# MOUNT WHITNEY AS A SITE FOR A METEOROLOGICAL OBSERVATORY.

By ALEXANDER G. McADIE, PROFESSOR OF METEOROLOGY.

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In reply to a letter dated June 15, 1903, from the Chief of the Weather Bureau, asking for a report on the advantages and disadvantages of Mt. Whitney as a site for a meteorological observatory in connection with the proposed astrophysical observatory, the accompanying notes based on observations made during a hasty trip to the summit in July, 1903, in company with the Sierra Club of San Francisco were submitted.

*Accessibility*. - Mt. Whitney is situated in latitude 36° 34' 33" north, and longitude 118° 17' 32" west. It may be reached in several ways.

I. From Lone Pine on the Carson and Colorado Railroad, along the county roads to Carroll Creek, up zigzags of a trail, across Cottonwood Creek to Horseshoe Meadow, a climb of nearly 5,000 feet in ten miles, and thence by trail to Volcano Mountain.

II. By trail from the Kern River, at its southern end, working north along the Kern River to the East Fork, thence south to Crabtree Meadow, thence to Langley's Camp on the eastern side of Mt. Whitney, 2,800 feet below the summit.

III. From the northern end of Kern River, working south to East Fork, thence as in II.

The trails on the western side of the mountain are not steep, nor especially difficult and dangerous. A good climber can go from Langley's Camp to the summit in less than four hours.

On the top of the mountain, or peak, is a flat of several acres. On the extreme eastern edge a small monument of rocks has been erected. The eastern side of the peak is

precipitous, a sheer fall of about 6,000 feet sharply marking the mountain. About 11,000 feet below the summit lies the valley of Owens River, with Owens Lake to the southeast. On a clear, quiet day Lone Pine, almost directly east of Mt. Whitney, and distant about fifteen miles, can be seen. Independence, lying to the north-northeast, is hidden by a ridge. Between Independence and Lone Pine six streams flow to the east. The most important of these is Lone Pine Creek, which flows down from Mt. Whitney. According to the report of Mr. Charles C. Garrett, Observer at Independence, Cal., dated June 17, 1903, the quantity of water in this creek is as follows: -

" The flow of the stream varies very much in different years. Measurements taken two days ago at my request showed a flow of 660 miners' inches. The water is now at its highest point, and this is regarded as an average year. It is probable that at the time of lowest water not more than 8o inches flow. Measurements were taken in the months of October and December, 1893, for testimony in a water suit, and flows of 195 and 16o inches, respectively, were found. The principal owner of the waters of Little Pine Creek informs me that, in his opinion, the average flow of the stream for an average year is about 300 miners' inches."

On the eastern side of the mountain there are at least four lakes within three miles. There is a splendid supply of good water at Langley's Camp. Mt. Whitney is in the Mt. Whitney Military Reservation, and I am under the impression that one of the reasons urged in establishing the reservation was the desire to retain it for use as a station for scientific research.

The peculiar character of Mt. Whitney renders it a good site for meteorological work, inasmuch as comparisons can be made of the conditions in the free air over a confined and heated valley and the conditions existing on the westward slope of the Sierra, or plateau conditions. While we were on the summit a lady's veil was thrown over the eastern edge, and, although the temperature was but 53°, it was plain that there were high temperatures and strong ascensional currents on the eastern side of the mountain. The course of the veil was such as to suggest that with regard to the general flow of the air from west to east the mountain acts as a dam, or weir.

It is probable that for the greater portion of the year the peak is accessible. The average precipitation in this section is not very large. Snow remains in the crevasses until August or September. At the time of our ascent, July 8, 1903, we passed across one crevasse, which, however, could have been avoided by making a detour south of the gully. I do not know that the peak has ever been ascended in winter, but I believe there might be periods when this would be possible. No one of the other high mountains on the Pacific Slope, such as Shasta or Rainier, is so easy to climb as Mt. Whitney. Owing to the fact that the two peaks mentioned lie farther north and in the track of atmospheric disturbances, climbing is almost out of the question in winter, and hazardous even in summer. Mt. Whitney, therefore, of all the extremely high peaks on the Pacific Coast, is probably most suitable for a meteorological observatory.

