less foliated varieties shown by specimen 5821.

In passing up the canyon the granite becomes more and more prominent, until finally before the Cambrian is reached coarse white and red granite may be the great mass of the rock. So far as I could see the relations between the schists and granites are here what they are in the Archaean of the Lake Superior country; that is, they are mingled in the most intricate fashion and the passage from one to the other is gradual. In short, the relations are just what they would be if the schist existed before the granite and had been intruded by it. In the character of the coarse granite it resembles very closely the granitic core of the southern Black Hills. Also its relation to the schist are much the same. No photographs were taken of the relations of the schist and granite,

T. R.

see p. 38½

f 127. Mill Creek Canon Conglomerate, Cambrian on the right. Across ravine on the left is the granite

p 128 The plain of Great Salt

129. Lake looking down Mill Creek Canon

but they are mingled in the same intricate fashion as in the Weber Canyon.

Mill Creek has an easterly course, as is normal in the granite core, and passes into the Cambrian rocks in this direction. The Cambrian rocks and granite were not found in actual contact with each other, but on both sides of Mill Creek Canyon sharp ravines were seen running nearly north and south, on the east side of which is the Cambrian quartzite and conglomerate, and on the west side of which is the Archaean granites and schists. The quartzite and conglomerate was too heavily bedded to determine accurately strike and dip, but it appeared to strike nearly due north and south and to dip nearly vertical. This was determined by the layers of the rows of the pebbles, and there is little doubt in my mind but that this is the true strike and dip.

15826 Coarse foliated schist contained in the granite near where the Cambrian quartzite appears.

15827-28 Two phases of granite at the same locality. These specimens are taken from the finer grained phases. The coarser phases contain large areas of white quartz, some of them of a roundish form. These might readily be the source of the numerous white quartz pebbles which are found in the Cambrian quartzite.

15829 Coarse schist nearly like 15826. The rock which was found nearest to the Cambrian quartzite, it being lower down on the same hill-slope.

15830 Quartzite
15831 conglomerate
15832 } Three phases of the Cambrian taken in order in passing away from the granite within a distance of 200 paces.

Although carefully looked for, no unconformity was seen between the

Archaean schists at the lower part of Mill Creek Canyon and those higher up. They are all thoroughly crystalline schists, and the gneisses are banded and contorted, their dips changing rapidly within a short distance. While there may be such an unconformity as King describes it seems to me more probable that the discordance of which he speaks is due to the above cause rather than a true unconformity, for nowhere in the Archaean rocks is there any evidence, so far as I could see, of any fragmentals or anything upon which a lithological division could be made.

Wednesday, August 28, 1889.
Cascade to Needleton, Colorado.

In the middle of the afternoon, Cascade (on the Denver and Rio Grande Ry) was reached. The remainder of the ~~day~~ afternoon was spent in walking from Cascade to Needleton. The first place was supposed to lie within Endlich's metamorphic granite and the second near the junction line between this granite and his quartzite. The road from Cascade to Silverton follows the Rio Animas.

The rock at Cascade was found to be a coarse banded and contorted gneiss precisely like the fundamental complex of the Lake Superior country.

1589 33-34 Two phases of gneiss from this place. The gneiss is cut by numerous black bands of hornblende schist or gneiss which have dyke-like forms. These sometimes cut across the lamination and at other times are parallel to the

33 1/2

T. R.

Photo 789/127. Mill Creek Canyon conglomerate. Cambrian on the right. Across ravine on the left is the granite.

Photos 790/128 & 791/129. Looking down Mill Creek, from a point high up on the side of the canyon, over the Great Salt Lake plain.

same, just as in the Lake Superior region.

15835 Hornblende schist or gneiss, from one of the black dyke-like phases which cut 15833-34.

The gneiss continues of the same character for a long distance towards Needleton.

About a half mile from Cascade strike and dip were taken and found to be as follows: Strike, N. 30° E. magnetic; dip 85° SE.

Photo 797/130. The Needles; a group of high mountains apparently of white granite on the right of the road. Taken a little way east of Cascade, looking north of east.

✓ Photo. 793/131. The same, from a point on the Denver & Rio Grande a little farther on; looking almost due east.

✓ Photo. 794/132. A view of the course gneiss between Cascade and Needleton, cut by

granite veins of small size, and also containing the irregular masses of black hornblende schist above mentioned.

