

as the Lachen villages, people who pasture their flocks at high altitudes on the Tibetan frontier, should also prove useful. They are both of a sturdy race of mountaineers, not so independent as the pure Tibetan, and should prove amenable to training. They have also the merit of being hardy and accustomed to cold and the biting winds of the country. They should be in charge of their own sirdars, and I am rather doubtful as to the advisability of having Gurkha N.C.O.'s over them. A good cook with the expedition is of great importance, as it is most necessary to keep the digestion in good order at these altitudes.

---

### DR. KELLAS' EXPEDITION TO KAMET

**I**N the course of General Bruce's paper on Mount Everest, published last month, it was announced that Dr. Kellas and Major Morshead had succeeded last autumn in reaching the saddle of Kamet (at 23,500 feet), but that transport difficulties had prevented the formation of a camp at that height, or any further advance.

Dr. Kellas had planned the ascent of Kamet with special reference to the physiological effects at high altitudes and the use of oxygen. The Oxygen Research Committee and the Medical Research Committee, under the authority of the Department of Scientific and Industrial Research, undertook to supply the necessary scientific equipment, which was forwarded by the Indian Stores Department to Kathgodam. Dr. Kellas had left for India in March, and the equipment had to be got together and forwarded to him. Some unavoidable delay occurred owing to the discovery that the very light oxygen cylinders, which passed their tests when newly made, lost strength rapidly and were not safe. It was therefore necessary to send heavier cylinders. Further delay was caused in the transport to India by certain shipping restrictions in the carriage of gas cylinders and chemicals; and finally there was some unexplained delay on the Indian railways, so that the start of the expedition from Kathgodam was considerably late, and to this one must attribute any want of complete success in the investigation. The preparations of the Oxygen Research Committee were made under the disadvantage that owing to ill health Dr. Kellas had been unable to attend to them in the preceding winter, and had to leave instructions for execution after his start. The Society must gratefully acknowledge the value of the contribution to the Mount Everest problem thus made by the Committee in difficult conditions.

Dr. Kellas, who has remained in India with the intention of making another attempt on Kamet next summer, has sent us a copy of the report he has made to the Oxygen Research Committee; and in view of its immediate importance to the Mount Everest expedition, we assume his permission to print the following extracts from it:

At the end of the first week in August part of the expedition started from **Kathgodam**, and on August 19 joined Major Morshead at Chomoli, about 150 miles to the north. The permanent members of the expedition included Major Morshead and his transport officer, with eleven attendants—the latter being intended chiefly for survey work, and also for transport at high altitudes—and myself with two servants. There were about eighty-three coolie loads.

From Joshimath, 29 miles north of Chomoli, transport work was difficult, and repeated unavoidable delays occurred. Four bridges had been washed away in the Niti valley by floods, but the Deputy Commissioner of Garwhal, Mr. P. Mason, made such arrangements that we had only to build one bridge over the river Dhauli.

On August 29 we started from Niti, the highest village on the route (12,000 feet approx.), with about twenty-one yaks and forty coolies (each yak carrying two coolie loads), and on August 31 reached a base camp at the end of the Raikana glacier at an altitude of 15,380 feet.

Above this point the route was very rough, and all baggage had to be carried by coolies. Carriage of wood, which could be obtained about a mile below the camp, became of special importance. Even at this base camp (No. 1) want of acclimatization to altitude began to be evident in certain cases, and incidence of malaria was also troublesome.