All materials would have to be carried up by packtrain. I made some inquiry as to prices for this work, but could obtain no trustworthy estimates.

*The Elevation of Mt. Whitney*. - As will be seen below, few mountain elevations have been discussed more carefully than that of Mt. Whitney. Some barometric observations were made on our trip, although it was a hasty one and not altogether favorable for such work. Fortunately the weather conditions were very favorable. The greatest care was taken by Professor J. N. Le Conte and myself to read carefully, and

independently of each other, the heights of the mercurial column. Our chief purpose was to correct the prevailing estimate of the height of Mt. Whitney - viz., 14,900 feet, an elevation given on most of the maps in use in California.

Gannett, in his "Dictionary of Altitudes in the United States" (third edition, 1899), gives an elevation of 14,898 feet, and this we believe to be erroneous. The authority given is Whitney, but I am unable to ascertain if Professor Whitney made the ascent and measurement, or, as chief of the Geological Survey of California, used the measurement made by Carl Rabe for the survey. This latter was the first measurement of Mt. Whitney. His readings, as marked on the case of the mountain mercurial barometer (Green No. 1554) used by him, are 17.836 inches, 32°; 17.848 inches, 42°.

The elevation deduced from the above readings was 14.898 feet, or exactly the same as the figures given by Gannett. This elevation, however, does not seem to be in accord with the readings, and if the altitude is determined on the assumption that the correction applied to the barometer was the same as applied in our observations (a doubtful assumption, it is true), the elevation would be about 13,701 feet, the sea-level pressure on that date being 30.01 inches at the given hour, the value of the mean temperature being 37.5° F., and the corrected reading at Mt. Whitney being 17.915 inches.

Two mercurial barometers were carried from San Francisco to Mt. Whitney summit and read at half-hourly intervals by Professor J. N. Le Conte, University of California, and myself. One of the barometers was the same instrument used by Rabe (Green No. 1554). Our readings on the summit were as follows: -

SUMMIT OF MT. WHITNEY, JULY 8, 1903. OBSERVERS: J. N. LE CONTE AND A. G. McADIE.

| Pacific Time | Green, No. 1554 | | Green, No 1664 | |
|---|---|---|---|---|
| | Barometer | Attached thermometer | Barometer | Attached thermometer |
| | *Inches* | *°F* | *Inches* | *°F* |
| 9:30 a.m. | 17.630 | 51 | 17.652 | 54 |
| 10:00 a.m. | 17.638 | 51 | 17.652 | 55 |
| 10:30 a.m. | 17.646 | 55 | 17.660 | 55 |
| 11:00 a.m. | 17.650 | 55 | 17.660 | 54 |
| 11:30 a.m | 17.650 | 50 | 17.667 | 52 |
| 12:00 noon | 17.650 | 49 | 17.668 | 51 |
| 12:30 p.m. | 17.652 | 48 | 16.674 | 54 |
| 1:00 p.m. | 17.654 | 49.5 | 17.674 | 53 |
| | 17.646 | 51.7 | 16.663 | |
| | -0.036* | | -0.041* | |
| | 17.610 | | 17.622 | |
| | +0.088** | | +0.068** | |
| | 17.698 | | 16.690 | |

*Reduction to standard temperature.

**Sum total of the probable instrumental error, scale correction, capillarity, and gravity corrections for latitude 37° and for altitude 15,000 feet.

The mean of our pressure-readings on the summit was 17.690 inches, while the mean of the Langley readings was 17.588 inches. There are only four of the series by

Langley which were taken at hours comparable with ours, - namely, September 4, 8 :30 A.M.; September 5, 12 :40 P.M.; September 6, 8 :17 A.M.; and September 6, 9 A.M. The mean of these corrected and reduced is 17.6og inches. The difference, therefore, is but 0.081 of an inch. The temperatures also agree fairly well.

Professor Langley gives the elevation of Mt. Whitney as 14,522 feet, or 10,762 feet above his base-station at Lone Pine.

