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A TRIP TO THE SUMMIT OF ORIZABA

By W. A. COGSHALL

THE ALTITUDES OF ORIZABA AND
POPOCATEPETL
EFFECTS OF HIGH-MOUNTAIN
CLIMBING

By A. E. DOUGLASS

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Plate LV.



ORIZABA.

A Trip to the Summit of Orizaba.

BY W. A. COGSHALL.

Read October 20, 1897.

THE peak of Orizaba, known to the ancient inhabitants of Mexico as Citlaltepētł, is one of three high mountains on the southeastern edge of the valley of Mexico, which form the most conspicuous landmarks for many miles around. Looking south and east from the city of Mexico, one may see the great volcano Popocatepētł, forty miles away, with its smooth regular cone, capped with snow the year round and on clear days standing out against the blue sky as distinctly as though it were but a few miles distant at the most. Farther to the east and at about the same distance stands Ixtaccihuatł, the "White Woman," so called because of the resemblance of its long, irregular, snow-capped crest to the form of one sleeping. Beyond these two and nearer the Gulf coast stands the highest and most imposing of the three, just at the point where the railroad leaves the high tableland of Mexico, and descends into the low, tropical country of the coast.

Many travellers in Mexico make it a point to ascend Popocatepētł, and it is a trip well worth taking; but fewer have attempted to climb the higher and more difficult peak of Orizaba. It was, therefore, after having made the easier ascent of the former that we set out from the city of Mexico with both mercurial and aneroid barometers, thermometers, etc., to determine the height of the greater volcano. We left the city on April 27 at seven A. M., by the Mexican and Vera Cruz railroad,

passing along the shore of the once great lake Texcoco, and through several small towns. About twenty-five miles from Mexico the road passes near some of the old Aztec ruins which are so abundant in some parts of that country. Near the modern town of San Juan Teotihuacan stand several pyramids of different sizes, built very regularly, and still showing plainly that they are the work of a race now passed out of existence. The two most conspicuous ones are the "Pyramid of the Sun" and the "Pyramid of the Moon." About them at one time existed a city of unknown size, and many interesting relics have been found near by.¹ At the small station near by are dozens of men and boys all trying to sell to unsuspecting travellers stone idols, jugs, arrowheads, and other articles which at first sight one might be inclined to believe genuine, and according to the earnest protestations of the venders, such they are.

Leaving behind this city of idols, we continue in a southeasterly direction through several well-known towns. Perhaps the most interesting of these is Apizaco, known to those who have passed through it as the "Cane Station," for apparently almost the whole population is engaged either in making canes or in selling them. Canes of all sizes, shapes, colors, designs, and prices; canes in long rows against the side of the station; canes by the armful being pushed into the car windows, and every vender trying his best to make you understand that he has the only canes worth buying, and that they are the cheapest ever heard of. They are cheap indeed. A small hand-carved stick can be had for five cents in Mexican money, or an elaborately carved coffee-wood cane of moderate size, or one that looks like the trunk of a young tree, all varying in price up to about a dollar.

After leaving this place, there is little of special interest till the station of San Andres is reached, at which point we leave the

¹ Among these may be mentioned one of the largest idols or sacrificial stones now in the National Museum of Mexico. This stone was known and accurately described by the early historians, but by some chance it was lost sight of. Years afterward it was found that the great stone at San Juan had exactly the same dimensions as the lost one. When the half-buried mass was dug out and turned over, it was found to be the lost idol, turned face down. The larger of the two pyramids mentioned is two hundred and seventy feet high, and is about five hundred feet square at the base.

railroad. Here there is only the station, but by taking a street car drawn by four mules, we go a couple of miles back from the railroad to the town of San Andres Chalchicomula. This is a little city of about five thousand inhabitants, and surprisingly well kept and pretty for such an out-of-the-way place. There are a well-shaded public square or plaza, with a couple of fountains, two or three churches of spotless white with the round-topped towers seen so commonly in Mexico, a very good restaurant (also a very poor one), and several good-sized stores, beside the numerous small shops so common in most Mexican towns. From the roof of the little hotel may be seen the great volcano, with a smaller peak standing almost in front of it, looking very steep and rugged, and having altogether the appearance of a very hard climb, — which appearance is not at all deceptive.

