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promised the title of Count, and not obtaining it, asked leave in 1518 to emigrate. The King put him off for some months in the hope that he would change his mind, and in the mean time matters were arranged. D. Manoel was loth to lose a subject who had rendered signal service to the country and brought him great wealth; the Duke of Braganza agreed to cede his towns of Vidigueira and Ville de Frades in exchange for one of da Gama's pensions and a cash payment, and on 29 December 1519 the Navigator realized his ambition to become a peer.

In 1524 King John III. sent him to India as Viceroy to reform the abuses that already afflicted the State from the Governor downwards, and Gaspar Correa has described for us his pomp, incorruptibility, and severity. Knowing the value of splendour, he took out servants, plate, and tapestries worthy of a king, and had a guard of two hundred men in his livery. On landing at Goa he astonished every one by accepting no gift from either Christian or Moor. He removed corrupt officials, and threatened his predecessor, who was one of them, with death if he disobeyed. But in three months the terrible Viceroy had passed away; a carbuncle on his neck, added to the heat of his temper, and untiring work extending to small details, with worry over the succession, killed him in his sixty-fourth year.

Those who would know more and do not understand Portuguese should read 'Vasco da Gama and His Successors,' by K. G. Jayne (London, 1910). Students have the *Roteiro* (in Ravenstein) for the first voyage, Thomé Lopes (in Ramusio) for the second, and Correa for the third.

The portrait here reproduced is considered the most authentic; the original was given by a descendant of da Gama to the late King Carlos, and he presented it to the Lisbon Geographical Society, to which it now belongs.

EDGAR PRESTAGE.

PHYSIOLOGICAL DIFFICULTIES IN THE ASCENT OF MOUNT EVEREST

Major R. W. G. Hingston, I.M.S., Medical Officer to the Expedition of 1924

Read at the Afternoon Meeting of the Society, 10 *November* 1924.

THE primary object of the Mount Everest Expedition was to reach the highest summit on the Earth. Everything else was subordinate to this. Elaborate scientific investigations were impossible, and anything involving complicated apparatus was altogether out of the question. We had to content ourselves with simple experiments and with the records of the experiences of individual climbers. These, nevertheless, may be

worth discussion. They will give us some idea of the physiological difficulties involved in an ascent to so great a height.

Alterations in Breathing.—The most obvious of these is the difficulty in breathing. Owing to the gradual nature of our ascent this shortness of respiration was scarcely noticeable below 10,000 feet. It was definitely apparent above 14,000 feet, and above 19,000 feet the slightest exertion made breathing laboured and severe. When the body was at rest, even at extreme altitudes, the rate of breathing was apparently normal and as comfortable as at sea-level. But the very slightest exertion, such as the tying of a bootlace, the opening of a ration-box, the getting into a sleeping-bag, was associated with marked respiratory distress. The difficulties of the ascent were thus enormously increased. The breathing was quicker rather than deeper, but it was necessary to stop at frequent intervals and take a series of long deep breaths. This very quickly brought relief and made one ready for a further advance. Norton told me that, when he found himself dropping behind, his only chance of catching up the party was by taking a number of these deep long breaths. Somervell gives a record of his breathing at 27,000 feet. At that altitude he had to take seven, eight, or ten complete respirations for every single step forward. And even at that slow rate of progress he had to rest for a minute or two every 20 or 30 yards. At 28,000 feet Norton, in an hour's climb, ascended only about 80 feet. This was the highest point reached without the aid of oxygen. The strain at that altitude was certainly intense, but when we remember that the supply of oxygen is only about one-third of that available at sea-level, we are surprised that men can make these strenuous efforts, and still more that they can remain in comparative comfort when they sit down to rest.

The alteration in the rhythm of the breathing—commonly known as Cheyne-Stokes respiration—was frequently noticed during the expedition. I heard one member of the party breathing in this way as low as 12,000 feet. Though as a rule it seldom occurs when awake, yet at the base camp I was conscious of this type of breathing before passing off to sleep. Illness at high altitudes markedly increases it. It was most pronounced in one member when suffering from fever at 15,000 feet, and still more so in a Gurkha when dying of cerebral hæmorrhage at 18,000 feet. The rapid breathing of cold dry air produces some important secondary effects. It causes inflammation of the respiratory passages. Every member suffered from sore throat, from hoarseness, or from loss of voice. Most had irritating coughs, but with little expectoration. Some of the porters developed severe bronchitis: one had a profusely ulcerated throat, another persistently coughed up blood. Dr. Kellas was of opinion that the breathing was less laboured in a high wind. He thought that the wind might have the effect of packing the air into the lungs; also that it swept away the exhaled air and thus prevented it from being inhaled by the next breath. Our experiences did not agree with his.