We found deposited on the summit a record of an ascent made on August 23, 1902, by Professors Kellogg, Hallock, Putnam, and others, in which it is stated that the temperature was then 34 ° F., and the boiling-point, as determined by William Hallock, 186.4 ° F. It is interesting to note that the pressure corresponding to this boiling-point would be 17.58 inches.

On October 8, 1895, Hutchings and others ascended the mountain and reported that water boiled at 187° F.

*Wheeler's Determinations*. - Wheeler gives as the height determined by the adopted mean of barometric observations made by the observers of his survey party of 1875, 14,471 feet. The mean of three readings, at half-hour intervals, on September 24, 1875, after being corrected and reduced, was 17.796 inches; temperature, 35.3°; wet-bulb reading, 29.0°. A similar mean for October 13, 1875, was 17.840 inches; temperature, 36.7°; wet-bulb reading, 32.2°. The corrections applied are not accessible, but the records are probably in the office of the Chief of Engineers, U. S. Army.

" It is," says Wheeler, "the highest point measured by careful barometric observations within the territory of the United States, except Alaska."

The record of the observations made by Rabe in 1873, with the barometer, Green No. 1554, is as follows: -

| Barometer | Attached thermometer |
|---|---|
| *Inches* | *°F* |
| 17,836 | 33 |
| 17.848 | 42 |
| 17.842 | 38 |
| -0.015* | |
| 17.827 | |

*Reduction to standard temperature.

These readings, corrected for temperature only, differ from the values obtained by us, by +0.217 inches. The difference from the readings of the other barometer (Green No. 1664) was +0.205 inches.

It will be noticed that in the readings made in 1903 there is a decrease in temperature during the observations, as shown by both attached thermometers, and moreover the temperatures themselves are not similar. Barometer No. 1554 is a small mountain barometer with a scale reading from twenty-four to eleven inches. Barometer No. 1664 has a scale reading from thirty-three to fourteen inches. Both instruments were filled with clean mercury June 23, 1903, and the longer instrument carefully read and

compared with station barometer No. 387 in the Weather Bureau office at San Francisco. Its mean correction was + 0.068 inches. It may be ques-tioned whether this correction properly applies to readings at high elevation, but for the present we will assume that it does so.

We must consider next the various simultaneous base readings.

| Hour (Pacific Time) | Mount Whitney | Independence Elevation 3910 feet | Mount Tamalpais Elevation 2375 feet | San Francisco Elevation 155 feet |
|---|---|---|---|---|
| 10 a.m. | 17.680 | 25.965 | 27.55 | 29.90 |
| 11 a.m. | 17.689 | 25.953 | 27.56 | 29.89 |
| 12 noon | 17.701 | 25.936 | 27.56 | 29.88 |
| 1 p.m. | 17.704 | 25.919 | 27.56 | 29.86 |

The above are the so-called station-pressures, that is, the observed readings corrected for temperature, scale correction, capillarity, and gravity. Independence is the Weather Bureau station nearest to Mt. Whitney, and the observations were made at that point by Mr. Charles C. Garrett.

The sea-level pressures at Independence and at San Francisco were as follows: -

| Hour | Independence | San Francisco |
|---|---|---|
| 10 a.m. | 29.88 | 30.06 |
| 11 a.m. | 29.86 | 30.05 |
| 12 noon | 29.85 | 30.04 |
| 1 p.m. | 29.82 | 30.02 |
| Mean | 29.85 | 30.04 |

The observations at San Francisco and at Mt. Whitney are probably the most satisfactory of all, and these we shall proceed to use in determining the true elevation.