After dinner, served in a room of the hotel, we made some inquiries in regard to getting horses and guides, and about five o'clock that afternoon found that there were no horses to be had. Many of the native Indians, who know the mountain trails, were engaged in carrying down snow and ice, which is one of the chief occupations of the town. We were told that the natives will make a trip up to the snow line, and bring down a large load to be shipped to the cities of the hotter parts of the country, between four o'clock in the morning and dark, and go all the way on foot. Certain it is that they can do great feats of mountain climbing. We finally found that we could secure guides, and that they would do their best to get us mules if no horses could be found. Nothing more could be done till morning, so after one of the party (we will not say which one) had dropped two mercurial barometers on the floor and broken the tube of one and the attached thermometer of the other, we slept the sleep of mountain climbers with a big day ahead.

Next morning a half dozen Mexicans appeared with seven or eight little mules and one horse, but only one of these animals had a saddle. All the rest had on their backs the large thick cushions to which are fastened the packs they usually carry. These, we found, made very comfortable seats as long as the mules were peaceable, which they usually were.

Beside the mules for the four Americans in the party, there

were two others to carry water, blankets, provisions, etc. ; so we made quite a procession as we filed through the streets of San Andres about ten o'clock in the morning. It was slightly cloudy, and we had not been able to get a really good view of the distant peak. As the morning went on, it became more and more threatening, till the sky became entirely overcast.

Upon leaving the town, we began at once to ascend the small foothills which extend several miles from the larger peak. After gaining a small plateau above the city, we passed through the village of San Francisco, a place with which the mules were evidently familiar, as they wanted to enter every pulque-shop and drinking-place along the street. We finally succeeded in getting them past temptation, and followed the rough road for several miles beside an old stone aqueduct which brings water from the mountain springs to San Andres. After an hour's riding we left the main road and the old aqueduct and followed one of the many mountain trails, which are generally only rough paths. The ground rose quite rapidly most of the time.

At one o'clock we stopped near a little stream for lunch. Here the Mexican guides built a fire and fed the mules, while we rested. After a stay of about an hour we started on again, and now the clouds had become so heavy that a few hailstones and a little rain fell at times. There was every prospect that there would be snow a little higher up, and the guides held a council to see if all were provided with colored glasses. Not expecting a storm, none had been brought ; so one of their number started back after them, intending to overtake us before we should need them. We were then fully ten miles on our journey, and had reached an elevation of about eleven thousand feet, or three thousand feet above the town we had left that morning. This Mexican, who started back at two in the afternoon, went to San Andres, got the glasses, and overtook us at an elevation of thirteen thousand feet at four o'clock next morning, making a trip all the way on foot of fully thirty miles, with a descent of three thousand feet and an ascent of five thousand.

We now continued up the mountain, but soon had to stop under a large pine-tree because of the heavy rain and hail. We built a good fire, and made ourselves quite comfortable ; but, as it was getting late and we could not stay there all night, we

started on in the rain. There was but one umbrella in the party, but we managed to keep partly dry with the aid of some large *petates*, or wicker mats, which we put around us. We had now reached an elevation where it had snowed a short time before, making a couple of inches of slush, through which the Mexicans walked for two hours with only their leather sandals on their feet. After winding around among the hills and smaller peaks, we came into a little valley whose upper end vanished in the clouds. Riding up this valley for half a mile, the guide turned toward the steep side to the west, and, climbing up a few feet, we saw the place where we were to pass the night, "La Cueva del Muerto," or Dead Man's Cave. It was a cave about large enough for the whole party to get into, and with a good fire we were soon dry and comfortable. It was dark when we reached this refuge, and was rapidly growing cold, a change very noticeable at high altitudes.

Next morning at daylight we were ready to start on the last stage of our ascent, and soon three of the party were again on their mules, and following the guides, who now had wrapped their feet in plenty of heavy cloth as a protection against the sharp volcanic rocks and the snow. The fourth of our company had not been well the night before, and was now too ill to continue, so he was left at the cave with a native. It had partly cleared during the night, and we could now see the great peak ahead, and behind us the smaller hills over which we had come the day before, and part of the immense valley below with a few small villages.

