

## LEVELING UP MOUNT WHITNEY

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MOUNT WHITNEY, in California, is, as far as I know, the only one of our very high mountain-peaks whose elevation has been determined by first-order (or what is sometimes known as *precise*) leveling. This work, which involved leveling to the summit of the mountain from Lone Pine on the railroad in Owens Valley, was done by engineers of the U. S. Coast and Geodetic Survey in 1925 and 1928.

The elevation of Mount Whitney, as thus determined, is found to be 14,495.811 feet above mean sea-level. As there is an uncertainty of one or two tenths of a foot, it is suggested that 14,496 feet be used as the elevation of the mountain.

This elevation is based on an adjustment of 2340 miles of levels in southern California and western Arizona. These levels are based on mean sea-level, as determined by observations at the tidal stations at San Francisco, San Pedro, and San Diego. From this adjustment the elevation of a bench-mark at Mohave was determined. From this bench-mark, elevations were computed along the line extending from Mohave northward through Owens Valley. This line of levels of the U. S. Coast and Geodetic Survey agrees very closely with the leveling run by the U. S. Geological Survey and by the Los Angeles Aqueduct. The line of levels of the Coast and Geodetic Survey north of Mohave furnishes the elevation of a bench-mark at Lone Pine, in Owens Valley, from which the leveling up Mount Whitney was extended. The elevation of the bench-mark in Lone Pine is 3726.042 feet, and the difference between it and the summit of Mount Whitney is 10,769.769 feet. The summit is indicated by a tablet set in the rock.

The determination of the elevation of Mount Whitney by first-order leveling is part of the coöperative work of the Coast and Geodetic Survey and the Committee on Seismology of the Carnegie Institution of Washington. The purpose of the work is to lay the foundation for the detection of vertical and horizontal movements

of points on the earth's surface between earthquakes, and also to determine the amount of movement that may occur during any one earthquake. Some time in the future the Mount Whitney leveling will, no doubt, be repeated, in order that we may learn whether or not that great mountain mass is rising or sinking.

First-order leveling is executed with instruments and rods of the highest type, and the average correction to a line of levels necessary to close a circuit is about .1 mm. per kilometer, or .006 inch per mile. This gives a clear idea of the extreme accuracy with which the first-order leveling is done.

To Mr. Lansing G. Simmons, an engineer of the Coast and Geodetic Survey, was assigned the task of running the line of levels to the top of the mountain in the summer of 1925. He went to Lone Pine early in August, and by the 10th of the month the party was organized, camp equipment and food purchased, and everything was in readiness to be packed into the mountains. Simmons decided that it would be best to start the work at the summit and proceed downward to the valley, in order that he might avoid the early snows which come on the high peaks. In his report on the work, Simmons made the following statement:

"Contrary to the opinion of the Washington office, the trail to the Whitney summit had been destroyed by slides, and animals had not been taken even as far as Whitney Pass for several years. After interviewing the local packers, it was decided to pack the outfit over the divide of the Sierras at Army Pass, about 10 miles south of Whitney Peak, and approach the peak from Crabtree Meadows. By using this route, the back packing was cut down to a minimum.

"By August 14th the entire equipment had been taken up as far as the animals could go, an elevation of about 3000 feet remaining to be back-packed in order to put the equipment at the initial camp from where the line was to be started at the summit. It took eight men three days to pack enough stuff up to the initial camp, which was at the divide of the Sierras about one mile south of the Whitney peak and at an elevation of about 14,000 feet, to begin operations. Some of the men suffered severely from the effects of the altitude but all became more or less acclimated after a few days. The only water was melted snow and the only fire was from a gasoline stove, as the camp was about 2500 feet above the timber line. Army pup tents were used for shelter.

"After about a week's leveling at the summit, in which time the strip between the summit and a permanent benchmark near the initial camp was completed, attempt at further progress was abandoned. The high winds, freezing temperatures, snow and sleet storms, and the fact that the camp would have to be moved along on our backs until we had reached Lone Pine Lakes at the foot of Whitney Pass, proved conclusively that that stretch of the work could never have been completed before real severe weather set in. Accordingly, the outfit was taken on our backs over Whitney Pass and down to Lone Pine Lakes, where it was packed on animals into Lone Pine. Camp was then established at Lone Pine."