On September 3 an advance was made along the east Kamet glacier—which was found to be quite incorrectly given on the map—and a camp formed at about 16,800 feet. This camp was on fine sandy detritus on a bank above the glacier, and was generally regarded by the coolies as the last comfortable camp. A delay occurred here due to difficulties in connection with transport of wood, and it was September 8 before Camp No. 3 was formed at 18,500 feet on rough glacial detritus above ice. This third camp was near the base of Kamet, which rose in a series of rock precipices to the north-west, forming a comparatively sharp peak. Between this peak and the ridge of east Ibi Gamin (24,170 feet), to the north-east there was a snowy saddle of altitude about 23,500 feet, which obviously indicated the route to the summit. The increase of height between this third camp and the saddle—namely, 5000 feet—consisted firstly of 2500 feet of sharp ascent, chiefly steep scree, but partly débris-covered glacier, then came 1000 feet of precipitous rock, and finally about 1700 feet of snow and ice. From the configuration of the mountain it seemed likely that the tops of these three “pitches” would necessarily represent positions for camps 4, 5, and 6. At this third camp my chief servant became so incapacitated—he had been accidentally benighted on the glacier along with Major Morshead’s servant—that he had to be sent back to Niti.

On September 11 we moved up to a camp above the screes—camp No. 4—our tents being pitched at 21,000 feet (approx.). Here the transport was unsatisfactory, and we were detained about a week. At this camp it became evident that our remaining servants would be unable to go higher. Both seemed to have reached the limit of their acclimatization powers, in spite of being adequately protected, and suffered from the cold—approx. 0° Fahr. during the night—while my servant again had attacks of malaria.

On September 19 we climbed the rocks, and formed a camp on snow at approximately 22,000 feet. After a day at this camp to allow acclimatization to take place, we ascended to a little above the saddle along with three coolies from the village of Mana, starting at 9 a.m. and reaching the saddle at 3 o'clock. At 3.30 we had attained about 23,600 feet, our maximum altitude,

but the coolies declined to attempt Ibi Gamin (24,170 feet), which seemed feasible, or to ascend further on Kamet. Starting back at 3.45 p.m. (approx.) we descended rapidly, and reached our 22,000-foot camp about 5 p.m. The wind was cold, and the three coolies with us suffered more than Major Morshead or myself, and complained of headache. A considerable amount of step-cutting was necessary, which was shared.

Next morning Major Morshead unfortunately had to descend, as his period of leave had expired, taking all the coolies with him. The coolies refused to entertain the idea of moving a camp up to the saddle, alleging that the winter storm was due, and that we would be snowed up. The threatened incidence of this winter storm had been their continual complaint since reaching Camp No. 3, but otherwise the men from Mana village (10,000 feet), some of whom were coolies who had been with me previously in 1911 and 1914, behaved very well, and indeed were the mainstay of all the hard work carried out. On three occasions at Camp No. 4 we had about a couple of inches of fresh snow, the bulk of which quickly evaporated.

At the base camp I tried to get coolies to come and pitch a camp on a pass between the Raikana glacier and the Ganeshganga valley to the north, from which one could carry out experiments with the oxygen cylinders and Prof. Hill's rubber bag on a beautiful snow-peak 21,700 feet high, which evidently could be climbed. Even a heavy snowstorm could have been weathered in such a position, but the coolies refused to obey the transport officer, and would not even transport wood a distance of 3 miles to a base camp below the Ganeshganga peak mentioned. In addition to this, when on two consecutive days the yakmen had driven off their yaks unloaded, and men had to be sent after them to bring them back, it was evident a retreat was necessary.

We therefore made a double march to Niti on October 1, and on the following day reached Malari, a large village about 10 miles to the south. I had not agreed to the retreat from the Raikana glacier until the transport officer had promised to try and make an arrangement at Malari to visit the Bagini glacier to the south-east, and form a high camp on a suitable mountain for carrying out experiments, and I had fixed upon Dunagiri Peak (23,184 feet), the finest mountain of that region, for the purpose.

On October 3 we moved south from Malari, and on the 5th reached Dunagiri village (11,150 feet), about three days' march from the mountain of the same name. It soon became evident, however, that the Dunagiri men were somewhat inefficient coolies and knew nothing of snow work, so that the idea of forming a camp at 20,500 feet on Dunagiri was abandoned, and a camp formed at 18,000 feet on a more accessible mountain about 21,000 feet high to the north-west of the Bagini glacier.