At 7.30 we had reached a point beyond which the mules could not go, and from there on we must climb. The ground was very rocky, in fact was part of a great lava stream, which at some past time had flowed down the side of the mountain. This stream reached nearly to the summit, which did not seem to be over half a mile away. The guide, when questioned, said that it would take us seven hours to get to the top, and he was right. Here the real climb began, over about two inches of snow covering the roughest pile of rocks that can well be imagined. A guide stayed with each of the party, and each one took the gait that suited him best. At ten o'clock the top appeared no closer than it had at seven, but the distance below, over which we had

just come, seemed a long way. Now the clouds began to blow over the crest of the great mountain, and at times completely surrounded us, while at other times they cleared away, and the sun shone down through the rare atmosphere with a terrible heat. It was impossible, at that altitude, to go more than a few steps without resting, and before reaching the top the exhaustion attending every slight effort became very troublesome. As the day went on, the clouds became heavier and more numerous, so that when, at 1.15, I reached the edge of the crater, I could see across it or down into it only by short glimpses. It was very cold and the wind was blowing a heavy gale. White frost was forming on our clothing, and it was impossible to stand still very long. The crater of this famous mountain is much smaller than that of Popocatepetl, probably a thousand feet across and about the same depth; the inside is much steeper, going almost straight down on all sides, and the edge so liable to cave in under one that it is dangerous to get very close.

After a stay of a few minutes at the edge of the crater we went around to the highest point, only about fifteen minutes' climb. Here is an old cross made of iron pipe, which zealous piety went to great trouble to put up, now blown down by the wind. We took our barometer readings, and, on account of the intense cold and the discomfort arising from the great altitude, at once prepared to descend. After going down some eight hundred feet, I met another of the party who, with the assistance of two Indians and a rope, was taking an easy way to reach the summit. A short distance farther down I met the guide who had overtaken us at four that morning, bringing up a note from the third member of the party, who had turned back at an elevation of over seventeen thousand feet.

The descent to the cave was marked by no incident worthy of special mention, and after spending another night here, we set out early for San Andres, making close connections there with the restaurant and the train for Mexico. It is unfortunate that no good photographs of the crater were secured, but the dense clouds and various other causes prevented. The barometer readings indicated an altitude of about eighteen thousand six hundred feet, or some eight hundred feet higher than Popocatepetl.

The Altitudes of Orizaba and Popocatepetl.

BY A. E. DOUGLASS.

Read October 20, 1897.

THE recent ascent of Orizaba described by Mr. W. H. Cogshall in the preceding article, and in which I participated to the height of 17,300 feet, gives me the occasion for some remarks upon the altitude of the two great Mexican mountains and upon the effect of high climbing or so-called mountain sickness.

The peak of Orizaba is situated about half-way between the city of Mexico and the coast, and upon the very edge of the tableland, so that the ascent from the east is four thousand feet greater than on the inland side. It is undoubtedly higher than Popocatepetl, and therefore probably the highest mountain in North America.

Readings of a mercurial barometer placed upon its summit were made by Miss Annie S. Peck¹ and Mr. W. A. Cogshall of our expedition, on April 29, 1897. The mercury stood about half an inch lower than upon the other mountain, thus indicating a difference in altitude of some eight hundred feet. The mean reading on Orizaba was a trifle under 15.40 inches, and the temperature of the air was 26.4° F. But during the observation the upper portion of the mountain was enveloped in cloud, and a gale was blowing over it; there was probably a clear space over the level country between Orizaba and Mexico, and it is certain that at the city of Mexico the sky was entirely cloudy. It is probable, therefore, that local meteorological conditions considerably affect the result.

One of the most complete measurements ever made was by Dr. F. Kaska of Mexico, who ascended three times to the summit, and spent a number of nights there. His results with a mercurial barometer place the height of the mountain at 18,260 feet.

¹ Of the New York World expedition. Thanks to her, Mr. Cogshall obtained readings of her Fortin barometer at the top of the mountain, the barometer loaned me by the Mexican Meteorological Observatory having been broken. Miss Peck's discussion of her results, with calculations made by the United States Weather Bureau, will appear, as I understand, in the National Geographical Magazine.