15836 Coarse gneiss. A fresh piece from a cut about 1½ miles from Cascade toward Needleton.

For some distance beyond this point the coarse gneiss is quite free from the black hornblende schist or gneiss. After a time, however, this rock again appears and increases rapidly in quantity. A little farther on it is as abundant as the coarse gneiss, the two rocks being interlaminated.

✓ Photo. 133 795 was here taken to represent this phase.

The strike is now N. 15° E. magnetic; dip 85° E. The dip is somewhat lower a little farther on.

Passing on, the black hornblende rock continues to increase in quantity until

(continued from page 36.)

| | |
|---|---|
| little veins of white quartz, and also veins of feldspar in places. Before Needleton is reached some of the white gneiss is again found, although not so coarse as to the west. | |
| 15839 Black gneiss } The two in contact<br>15840 White gneiss } and interlaminated.<br>Just west of Needleton. | |
| (continued page 37) | |
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it supplants the coarse white gneiss.

15837 Black hornblende gneiss was here taken.

✓ Photo. 796/134. The Needles again from a point farther on toward Needleton.

✓ Photo. 797/135. Looking toward south wall of canyon of Rio Animas from point a little farther on.

✓ Photo 798/135A. Looking east up the Animas.

15838 Black gneiss a little farther on. Strike N 15° E. magnetic; dip 80° E.

A little farther on the strike is N 30° E. magnetic and dip 70° W.

✓ Photo 799/136. Looking south across canyon of Animas, from the door of stopping place at Needleton. 6 P. M.

The coarse black gneiss continues from a point about half way between Cascade and Needleton to Needleton. For the most part it is practically free from any mixture of the white gneiss. However it contains

(see page 35 1/2)

Thursday, August 29, 1889.
From Needleton to Silverton, Colorado.

The day was spent in walking along the railroad between these two points.

Almost immediately upon leaving Needleton the white gneiss again becomes prominent, and a short time preponderates over the black phases. The black schist and coarse white gneiss are abundant for about two miles from Needleton, at which point the granite and coarse gneiss almost exclude the schist. This state of affairs continues for a long way.

15841-42 Two phases of the coarse gneiss and granite, about 2 1/2 miles from Needleton toward Silverton.

✓ Photo. 801/138. Coarse granite containing a schist in dyke-like form, about 2 1/8 miles beyond Needleton.

15843 Coarse gray granite 4 3/4 miles beyond

Needleton. This is the prevailing phase of rock for some distance.

15844 Reddish granite, farther on.

The almost solid granite represented by the above specimens, and composed of many phases not represented, continues to six miles from Needleton. It is so massive that no structure could be made out. The many phases are mingled in the most intricate fashion.

Shortly after passing the 6th mile post schist again appears, and shortly becomes predominant. As soon as an opportunity was obtained strike and dip was taken. Strike N. 80° E magnetic, and dip vertical.

About the 6th mile post quartzite bowlders were found mingled with those of the granite in the loose material of the Animas. In continuing toward Silverton these become more abundant.

By the time the 7th mile post from Needleton is reached the black horn-blende schist has become predominant. It contains white quartz veins just as in the vicinity of Needleton. The strike is here East and West, magnetic, and the dip 75° S.

15845 represents this phase of rock.

A little farther on, about 7¼ miles from Needleton, is the place where the change from the granite-schist area to the quartzite area is found. The contact of the two rocks was not found. As common between rocks of different character, a break occurs. This break at the narrowest place is about 25 steps. The quartzite, however, strikes in marked unconformity to the schist, being N. 50° E., magnetic. No proper dips could be taken in the quartzite as it is bent in fold after fold, the anticlinals and synclinals of which are horizontal, so that the average of the dips would be

about vertical.

15846 Coarse gneiss which in the granite schist area is nearest the quartzite.

15847
15848
15849
15850
} 4 phases of quartzite from the ledge nearest the granite-schist area. Some of these quartzites have a color similar to that to the coarse reddish and grayish gneisses; yet I think there is no doubt that chemical analyses and microscopic determinations will show a fundamental difference to exist between these quartzites and any of the granites, gneisses or schists. They will be found to be completely crystalline, while I have little doubt that the quartzite will be found to be a fragmental rock.

. Evidently there has been dynamic action since the formation of the quartzite, as shown by its sharp
15851 corrugations 15851, and this doubtless explains why the discordance in strike and dip between the quartzites and granite-schist area is not greater.