About a week's work was carried out at this high camp, and Dunagiri was regained on October 16. From there continuous travel *via* Joshimath, Karuprayag, and Ranikhet brought us to Kathgodam on the 5th, and thence to near Darjeeling on November 9, after an absence of four and a half months.

#### *I. Experiments with Cylinders of Compressed Oxygen.*

On testing the weight of the oxygen cylinders at Kathgodam it became evident that they were almost certainly too heavy for high altitude work.\*

\* They are nearly three times the weight of the cylinders previously shown to me, and had I known that these alone were available I would have cut down the number requisitioned from seventy-two to twenty-four. I quite recognize, however, that everything was done that was possible in the circumstances.

Their weight (16 lbs. approx., or with pressure regulator, etc., nearly 20 lbs.) is as much as most coolies care to carry as a load even at 20,000 feet. Preliminary experiments at 21,000 feet on Kamet confirmed that they were unsuitable, but no opportunity of working out systematic experiments occurred until after reaching the camp at 18,000 feet, near the Bagini glacier.

Experiments were carried out over three different courses: (1) a long course involving an easy snow ascent of 3000 feet (approx.) and return; (2) a medium course involving an ascent of 600 feet over rough snow, and return by a rock scree; and (3) a short ascent along a stony arête of about 200 feet.

In a typical experiment over the long course coolies took  $2\frac{1}{2}$  hours without oxygen cylinders, and 3 hours 40 minutes using oxygen cylinders, the use of oxygen being stopped at the summit.

Most of the experiments were carried out on the medium course, and the results were consistent. In one typical case 39 minutes were required with an oxygen cylinder, and 28 minutes without it, and a different man took 43 minutes with a cylinder and 30 minutes without.

On the short course typical results were 8 min. 20 sec. without cylinder, and 10 min. 30 sec. with it; and 8 min. 20 sec. without, and 11 min. 20 sec. when using one.

The conclusion from above results must obviously be that the cylinders are too heavy for use above 18,000 feet, and below that altitude they are not required. They would be quite useless during an attempt on Mount Everest.

It would seem advisable in the circumstances to carry out experiments with cylinders of double the capacity filled to half the pressure, so that a light cylinder similar to that shown to me in 1919 by Colonel Stewart could be safely employed. A volume of 140 litres (*i.e.* 5 cubic feet) of oxygen might be helpful, if the weight of the cylinder were not above, say, 7 lbs.

### II. *Prof. Leonard Hill's Rubber Bag and Oxylith.*

Two sets of experiments were carried out. In the first set the subjects breathed oxygen from a freshly filled bag containing strong solution of caustic soda for about five minutes, shaking the bag from time to time to promote absorption of carbon dioxide. They then immediately started up the short course mentioned above—the stony arête—and returned to the starting point, the time required being noted. After about fifteen minutes a repeat experiment was carried out without breathing from the bag.

As a rule the times were practically identical, so that it seemed that no benefit accrued from breathing oxygen while resting, and that the excess amount in the lungs at starting was of negligible value in promoting ascent.

Such a result might be expected from theoretical considerations. In the experiments of the Anglo-American Expedition on Pike's Peak (14,100 feet), it was found that about 345 c.c. of oxygen\* per minute was required by the body when standing erect, and that nearly six times as much (1940 c.c.) was required when ascending a gradient of 1 in 4. The healthy body at rest would therefore probably have little difficulty in providing itself at 18,000 feet—and probably even up to 30,000 feet—with the necessary oxygen; but it is obvious that the great increase required immediately an ascent is started would be practically uninfluenced by any small residue of oxygen in the lungs.

\* This is substantially the same as the values found by Haldane and by Zuntz for near sea-level.

The second set of experiments were carried out while breathing continuously from the freshly filled bag during the ascent. The apparatus was carried under the arm, which was inconvenient.