Professor Bigelow's modification of the Laplacian equation, as given on page 490, equation 6o, of his "Report on International Cloud Observations," (Vol. II of the Report of the Chief of the United States Weather Bureau, 1898-99), or equation 52, p. 66, of his "Report on the Barometry of the United States," etc., (Annual Report of the Chief of the United States Weather Bureau, 1900-1901, Vol. II), is as follows: -

$$h - h_o = (56517 + 123.3\Theta + 0.003h)$$
$$\left(1 + 0.378\frac{e}{B}\right)(1 + 0.0026\cos 2\phi)\log\frac{B_0}{B}.$$

Using the values for 10 A.M. July 8, $B_o$ – 30.06 inches, as at San Francisco, $B$ = 17.680 inches, as on Mt. Whitey, and a mean temperature $\Theta$ = 53°, we obtain

$$\log B_0 = \log B + \frac{h - h_o}{56517 + 123.3\,(53) + 0.003\,h}\left(1 - \beta\right)\left(1 - \gamma\right),$$

Whence $h$ = 63096 x 0.230507 = 14,515 feet.

*Previous Determinations of Altitude*. - On page 201 of his "Researches on Solar Heat" (Professional Paper of the Signal Service No. 15), Professor Langley gives what is

probably the best series of observations as yet made on Mt. Whitney. The observers were Mr. E. 0. Michaelis, Mr. J. J. Nanry, and Mr. J. E. Keeler.

The readings given in Table 173 of his work are as follows: -

*Prof. Abbe having kindly pointed out that I had not made full use of the Independence readings, I give herewith the following values: 10 A.M., 14,441 feet; 11 A.M., 14,414 feet; noon, 14,378 feet; 1 P.M., 14,355 feet, which, as the editor remarks, are to he considered as only a portion of a continuous 24-hour series. Having also seen Mr. Heiskell's computations, I would add that the values 14,530 and 14,532 obtained by him by using the Bigelow tables agree with the values obtained above in which the value of $\theta$ was 53°, or a degree less than that used by him. Recomputing the elevation, but using a temperature of 54° and sea-level pressure of 30.o6, my computation gives 14,572. The sea-level pressure used by Mr. Heiskell was 30.04 inches and the station-pressures 17.694, which, according to the method of computation used above, would give an elevation of 14,534 feet - A.M., November 20, 1903.

READING OF BAROMETER NO. 2018, SIGNAL SERVICE, ON THE SUMMIT OF MT. WHITNEY

| Date | Time | Reading | Attached Thermometer | Reading |
|---|---|---|---|---|
| 1881 | | *Inches* | *°F* | *Inches* |
| September 2 | 6:00 p.m. | 17.600 | 30.0 | 17.599 |
| 2 | 9:00 p.m. | 17,597 | 26.5 | 17.603 |
| 2 | 12 midn't | 17,569 | 25.5 | 17.576 |
| 3 | 3:00 a.m. | 17.529 | 22.5 | 17.540 |
| 3 | 6:00 a.m. | 17.518 | 22.5 | 17.529 |
| 3 | 8:15 p.m. | 17.514 | 28.2 | 17.516 |
| 4 | 8:30 a.m. | 17.627 | 52.8 | 17.591 |
| 5 | 12:40 p.m. | 17.600 | 62.5 | 17.546 |
| 5 | 5:07 p.m. | 17.680 | 61.5 | 17.628 |
| 5 | 6:30 p.m. | 17.640 | 42.0 | 17.622 |
| 5 | 8:20 p.m. | 17.599 | 38.0 | 17.588 |
| 5 | 10:22 p.m. | 17.558 | 32.0 | 17.555 |
| 5 | 12 midn't | 17.558 | 31.5 | 17.555 |
| 6 | 1:00 a.m. | 17.610 | 30.0 | 17.610 |
| 6 | 3:00 a.m. | 17.610 | 30.0 | 17.610 |
| 6 | 5:00 a.m. | 16.610 | 28.0 | 17.613 |
| 6 | 8:17 a.m. | 17.692 | 52.0 | 17.657 |
| 6 | 9:00 a.m. | 17.680 | 54.4 | 17.640 |

Professor J. N. Le Conte, on July 8, 1903, made measurements of the height by angles of elevation and depression between Old Camp Independence, Lone Pine, and the Peak and return, and obtained a result of 14,470 feet.