8 THE ALTITUDES OF ORIZABA AND POPOCATEPETL.

Various measurements ¹ of the heights of these mountains are as follows:—

POPOCATEPETL.

Observer.	Published result.		Using Heilprin's Corrections.	Year.	Method.	Authority.
	m.	ft.	ft.			
1. Humboldt.	5403	17,713	17,590	1804	Triang.	Humboldt's Cosmos.
2. Glennie .	5451	17,884	(17,758)	1827	Merc.	Humboldt's Cosmos.
3. Birbeck .		18,017 <i>a</i>	(17,891)	1827	Merc.	Humboldt's Cosmos.
	5442	17,854	17,728			
4. Doignon .	5403	17,726	17,600		Merc. ?	Humboldt's Cosmos.
5. von Gerolt	5150	16,896 <i>b</i>	(16,770)	1833	Merc.	Humboldt's Cosmos.
6. Craveri . .	5291	17,360 <i>c</i>	(17,234)	1855	Barom.	Humboldt's Cosmos.
7. Carl Heller	5408	17,745 <i>d</i>	(17,619)	1856 ?		Humboldt's Cosmos.
8. Sonntag .	5420	17,785	17,659	1857	Triang. Barom.	Smithsoni- an Cont.
9. Ponce de Leon . .	5391	17,688	17,616	1870	Triang.	Know. XI. <i>e</i> Boletin
10. Almazan .	5406	17,737	17,637			Mensual del
11. Glennie, Taylor & Quintana	5463	17,924	17,824			Observa- torio Mete- orologico-
12. Burkart .	5353	17,563	17,463			Magnetico Central de Mexico, Abril, 1897 (and Sr.
13. Aguilera & Ordoñez .	5450	17,881	17,781		Hipsom.	Zendejas).
14. Heilprin .	5341	17,523 <i>f</i>	17,523	1890	Aneroid	Proc. Phil. Acad. Sci. 1890, Pt. II.
15. Douglass .	5436	17,815 <i>g</i>	17,743	1897	Merc.	Appalachia, July, 1897.

NOTES.

a As corrected by Burkart, but thought by Heilprin to be more nearly right.

b Taken at Roca del Fraile, below crater.

c Altitude here increased 200 feet to reduce to Humboldt's standard elevation of the city of Mexico.

d Humboldt merely describes Heller's result as within 32 feet of his own; it may therefore be 17,681.

e I take this reference from Heilprin's Report in the Proceedings of the Academy of Natural Sciences of Philadelphia, 1890, Part II.

¹ Sr. Zendejas mentions as additional reference, Beiträge zur Geologie und Paläontologie der Republic Mexico, von Felix y Lenk, I Thiel, Leipzig, 1890.

THE ALTITUDES OF ORIZABA AND POPOCATEPETL. 9

f Heilprin uses the tables of Delcros, and obtains practically the result given by the Smithsonian tables (based on those of Guyot), omitting the humidity correction. The correction in the latter tables for an average degree of humidity amounts to + 70 feet.

g My result by Smithsonian Meteorological Tables, 1896, using a humidity correction of + 39 feet, for observed relative humidity; for an average amount of humidity the height becomes 20 feet more. Señor Zendejas of Mexico obtained 5400 metres (17,717 feet), using the tables of Mathieu without humidity correction, and 5417 metres (17,772 feet), using the formula of Diaz Covarrubias, probably also without humidity correction. (See "Boletin Mensual" as quoted for Ponce de Leon and others.)

ORIZABA.