I suspect that Endlich's transition between the quartzites, the granites and schists is a mistake. He has perhaps thought the banded quartzite the same as the gneiss

His belief in the metamorphic granite is without doubt due in part to the fact of the intricate mixture of the granite, coarse gneisses, and fine-grained black hornblende schists or gneisses. He has assumed that these banded rocks are sedimentary, and that by a farther stage of alteration all structure is lost. What he says as to the sharp contrast between sedimentaries and granites probably only means the sharp contrast between hornblende-schists and coarse gneisses or granites. If this is the case, the statement is a true one, for specimens showing both kinds of these materials could be obtained at a hundred places along the Rio Animas.

At Elk Park the strike of the heavy

quartzite layers is N. 80° W; dip, 60° to 70° S. There is here a strong banding of the layers, hence the strike as above determined may be quite a distance from the truth, as it was taken from the apparent direction of the ends of the layers as seen at some distance.

15852 Quartzite. Just after leaving Elk Park. about 8½ miles from Needleton.

15853-54 Peculiar phases of quartzite abundantly found interlaminated with a quartzite like 14852. 9 miles from Needleton.

The strike of the laminae of the quartzite was taken a short distance beyond the 9th mile post, and was found to be, Strike N 45° E; dip, vertical. Heavy joints in the quartzite here and elsewhere run in a different direction, at a widely different angle from what I have taken as bedding. However, the rows of small pebbles & the layers of fine and coarse material appear to be parallel to the laminae, the strike & dip of which were

taken

15855-56 Conglomeratic quartzites. About 9¼ miles from Needleton.

The quartzite is here very crystalline, and becomes more so in passing along.

15857 Crystalline quartzite. About 9½ miles from Needleton.

Next to this quartzite is a short distance in which there is no rock.

15858 Then again appears 15858, granite,
15859 and 15859 crystalline schist, which are precisely like the crystalline schists and granite found in the morning before the quartzite was reached.

Here again there is not the slightest indication of a transition from one kind of rock to the other. The granite and schist have many phases, in fact, all the phases shown by the morning specimens, and more, because

these specimens by no means represent the numerous varieties of rock found in the granite and schist area.

Photo. 802 139. Looking up the Animas about northeast when within the schist area

Photo. 803 140. Schists cut by granite. about 10½ miles from Needleton. The strike is here N. 75° W, magnetic; dip, 35° to 40° N.

Photo. 804 141. The same exposure as 803 140 from another side. Looking east nearly parallel to the strike.

From the above point the dip of the schists is flatter for some distance, and about ½ mile farther on is not more than 10° or 15° to the east. However, after the 12th mile post is passed the schist is found to have a high dip, about 75°.

Photo. 805 142. A sill coming down the

side of the Animas canyon. About 2 miles south of Silverton; looking east.

From 10½ miles from Needleton to the 13th mile post the black schist and fine-grained evenly banded gneiss are predominant, although here and there are contained granite veins.

A little beyond the 13th mile post
15860 appears 15860, granite, which continues until Silverton is reached.

General.

From the foregoing it appears that in the 14½ miles between Needleton and Silverton there is, along the railroad, about 2¼ miles of quartzite, which run from about 7¼ to 9½ miles from Needleton, or for a little distance both north and south of Elk Park. The remainder of the distance is occupied by an intricate mingling of granite, gneiss and schist, which are contorted and thoroughly crystalline

—which have, in fact, all the lithological characteristics of the fundamental gneiss or oldest Archaean, which I cannot doubt this complex really is.

I saw absolutely no such thing as a transition between the schists, granitic rocks and the quartzites. How it happens that Endlich gives the whole valley of the Animas from Needleton to Silverton the color of quartzite is incomprehensible.

Friday, August 30, 1889.
From Silverton to Ouray, Colorado.

The distance from Silverton to Ironton was made on the Silverton Railway, and the distance from Ironton to Ouray, about 7 miles, was traveled on foot.

The eruptive rocks of late age appear at Silverton and cover the granites, schists, etc. This state of affairs continues to beyond Ironton.

A number of photographs were, however, taken on the way.

Photos. 806-807 143-144. Silverton and its surrounding mountains.

Photos. 808-815 145-152 inclusive. Views of scenery of eruptive rocks between Silverton and Ironton.

15861-6263 3 phases of recent eruptive rocks collected in the first 1½ miles on the foot journey from Ironton to Ouray.

The order is that given.

Emptive rocks continue for about 2 miles from Ironton toward Ouray, where first appears interstratified red quartzite and reddish and green slates, the strike of which is N. 75° W., magnetic, and dip 65° S.