*Historical Notes:* - The mountain was first seen from Mt. Brewer by members of the Geological Survey of California, Brewer, King, and others, in 1864, and named Mt. Whitney. On August 18, 1873, John Lucas, C. D. Bigole, and A. H. Johnson, climbed the peak and called it Fisherman's Peak. On September 1, 1873, Clarence King, then in New York, learned that the peak which he had climbed in 1871, now known as Sheep Mountain, Old Mt. Whitney, and Mt. Corcoran (Bierstadt), lying to the south of Whitney, was not Mt. Whitney, and hastening West climbed the right peak September 19, 1873. On September 6, 1873, the mountain was climbed by Carl Rabe, and the first mercurial barometer (Green, No. 1554) carried to the summit. Professor Langley's expedition is,

well known. He reached Lone Pine on July 24, 1881, and left on September 10th by way of Lone Pine Canon. The journey, in brief, is described in pages 36 to 44, Professional Paper No. 15, Signal Service, published in 1884.

I cannot do better than quote Professor Langley's statement, given on page 44 :-

" I do not think the Italian Government, in its observatory on Ætna, the French in that of Puy de Dome, or any other nation at any other occupied station, has a finer site for such a purpose than the United States possesses in Whitney and its neighboring peaks; and it is most earnestly to be hoped that something more than a mere ordinary meteorological station will be finally erected here and that the almost unequaled advantages of this site will be developed by the Government."

Smithsonian Institution Photo

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## COMPUTATION OF THE ALTITUDE OF MT. WHITNEY.

(A report by Mr. H. L. HEISKELL to Prof. F. H. BIGELOW, dated Oct. 21 1903.)

Relative to the observations made on Mt. Whitney, Cal., by Professor McAdie on July 8, 1903, at 10 A.M., 11 A.M., noon, and 1 P.M., and used by him in connection with simultaneous observations taken at Independence, San Francisco, and Mt. Tamalpais, to determine the height of the summit, I find that the observations are too few, and taken at a bad time of the day, to give any very accurate results.

Three essential elements must be considered in barometric hypsometry: temperature, pressure, and vapor-pressure, and the observations should be taken at different times of the day and on different days, so as to obtain a true mean; an error of one degree in mean temperature causes an error of twenty feet in the height of Mt. Whitney; an error of .001 of an inch in pressure causes an error of one foot in the computed height. In these observations the attached thermometer is read for temperature

and there are no hygrometric observations; then again the temperature at Independence, etc., was taken from the thermograph, so that a possible error of from one hundred to two hundred feet is not improbable.

From the data available, using your formula in your Barometry Report, I make the height of Mt. Whitney as follows:

| By using the simultaneous observations taken by the observer at Independence and by Professor McAdie at Mt. Whitney, the elevation is | Feet |
|---|---|
| San Francisco and Mt. Whitney | 14,651 |
| Mt. Tamalpais and Mt. Whitney | 14,532 |
| | 14,618 |
| Mean | 14,600 |

If we reduce the observations at Independence, San Francisco, and Mt. Tamalpais to sea-level, and then compute to Mt. Whitney, we have –

| | Feet |
|---|---|
| Independence and Mt. Whtiney | 14,590 |
| San Francisco and Mt. Whitney | 14,532 |
| Mt. Tamalpais and Mt. Whitney | 14,595 |
| Mean | 14,572 |

or a difference of twenty-eight feet from the preceding.

Professor McAdie, using observations taken at San Francisco only calculates the height at 14, 515.

On September 2, 3, 4, 5, 6, 1881, Professor Langley had a very accurate and careful series of eighteen simultaneous observations taken at Lone Pine and Mt. Whitney and published in his "Researches on Solar Heat." His barometers were carefully compared, and his temperature and hygrometer observations were made by ex-perienced observers, so that the accuracy of the work can hardly be questioned. In 1900 Mr. Gannett deduced from railroad-levels the elevation of Lone Pine at 3,661 feet above sea-level, but in 1881 the height of Lone Pine was given by Mr. George Davidson to Professor Langley as 3,76o feet, or nearly 100 feet higher. The means of eighteen simultaneous observations at the two points are as follows: -

| LONE PINE | MT. WHITNEY |
|---|---|
| Pressure …….26.018 | Pressure……..17.586 |
| Temperature……69.57 | Temperature……37.20 |

Using the height of Lone Pine, as given by Mr. Gannett in 1900 (3,661 feet), and the barometric observations of Professor Langley, I make the height of Mt. Whitney 14,423.