Observer.	Published results.	Using Heilprin's Corrections.	Year.	Method.	Authority.
	m. ft.	ft.			
1. Ferrer . .	5450 17,879		1796	Triang.	Humboldt's Cosmos.
2. Humboldt.	5296 17,375 <i>h</i>		1804	Triang.	Humboldt's Cosmos.
3. Almazan .	5461 17,917				Sr. Zendejas, Mexico <i>i</i> .
4. Langara .	4558 14,955 <i>j</i>				Sr. Zendejas, Mexico <i>i</i> .
5. Reynolds .	5431 17,818		1848		Boletin del Observatorio Met.-Mag. Cent. Mexico, Abril, 1897.
6. Doignon .	5586 18,327		1851		
7. Ratzel . .	5509 18,074				
8. Smith & Roberts.	5510 18,077				
9. Niox . . .	5520 18,110				
10. Saussure .	5395 17,700				Aneroid
11. Scowell .	5434 17,829				
12. Kaska . .	5565 18,260		1874-77*	Merc.	Sr. Zendejas, Mexico.
13. Plowes, Rodriguez, Vigil . .	5384 17,664	17,416	1877	Triang.	Dr. F. Kaska, Mexico <i>k</i> .
14. Müller . .	5521 18,112		1884?	Triang.	Heilprin's Report in Proc. Phil. Acad. of Sci., 1890, Part II. <i>l</i> .
15. Heilprin .	5549 18,205 <i>m</i>		1890	Aneroid	
16. Cogshall .	5630 18,470 <i>n</i>	18,400	1897	Merc.	Present Paper.
17. Miss Peck.	5669 18,600 <i>n</i>	18,530	1897	Merc.	Present Paper.

NOTES.

h Humboldt states that in his measurement the mountain was distant, and the angles of elevation were small; he himself therefore adopts Ferrer's result.

i These data were very courteously collected and forwarded to me by Señor Don José Zendejas, subdirector of the Central Meteorological Observatory in the city

of Mexico. The article in the "Boletin," also cited as an authority, was written by him. I cannot say whether the six values here quoted from the "Boletin" were independent measures or not; the similarity between Ratzel, Smith and Roberts, and Niox suggests that these three were not independent.

j Probably some other part of the mountain, or, perhaps, summit of "La Montaña," near Orizaba.

k In his letter, Dr. Kaska regrets that he had mislaid the notes made on his various ascents, but gave the height derived from readings of a mercurial barometer as 5564.8 m. Heilprin, quoting from Myer's *Konversations-Lexikon*, calls it 5500 m. Dr. Kaska obtained readings of an hypsometer, also, but had not reduced them.

l Heilprin quotes Müller's result from Grisebach, in *Vegetation der Erde*, 2d ed., 1884, II., page 563; and the result of Plowes, Rodriguez, and Vigil from *Anales del Ministerio de Fomento*, III., 1877, pages 99 and 113 (Mexico). Sr. Zendejas also refers to this authority.

m From Deleros' tables, omitting, as before, the humidity correction, which amounts to + 67 feet according to the Smithsonian tables.

n Based on the Smithsonian meteorological tables, 1896, and obtained in the following way: A comparison with observations made in the city of Mexico at the same hour gave for the "Published Results" 18,598 and 18,733 feet, respectively, using a correction of + 43 feet for observed humidity. Sr. Zendejas, using the same observations that gave the 18,733 above, obtained 5694 m. (18,681 feet), but upon comparing with observations at Puebla, he obtained closely 5650 m. (18,537 feet), and with observations at Vera Cruz, 5600 m. (18,373 feet). As the mountain is not very far from Puebla, the interpolated figure becomes about 5635 m., or about 200 feet below the Mexican value; and we must assume that this 200 feet includes the error found by Heilprin for the level of the city of Mexico. Applying corrections of - 130 and - 200 feet to the first results above gives the heights entered in the two columns of the table, which therefore depend on the correctness of the elevation of Puebla as used by the Meteorological Bureau.

Many minor errors and disagreements in these heights arise from differences in the tables for computing altitudes, as was evident in the notes. The humidity correction is important, and in the Smithsonian tables should not be omitted in either the English or French measure. When the humidity is not observed, the correction should be taken from the English measure, even though the observations be in French measure.

Errors also arise from variableness of the meteorological conditions, and this is probably one of their chief sources. Even the best tables cannot correct perfectly an individual observation, on account of the (usually) large horizontal separation of the upper and lower stations. So an average of all good measures tends to eliminate errors due to this cause.

But errors also arise from mistakes in standard levels, and when one is detected, the previous values of the mountain-

height should be revised. This Heilprin has done so well for Popocatepetl that I need do little more than give his corrections a general application. He found an error of 126 feet in the level of the Plaza of the city of Mexico (it was formerly too high), and quotes Sonntag as authority for believing that all previous computers had also used this erroneous value. Hence we correct for an error of 72 feet in the altitude of the lower station in the last measures of the two mountains; and for the remaining measures, whose dates I have not learned, an approximate error of 100 feet is assumed. From the same source, the railroad surveys, he found a large error in the result of Plowes, Rodriguez and Vigil upon Orizaba. However, with regard to other measures of Orizaba, I cannot assume any particular error from my ignorance of their comparison stations.