Mount Everest is noted for its heavy winds. They caused considerable obstruction to the breathing. A moderate breeze had a freshening effect, but a strong wind impeded progress, and there was a feeling of suffocation when facing powerful gusts.

I made some experiments on the respiration. The power of holding the breath is a simple test to which pilots are submitted in the Royal Air Force. The following table shows the diminution in this power at successive altitudes in the ascent. The first column is the most complete. Where at sea-level the breath was held for 64 seconds, at 21,000 feet it was held for only 14 seconds.

Altitude in feet.	*Time breath held (in secs.).*									
	R.W.H.	E.O.S.	B.B.	G.B.	E.F.N.	G.L.M.	J.V.H.	A.C.I.	T.H.S.	N.E.O.
Sea-level ...	64	—	120	—	—	—	90	120	—	—
7000 ...	40	40	60	40	40	50	42	80	60	55
14,300 ...	39	32	35	32	37	40	—	47	48	—
16,500 ...	20	23	35	20	31	—	23	30	41	28
21,000 ...	14	17	—	20	—	—	17	—	—	—

Another test used amongst airmen is the measurement of the expiratory force. This consists in blowing a column of mercury up a graduated glass tube. The height reached by the mercury is read off, and this gives a measure of the expiratory force. If the expiratory force is much below the average it suggests that the airman will be incapable of sustained effort. The following table gives the results of our experiments. It suggests that with increasing altitude the expiratory force tends to improve. Look again at the first column. At sea-level the expiratory force was 110 mm. Hg; at 21,000 feet it was 150 mm. Hg. The third, fourth, fifth, sixth, seventh and eighth columns also show that an improvement has occurred.

Altitude in feet.	*Expiratory force in mm. of Hg.*									
	R.W.H.	E.O.S.	B.B.	G.B.	E.F.N.	G.L.M.	J.V.H.	A.C.I.	T.H.S.	N.E.O.
Sea-level ...	110	—	—	—	—	—	—	—	—	—
7000 ...	110	120	140	160	110	110	130	160	120	110
14,300 ...	110	90	160	190	120	120	—	160	120	—
16,500 ...	140	130	210	200	170	—	120	170	120	100
21,000 ...	150	120	—	210	—	—	150	—	—	—

I did not anticipate this improvement in the expiratory force. But the test has little to do with the function of respiration. It is more an indication of physical fitness and muscular strength. And this tends to improve during an ascent, when the progress is slow enough to be accompanied with acclimatization and before the wasting of high altitudes becomes marked. The march across Tibet made us tougher and harder. Hence the expiratory force improved. Mosso came to a similar conclusion in the Alps. He made his men perform exercises with dumb-bells, and was surprised to find that they did much more work at a height of 4560 metres than when they performed the same exercises at Turin.

Circulation.—I pass to the changes in the circulation. Blueness of the face and lips, lividity of the nails, coldness of the extremities, were the indications noticed of the impaired circulation at altitudes above 19,000 feet. Three of the members experienced giddiness. One noticed that it was immediately relieved by taking a deep breath. Once the extremities become cold at these high altitudes there is a great difficulty in regaining warmth even in the interior of a sleeping-bag. The pulse is not markedly accelerated while at rest, but increases rapidly on the slightest exertion. Norton's normal pulse is 40, and it was only 60 when he was resting at 27,600 feet. An intermittent pulse may develop at high altitudes. In one instance, after crossing a pass of only 14,000 feet the pulse missed four beats every minute without causing any particular symptoms or distress. This irregularity of the pulse seems to be a common feature. Mosso states that, when on Monte Rosa, he noticed that nearly all the members of his party showed some signs of irregularity of the heart. Hæmorrhages at high altitudes have often been described, from the gums, the lips, the conjunctivæ, the nose. Nothing of the kind occurred amongst the members of our expedition.