When Simmons telegraphed the condition of the trail and of the weather, he was directed to descend the mountain to the vicinity of Hunter's Camp, at an elevation of approximately 8400 feet, and run a line from there to Lone Pine. It was contemplated that the leveling from that elevation to the summit of the mountain would be run during another season after the trail had been opened.

Simmons and his men undoubtedly endured many hardships resulting from the strenuous work involved in climbing the peak and in carrying equipment, food, etc. A young engineer who, apparently, had the spirit of an explorer, as is indicated by the fact that he passed the civil-service examination and entered the Coast and Geodetic Survey early in August, 1925, reported to Simmons at his initial camp near the summit of Mount Whitney on August 20th. He resigned from the survey a week or two later, after the party had been operating at high altitudes in strong winds, freezing temperatures, and snow and sleet storms. The rest of the party seem to have been made of sterner stuff, for they continued leveling on the lower ridges of the Sierra Nevada and along the railroad running through Owens Valley.

The completion of the leveling was delayed until the early summer of 1928, hoping that the trail would be opened to the summit of Mount Whitney by the Forest Service or by the people living in Owens Valley near the foot of the mountain. This, however, did not occur; so in the spring of 1928 Mr. J. H. Brittain, a young engineer of the Coast and Geodetic Survey, who had had much experience in mountainous regions in connection with the geodetic work of that bureau, was directed to proceed to Lone Pine, organize a leveling

party, and finish the leveling. He was also authorized to use his personnel to open the trail to the summit, in order that camp equipment, food, etc., could be carried by horses to the summit.

Brittain made his first camp at an elevation of 10,400 feet, and the leveling was done from that point between the elevations 8370 and 11,500 feet. He reported that one day was spent in clearing the trail to the latter height. Camp was next moved to an elevation of 12,000 feet, the packing being done by the men for the last 500 feet, because snow-drifts blocked the trail, making it impossible for horses to go over it. From the 12,000-foot camp the leveling was completed to the summit, as it was impracticable to camp above that elevation. Pack-mules were hired in Lone Pine, and were used continuously in transporting food and other supplies from the town up to the first camp and, later, to the point on the trail just below the second camp. Tents were used as shelter for the members of the party. At the second, or higher, camp gasoline stoves were used for cooking and heating the tents, as the camp was a thousand feet above timber-line and fuel was not available except by packing it up the mountain. Brittain reported that much assistance was rendered him by members of the Forest Service and by Mr. G. W. Dow, proprietor of the Lone Pine Lumber Company, in organizing the party, and also preparing for the leveling up Mount Whitney. The local information furnished Brittain undoubtedly helped him to plan his work to the best advantage.

Letters received from Brittain during and just after the completions of the work up Mount Whitney indicated that the party was not hampered by bad weather conditions, although at night the temperature was quite low and the men had some difficulty in keeping warm. Pictures accompanying his report indicate that the trail was exceedingly rugged and the leveling very arduous. The officials of the Coast and Geodetic Survey in Washington expected Brittain to be engaged on the work for considerably more than a month, but in his report he stated that "the leveling started June 2 and was completed June 24th, 18 days were spent in leveling." This was about half the time that the office expected would be spent on the work. One of his letters reported that the party was "about all in" when the work was finished and the men got down to Lone Pine. It can easily be imagined that a day's work was quite strenuous, since the rough trail had to be climbed a maximum distance of about 2500

feet in the morning and descended a like amount in the late afternoon after the day's work had been done. In addition to the technical skill and executive ability exhibited by Mr. Brittain, another reason for the prompt execution of the work is shown by the following sentence from his final report on the Mount Whitney leveling: "The progress of the party was materially aided by the general efficiency and the interest taken in the work by the entire party."

The officials at Washington were very much surprised to receive a telegram on June 25th from Brittain stating that the work had been completed, but the explanation of this very rapid progress was only learned later on, when announcements were received of Brittain's marriage to a very charming young lady a few days after the completion of the work. Officials at the Washington office are wondering if it would not be well to send only engaged men on the most arduous and difficult pieces of work.