Accordingly I have added a column in the two tables in which these corrections are applied, and I use the values in that column in preference to the published results.

In combining these observations to get the most probable value of the heights of the mountains, the doubtful figures, in parenthesis, are discarded at once. With regard to Orizaba, the disagreement in the remaining values is so large that a number of results are undoubtedly in error. Ferrer may be right; Humboldt is admittedly wrong; Almazan I know nothing about; Langara is obviously wrong; we know practically nothing about those quoted from the "Boletin;" Mexican meteorologists look askance upon the results of Plowes, Rodriguez, and Vigil; Scowell and Heilprin used aneroid barometers.

For better comparison the measures and methods of measurement are placed in the following list; the method is denoted by a letter, following the height: T denotes triangulation; A, aneroid barometer; M, mercurial barometer; H, hypsometer.

POPOCATEPETL.

17,463 ? *
 523 A *
 590 T
 600 M (?)
 616 T
 637 ? *
 659 } T
 659 } M

ORIZABA.

17,416 T *
 700 ? *
 818 ? *
 829 A *
 879 T
 917 ? *
 18,074 ? *
 077 ? *

728 M	110 ? *
743 M	112 T
781 H, weight $\frac{1}{2}$	205 A *
824 ? *	260 M, weight 2
	327 ? *
<hr/>	400 M
(17,646 \pm 78)	530 M
	<hr/>
	(18,057 \pm 226)

The omission of any of these in an attempt to get the most probable means is perhaps a questionable procedure, but it is certain that if we wish to restrict the figures as nearly as possible to a uniform standard of excellence, we should discard the least reliable, namely, those about which nothing is known and those obtained from aneroid barometers. Making these omissions as indicated by the asterisks, we obtain:—

POPOCATEPETL	17,660 \pm 50 feet, or 5384 \pm 15 metres.
ORIZABA	18,240 \pm 160 feet, or 5560 \pm 50 metres.

Effects of High-Mountain Climbing.

BY A. E. DOUGLASS.

Read October 20, 1897.

MOUNTAIN climbing is a sport in which all the powers of endurance are brought into play. At low altitudes it is a question of firm muscles and of a sound heart; at high altitudes the lungs and digestive organs as well are put to a tremendous test. The various complaints, apart from mere fatigue, which have compelled persons to turn back, are, so far as I have seen or heard of them, nausea, high pulse, severe headache, intense nervous excitability, and hemorrhage. These are named with reference to frequency and seriousness, the first being the most frequent and at the same time least serious. It has been a matter of interest and some amusement to me to notice that in a person's first experience (if accompanied with exertion) these symptoms are never acknowledged to be due to the altitude.

Nausea is such an ordinary thing that a great many people

become sick while passing in a railroad train over the road from Arequipa, Peru, to Puno on Lake Titicaca, when the railway reaches an elevation of only 14,700 feet. In this case there is a minimum of exertion; when the ascent is accompanied by hard work the liability to nausea is much greater. If nausea occurs at night it need not be feared, for day will bring relief, but when it occurs by day it is usually best to turn back at once. There is as yet that unexplained difference between night and day. Night seems to have a very severe effect in comparison with day, all the symptoms of high altitude being exaggerated; day always brings a measure of relief. For example, one enthusiast who was sick at ten thousand feet climbed four thousand feet on foot the next day. Another sick at sixteen thousand feet, and a third feeling nauseated at fourteen or fifteen thousand in the morning were both obliged to go back at once. Several times at altitudes over sixteen thousand feet I have felt the first faint suggestion of nausea as the result of over-exertion; in each case it has disappeared in a few moments, leaving behind it a slight headache. People who are occasionally sick in this way at low altitudes are the ones most liable to nausea when far above the level of the sea. It is true of this, as well as of all other symptoms of mountain sickness, that if one takes absolute rest on the very first approach of the uncomfortable feeling, the real sickness may be warded off provided the altitude is not too high. Even if the altitude is very high, the sickness may sometimes be reduced to a mere headache, which, however, is liable to persist for some time thereafter.