In this case the gain while using oxygen was quite decisive, the advantage being up to 25 per cent. This again was to be expected, and clearly indicates that the light oxygen cylinders suggested above might be of considerable value as regards increase of rate of ascent at high altitudes. It is also evident that if such light cylinders cannot be obtained a modified form of Hill's bag, of considerably increased capacity—say, 150 to 200 litres—might be of use. Such a bag should preferably be made so as to tie on the back, the mouth-piece being brought over the left shoulder. The absorption of the carbon dioxide by caustic soda should be adequately arranged for.

It might therefore be recommended that bags of the type indicated above should be tested next year on the expedition to Kamet. Only two such bags would be required.

### III. *Observations on Mountain Sickness.*

Contrary to the author's observations in previous expeditions, mountain sickness, in one form or another, was not uncommon. Two reasons explain the difference. In the first place, in previous expeditions picked hillmen were employed, whereas in this case several men from near the plains were present; and in the second place, most of the coolies in preceding expeditions were Buddhists, who can vary their diet, whereas on this occasion the men were Hindoos, and handicapped by a comparatively rigid diet which in some respects is unsuitable for high altitudes, unless under special conditions, difficult to arrange for. As it is extremely difficult to cook the nitrogenous vegetable foodstuffs above 16,000 feet, fresh mutton should be supplied.

### IV. *Acclimatization to High Altitudes.*

Satisfactory acclimatization to the maximum altitude reached was attained by only two members of the expedition, namely, Major Morshead and myself. This is probably in some measure well shown by pulse and respiration rates, which were always taken at rest while sitting.

The time spent at the highest camp (22,000 feet), however, two and three nights respectively, was insufficient to arrive at definite conclusions as to the completeness of our adaptation to that altitude. In connection with the projected ascent of Mount Everest (29,141 feet), it is obvious also that capacity for acclimatization should be tested at higher altitudes, and next year the author hopes that it may be possible to camp for a week just below the Kamet saddle, at an elevation of about 23,400 feet.

A few cases of Cheyne-Stokes breathing were observed, although as a rule at least twenty-four hours were allowed for acclimatization to take place before making observations.

### V. *Suitable Diet for High Altitudes.*

In previous expeditions it had been observed that a depreciation of appetite seemed to occur after residence for some time above 20,000 feet. As it was possible that this might have been due to the diet, which had consisted entirely of tinned foods, chiefly cold because of difficulties regarding fuel transport, an attempt was made on this occasion to get an approximation to the diet usually taken at sea-level as already mentioned. Fresh mutton and

vegetables were used at the higher camps, and the food varied as much as possible. The effect was distinctly good, and no diminution of appetite was observed, even at the 22,000-foot camp; but, as already indicated, the time spent there was too short to form a definite opinion as regards completeness of acclimatization.

During the ascent to the saddle our appetites seemed good, but we had little time for halts, because of the amount of step-cutting necessary, and there was also a very cold wind. As liquid refreshment, we had a large Thermos flask filled with hot Bovril.

As a rule when camped on snow the fuel used is petroleum or methylated spirit, generally the latter, and in connection with the proposed ascent of Mount Everest we wished to find out whether a Primus lamp could be used above 21,000 feet. We had two Primus stoves with us of somewhat different constructions, and both worked well at 18,500 feet. At 21,000 feet the better of the two was fairly satisfactory, but at 22,000 feet we could not get it to work at all, and had to fall back upon a lamp burning methylated spirit. Next year, by employing flat slabs of stone as hearth, it might be possible to utilize wood at the camps on snow.

#### *VI. Experiments with Major Flack's Mercury Manometer to test any Variation of Strength and Energy with Increase of Altitude.*

Major Flack's apparatus can be so easily employed, that it was intended to carry out experiments with it even on the summit (25,447). The difficulties regarding transport already detailed, however, prevented results being obtained above 21,000 feet.

Observations showed that the expiratory force does not seem to vary at all with altitude up to 21,000 feet, but, as was to be expected, the capacity for sustaining a 40-mm. column of mercury rapidly diminishes as one ascends. The times during which the breath can be held at different altitudes were also taken: they should probably be approximately comparable with those for the 40-mm. column. The nose was held or clipped during the latter experiments, a procedure which experience shows to be absolutely necessary.