15864 Rare were taken, 15864, red quartzite
15865 Reddish slate.
15866 Green slate.

The horizontally bedded emptives are yet seen on the tops of the cliffs of Red Mountain Creek Canyon. Near the base of the canyon the rocks represented by the above specimens continue for a short distance, being mostly green slate toward the last. Then
15867 appears white vitreous quartzite.

Photo. 816/153. View at the point where the change occurs between 15864-65-66 & 15867; looking down the gorge of Red Mountain Creek Canyon. The wagon road is seen

on the side of the gorge. The dark colored rock is the slate. The white in the center of the picture is the quartzite.

Heavy beds of quartzite continue for a long distance. At some distance on
15868 is taken 15868, a pink and gray phase of quartzite which is here more common than the white variety.

Photo. 817 154. Looking west across Red Mountain Creek Canyon at a sill showing the upturned edges of the quartzite, upon which rest horizontally the bedded eruptives.

Photos. 818 155-156. Unconformity between the quartzite and bedded eruptives; looking down — i. e., northeast — in Red Mountain Creek Canyon.

Photo. 819 157. Looking down Red Mountain Creek Canyon toward Ouray, a little farther on, about north.

The heavy beds of quartzite, after continuing a long way, contain a narrow

layer of a nearly white phase like 15867.
15869 They then become slaty and have a strike N. 80° W., magnetic & dip 75° N.

This dip in a reverse direction from that shown by the previous observations may but represent an overturn; or, again, it is not impossible that we have passed in the above distance the axis of an anticlinal.

In a short distance the slaty quartzite runs into 15870, green slate, which has a very considerable thickness. This slate appears at the point where Red Mountain Creek joins the Uncompahgre.

We thus have a repetition of the strata first encountered and in a reverse order, so that the suggestion of an anticlinal becomes more probable. If this is the case, its axes have been truncated before the outflows of horizontal lavas which cap the cliffs appeared. The thickness of strata must, however, be very considerable even if thus repeated.

The slate above mentioned passes into
15871 green slaty quartzite, and this into
15872 red quartzite. We have thus completed the cycle of layers from the point where the clastic rocks first appeared dipping south.

Following this red quartzite is quartzite like that seen in the middle of the supposed anticlinal. These layers, if they occur at the Ironton end of the series, would be found farther south than any that were exposed. The quartzite here has a lower dip than before, about 45° N.

15873 represents this white quartzite.

15874-75 Two phases of slate, the next kind of rock found continuing toward Ouray.

Then again appears white quartzite. The dip still continues to the north, the angle gradually becoming lower.

The white quartzite just mentioned

15876 after a time runs into the white gray
15877 quartzite, and 15877 conglomerate containing red jasper pebbles. These pebbles give an excellent chance to determine Strike and dip: Strike N 65° E; dip 60° N.

From this point the slightly upturned edges of the red beds, supposed to be the Jura-Trias, are seen on looking toward Ouray, resting in apparent unconformity upon the upturned edges of the slate.

Photos 820 821 158-159 were here taken, looking down the canyon of the Uncompahgre. The horizontal beds are a deep reddish-brown. The slates below these dip at a high angle, 80° N.

15878 Slate is next found, and after an
15879-80 interval appear coarse quartzite and conglomerate. The conglomerate in places contains pebbles as much as an inch in diameter.

After some thickness of quartzite and conglomerate again appears slate;

then again quartzite.

By this time we are abreast the beds of the Jura-Trias, and they are seen to rest horizontally upon the upturned slates and quartzites, which here dip north at a angle from 60° to 70°.

Photo. 822/160 Shows this unconformity. Looking west toward the sun across the canyon. The Jura-Trias on the right, the slates and quartzites on the left.

This unconformity is one of the handsomest instances of its kind that I have seen. The layers of Jura-Trias cap the steeply inclined rocks in the foreground. Off to the right, north across a gulch, they come much lower down, but no slates and quartzites are seen. Above both the Jura and slates and quartzites on the left--south--gray eruptive rocks are seen running into high peaks.

a little farther on the strike of the quartzite and slate formation was taken and was found to be; Strike N 80° W., and dip nearly vertical.

15881 Peculiar rock found in quartzite area some distance back

after the last exposure of quartzite is passed, but separated from it by
15882 only a short interval, is 15882, cherty limestone and chert breccia. This latter is taken to belong to the Carboniferous. Its structural relations to the slates and quartzites and to the red beds could not be made out, as it is a detached exposure so massive as not to show its structure.