High pulse, or palpitation of the heart, affects many people at altitudes which could not be considered very high. Even as low as four thousand feet special complaints of heart trouble are heard, but I have suspected that it might be aggravated by the very dry climate in which the persons were living. Really high altitudes are very quick to affect the pulse. A certain scientist relates that at the top of Pike's Peak, a little over fourteen thousand feet above the sea, his pulse went up to 147 per minute. This is dangerously high. Another found on Popocatepetl, that after riding horseback five hours, from 8,300 to about 13,000 feet, all appetite was gone and his pulse

was so high as to cause some discomfort. After lying down a few hours, making absolutely no exertion whatever, the heart's action lessened, and at four in the morning he was ready to start for higher altitudes; nor was the pulse materially affected by the subsequent climb to the very top. In camping at very high altitudes it is decidedly advisable to sleep with the head somewhat elevated.

An incident which befell me several years ago resulted from an abnormal action of the circulatory system. In one of my first ascents I rode on mule-back for some nine hours, from 8,000 to 16,650 feet, and when at about 16,400 feet I counted my pulse and found it 120. Almost immediately after I was overtaken by an attack of vertigo, from which I was perhaps unconscious for an instant. Nevertheless in a few minutes we went on and shortly after camped for the night, and the next day I was able to go on mule-back and on foot some two thousand feet higher. As I have made that same ride many times since without the ill effects then experienced, I attribute the attack of vertigo to one or both of two things: either the wearing of a close-fitting felt hat, without lining, in a fierce tropical sun, or a very late dinner that day, taken at too high an altitude to allow digestion to work properly.

As already shown, an abnormally high pulse at night is not serious, for day may bring relief; but if it is so high at night that one loses sleep, then a degree of exhaustion ensues, and it is with the greatest difficulty that any more climbing is done the next day. Many persons give out from that cause, and it nearly caused failure on my first high ascent. On that occasion we climbed on foot from five in the morning till four in the afternoon, stopping one hour for lunch, and reached an altitude of 18,600 feet — an extraordinary altitude for spending the night. By that time I found that climbing only a few feet made the pulsations of my heart feel very uncomfortable, and while I was helping into a more comfortable position one of my companions who seemed much more used up than myself, a sudden feeling of sickness at the stomach came over me, with some headache. The feeling of sickness soon passed away, but the headache and jarring pulse and burning thirst remained to keep me awake nearly all night. I had reached the camping

place before any of the others, but the next day it took me twice as long as it did them to reach the crater, a matter of only five hundred feet. It was the most complete exhaustion I ever experienced.

There is a combination of increased pulse and indigestion which affects some people very badly. It is brought on by over-exertion, and is like the effects of the same thing at low altitudes. With great care after the first approach of the symptom, any serious trouble may be warded off, but if the weather is cold and rests for that reason are wellnigh impossible, repeated attacks come on, and it is merely a waste of time to remain longer at that altitude. It can best be described as an exceedingly disagreeable and enervating feeling located generally over the chest and stomach. Perhaps it chiefly affects those who are never subject to actual nausea.

I have never personally seen any one obliged to turn back from any of the three remaining causes, headache, nervous excitability, or hemorrhage. Perhaps headache ought not to be included in this list, because it seems to be a general result of high altitudes rather than a special characteristic of the person climbing. But for that reason it certainly deserves mention. It seems to follow the other symptoms. However, in some cases persons have ridden to 18,000 feet and only complained of a slight headache. One, at least, has climbed on foot from 14,000 to over 18,000 feet in less than six hours, and then hardly felt ill effects of any kind. In most cases a headache persists some time after return to lower elevations.

Only one case of nervousness has been described to me, and that occurred in a person who was naturally of a nervous temperament. Spending the night in a hut at an altitude of a little under 17,000 feet, he found his faculties confused and himself in an extremely excitable state, so that he could not lie still. For many hours he walked backwards and forwards, until finally day brought relief.