The results show clearly that the expiratory force is about the same at 21,000 feet as at 1600 feet. As a large proportion of the trunk muscles are involved in the expiratory effort, their tone and capacity for exerting force for a short period is apparently unaltered, and therefore probably the same is true for all the muscles of the body. If, when at high altitudes, however, one tries to keep the column of mercury at its maximum height, fatigue appears to supervene much more quickly than at sea-level, presumably because the oxygen supply to the muscles and brain is less; there is, however, a fairly rapid recovery.

One would not, of course, expect the time of maintenance of the 40-mm. column or the time of holding the breath to be the same at different altitudes, and the Table of Results showed a rapid diminution of capacity in both cases. One might reasonably suppose that the normal times in each case would be approximately proportional to the alveolar oxygen pressures, but the time of support of the 40-mm. column would be less than that of holding the breath for various reasons, perhaps more especially because the muscles in action would be using more oxygen, and the oxygen of the "dead space" would have less chance of being utilised.

## SUMMARY OF VARIATION OF ALVEOLAR OXYGEN PRESSURE AND TIMES OF HOLDING THE BREATH WITH ALTITUDE.

Place.	Altitude. Feet.	Calculated normal alveolar * oxygen pressures, mm. of mercury.	Times of holding the breath in seconds.		
			Morshead.	Kellas.	Sobhan Singh.
Kathgodam ... ..	1,600	95.5	—	82, 85, 93	—
Chomoli ... ..	3,620	87.5	50	—	—
Juma Gwar ... ..	8,250	71.0	60	67	50
Raikana Glacier ...	15,380	50.7	31	46½	26
Camp No. 3 ... ..	18,500	43.2	25	42	25
Camp No. 4 ... ..	21,000	37.9	—	33	23

VII. *Rate of Ascent.*

The times of holding the breath, and the alveolar oxygen pressures at different altitudes, are obviously connected with the possible rates of climbing, and it could be shown that, assuming 1000 feet change of altitude per hour on easy ground to be an average rate of ascent at the summit of Mont Blanc (15,780 feet), the rate at 23,000 feet would be about 600 feet per hour. On this occasion, excluding halts, our speed was only a little above half that value, viz. 320 feet per hour, but, considering the amount of step-cutting necessary, this was about what would have been expected. On previous expeditions the author has found that his rate of ascent on easy snow at 23,000 feet approximated to 600 feet per hour, agreeing with Longstaff's experience on Trisul. On such a basis, the calculated rate of ascent for the last 1000 feet of Mount Everest would be between 250 and 350 feet per hour. Possible rates of ascent may be further tested and elaborated in next year's report.

VIII. *Variation of Minimum Temperature with Altitude.*

Raikana Glacier.					
Base Camp No. 1	...	15,380 feet	31-8-20	Min. 30°	Fahr.
2nd Camp	...	16,800 "	4-9-20	" 23°	"
3rd "	...	18,500 "	9-9-20	" 15°	"
4th "	...	21,000 "	12-9-20	" 4°	"
5th "	...	22,000 "	19-0-20	" -15°	"

## THE DEATH OF MUNGO PARK

WE are indebted to Viscount Milner, Secretary of State for the Colonies, for the communication of the following despatch from Sir Hugh Clifford, Governor of Nigeria:—

Government House, Nigeria,  
3 May 1920.

MY LORD,

I have the honour to bring to your notice some interesting facts which appear to fix with reasonable certainty the date of the death of the explorer, Mungo Park, at Boussa. I enclose a note on the circumstances of Park's death in so far as they are recorded in the published account of his travels. From this it will be seen that the last recorded date in his journey down the Niger is the 19th November 1805, on which day he left Sansanding. The fact that he afterwards met his death at Boussa is established by the narrative of Amadi Fatouma and confirmed by native tradition. The story

\* Calculated from Miss M. P. Fitzgerald's values, *Phil. Trans. B.*, 5, 203, p. 359.