Professor Langley, in his report, using 3,883 feet for Lone Pine and his own barometric work, says Mt. Whitney, by barometer observations, is 14,625.

Professor Langley, by using Davidson's altitude (3,76o feet) for Lone Pine and barometer observations at Mt. Whitney, makes the height 14,522.

On August 17 to September 7, 1881, Professor Langley had sixteen simultaneous observations taken at Lone Pine and Mountain Camp to determine the height of the camp. To see how we agree on that height I herewith give the data: Using Davidson's height of Lone Pine (3,760 feet), the height of Mountain Camp is 11,624; using Gannett's height of Lone Pine (3,661 feet), Mountain Camp is 11,525. Professor Langley makes Mountain Camp 11,625.

From the above, I should say that the approximate heights are: Lone Pine (Gannett), 3,661; Mountain Camp (Gannett and Langley), reduced by me, 11,525; Mt. Whitney (Gannett and Langley), reduced by me, 14,423.

I should, therefore, suggest that the adopted height of Mt. Whitney be about 14,423 feet, as determined by using Professor Langley's observations and Professor Gannett's height in 1900 for Lone Pine.

(Photo courtesy of tr0mbley on flickr)

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## COMPUTATION OF THE ALTITUDE OF MT. WHITNEY.

Under date of January II, 1904, Professor Joseph N. Le Conte, of the University of California, says: -

" The Lone Pine railroad station is on the main line of the Carson and Colorado Railroad, and is on the eastern side of Owens River, close to the base of the Inyo Range. The town of Lone Pine is on the western side of the valley and on the western side of the river also. The distance between the two points is about three miles, and the railroad station bears about north 60 degrees east of the town. I visited the railroad station last September and spent some time with Mr. McGrath, the division superintendent. His memory of the altitude of the rail at the station, namely, 3,658 feet, was afterward corroborated in a letter from him to me after consulting the records of the survey at Carson City, Nev. Mr. Henry Gannett gives the same number in his " Dictionary of Altitudes," evidently obtained from the same source. This, however, is not the altitude of the point occupied by Professor Langley in his determination of the height of Mt. Whitney. There has never, to my knowledge, been a line of levels run between the two places, and the only determination of the height of the town that I have ever found is the one given by Captain Wheeler-namely, 3,810 feet; this, however, is barometric.

" There is a ' railroad tangent' at Lone Pine station over twenty miles long. It is absolutely straight and nearly level. It would be easy to measure off a base line four or five miles long, and arrive at a good measure of the elevation of the mountain; this might be still further improved by simultaneous angles observed from the mountain and the station. Such a measurement would depend on the elevation of the rail, of course, but this I think can be checked up. A survey has been run from this point to Mojave on the line of the Southern Pacific near Los Angeles. If the results of this latter survey could be obtained, we would know better how much reliance to put on the figures 3,658. It has long been a desire of mine to make this triangulation, for the angle of elevation is over 6° and the distance fifteen miles only. But I could not put very much faith on the levels over 550 miles of such rough country."

Under date of January 16, 1904, the Director of the United States Geological Survey, says: -

" Regarding the relative elevation of the railway station near Lone Pine, Cal., and the barometric station in that town occupied by Professor Langley, the only information that I have been able to get is to the effect that the difference in elevation is slight, probably not exceeding ten feet, the site of the town being the higher.

" More to the purpose, however, is the fact that this office has run a line of levels from the sea through the San Joaquin Valley, and up the south fork of the Kaweah River to Farewell Gap, thence connecting by vertical angles with the summit of Mt. Whitney, obtaining, as a result, 14,434 feet. I do not consider this result as conclusive, inasmuch as the last link in the chain consists of a single vertical angle at a distance of thirty-four miles."