The several cases of death on high mountains, which have not resulted from cold, losing one's way or other common causes, have all resulted from hemorrhage. This results from the breaking of large blood vessels; blood issues from the mouth, nose and eyes, and death comes too quickly for the patient to be

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brought down. But in the majority of cases where bleeding occurs there is ample time to get to a lower altitude and obtain relief. A little bleeding at the nose is of very slight consequence. A certain gentleman rode from 8,000 to 13,000 feet, and in the evening ran several hundred yards to test his condition. As a result his nose bled for a considerable time, but the next day he was by far the most active of his party in climbing on foot and, it is said, broke the record for the ascent of Popocatepetl.

High-mountain climbing does not always affect the same person in the same way, being dependent on his condition at the time of making the ascent. Nor does it affect all members of the same party alike, for it seems to touch in each the part which at the time is weakest; thus, some complain of indigestion, others of palpitation, and so on. Headache seems to be the only general symptom, for it affects almost every one and often persists for some hours after descent.

In view of the great difficulties in high-mountain climbing, much attention should be given to planning the trip beforehand in a thorough manner. One may adopt either of two ways: he may either follow Whymper's excellent example and remain two or three days at an altitude of about 16,000 feet to become accustomed to the rarefied air, or, if his time is more limited, he may make a dash for the summit, accomplishing the whole trip in the shortest time possible. For scientific or geodetic work Whymper's plan is much the best, and in the end entails less discomfort though more time and expense. It is in the rapid trips that much care is necessary in deciding upon the place to pass the night, the food to take, and the general supplies.

In two-day trips, such as Popocatepetl and Orizaba, the night is very properly passed at an altitude where mountain sickness is not likely to prevent sleep, that is, at about 13,000 feet. In quick climbs up to 19,000 or 20,000 feet I am still inclined to think this the best altitude for spending the night, making up for it by getting an early start the next morning. It is always best to spend the night at as low an elevation as possible. All this precaution is necessary from the fact already mentioned, that all the symptoms of mountain sickness are greatly aggravated at night.

In the way of food, a large quantity is not necessary for quick trips, but it should be of the kind most easily digested. Beef tea or other liquid foods should be taken, or fresh meat may be carried and a broth made from it. Bread without butter, toasted at an open fire, and water as hot as one can drink it, seem to tone up the stomach and do it good. It is doubtful if alcoholic stimulants are beneficial, the pulse being already greatly accelerated by the altitude and the exertion; but if one is suffering from the cold and is entirely accustomed to their use, it may change failure into success. It is, of course, best to have stimulants with one for use in case of an emergency. I recollect on one occasion being overtaken by night, and afterwards getting into a pool of water not yet frozen over—it was above snow line—and then being greatly comforted mentally and physically by its use.

The Indians who have lived for generations at high altitudes, and who are accustomed to severe labor at great heights, are, both in Mexico and in the Titicaca Basin, of small but powerful build, and have magnificent chest development. They belong to races that are used to carrying burdens on their backs, and so their limbs are strong. Near volcanoes many of them are in the habit of climbing for sulphur, and the work that they can do amidst conditions that entirely exhaust the traveller is phenomenal. In the ascent of the volcano, El Misti, at Arequipa, Peru, one Indian actually carried two packs of full weight, taking the first up a certain distance and then descending for the other, and made such good time that when we decided to camp for the night he, with the others, had already reached the crater, five hundred feet above us, and was recalled with the greatest difficulty. Years of practice would be necessary before we could perform such heroic labor.

The true mountain climber, it is said, enjoys every step of his climb. Yet, judging from what I have seen at altitudes over 16,000 feet, enjoyment at high altitudes is impossible for those who climb any great distance on foot. The exhaustion of climbing under such conditions is so severe as to take away most of the enjoyment in the exercise and in many cases renders the work detrimental to health rather than beneficial. It therefore seems to me legitimate, at elevations over 16,000 feet, to

take every possible advantage in the way of assistance, either by riding on animals or by being pulled up the slope by Indians, as is often done on Orizaba. Such assistance is practically always available on the high mountains in the tropics; either ice or sulphur is in demand in the towns below, and many Indians make a business of going to high altitudes.

Especially is this to be recommended, it seems to me, when the climber desires to obtain results of scientific value. The condition in which the observer finds himself makes a great difference in the results obtained, and everything beneficial to mind and body should be resorted to from a sense of duty to himself and those for whom he is gathering information.