The following table shows the changes in the pulse of one individual at successive altitudes above sea-level. The first column gives the pulse-rate when the person is at rest. There is no change except at the highest altitude, 21,000 feet. The second column shows the change that occurs when the person is made to stand up. There is an increase in the pulse-rate somewhat in proportion to the altitude of the experiment. Column 3 shows the change after regulated exercise. The exercise consisted in standing alternately on a chair and on the ground five times in 15 seconds. Again there is a marked increase in the pulse-rate, and this increase is greater the greater the altitude. The last column gives the time in seconds that the pulse takes to return to normal.

Pulse rate of one individual.

Altitude in feet.	*Pulse rate per minute sitting.*	*Pulse rate per minute standing.*	*Pulse rate per minute after regulated exercise.*	*Time in secs. of return of pulse to normal.*
Sea-level	72	72	84	20
7000	72	84	96	15
14,300	72	84	108	40
16,500	72	96	120	20
21,000	108	120	144	20

The blood pressure was taken with a sphygmomanometer in the manner adopted by the Royal Air Force. The following is a table of results. There seems to be no change in the blood pressure definitely associated with increase in height.

Blood pressure at successive altitudes.

Altitude in feet.	R.W.H.		E.O S.		B.B.		G.B.		E.F.N.		J.V.H.		G.L.M.		A.C.I.		T.H.S.		N.E.O.	
	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.	Sys.	Dias.
Sea-level...	120	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7000 ...	130	90	125	90	150	110	130	90	140	80	120	100	120	85	130	100	110	85	100	80
14,300 ...	135	95	115	80	145	85	130	90	135	90	—	—	120	90	130	100	130	90	—	—
16,500 ...	146	104	128	90	140	102	128	93	136	96	126	94	122	78	140	110	120	82	125	95
21,000 ...	138	118	100	80	—	—	110	90	—	—	100	80	—	—	—	—	—	—	—	—

A well-known change that takes place during an ascent to high altitudes is the increase in the number of red corpuscles per unit volume of blood. The conditions on Everest were too rough for these delicate determinations But further west, on the Pamir plateau, I had previously made a series of blood counts up to 18,203 feet. The following table shows the results :—

Date.	*Altitude.*	*Corpuscles per cu. mm.*
April 10	700 feet	4,480,000
May 12	4,390 ,,	5,240,000
May 21	8,000 ,,	6,040,000
May 28	10,000 ,,	6,624,000
May 30	11,960 ,,	6,760,000
June 1	12,400 ,,	6,800,000
June 21	13,300 ,,	7,525,000
June 23	15,600 ,,	7,840,000
June 26	16,900 ,,	7,640,000
July 27	18,200 ,,	8,320,000

There has been an increase in the number of red corpuscles from 4,480,000 at 700 feet to 8,320,000 at 18,200 feet. Another point of interest is that the people who live on the Central Asian plateau have a higher blood count than those at sea-level. The average blood count of the Sarikoli is 7,596,000, of the Kirghiz 7,920,000. The blood count of the European is about 5,000,000, but, on making an ascent to the Tibetan plateau, the corpuscles in his blood rapidly increase until they reach the number normal to the people who live permanently at those heights.

Muscular Power.—Airmen describe great muscular weakness when flying at considerable altitudes. Even working a camera-shutter calls for enormous effort. We did not notice such pronounced effects, probably because our ascent was slow. But if inhalation is inadequate the legs soon become tired. It is not the tiredness of a prolonged walk, but more a heaviness and a lassitude which quickly disappears with a short rest.

The endurance test employed by the Royal Air Force is said to indicate the stability of the medullary centres and the capacity of the individual to resist fatigue. The test consists in blowing a column of mercury to a height of 40 mm. and noting how long the person is able

to sustain it at that height. The pulse is counted in periods of five seconds during the performance of the test. The following table gives the result of this test. Every column shows a diminution in the powers of endurance at each successive height. Take, for example, the first column. At sea-level the subject could sustain the mercury for 45 seconds ; at 21,000 feet for only 15 seconds.

Endurance test.

Altitude in feet.	*Time in secs. Hg maintained at 40 mm.*									
	R.W.H.	E.O.S.	B.B.	G.B.	E.F.N.	G.L.M.	J.V.H.	A.C.I.	T.H.S.	N.E.O.
Sea-level ...	45	—	—	—	—	—	—	—	—	—
7000	35	30	60	50	20	60	35	45	50	50
14,300	30	30	25	40	25	35	—	45	25	—
16,500	23	23	23	15	23	—	17	25	22	20
21,000	15	15	—	15	—	—	10	—	—	—

The pulse-rate was taken during the above test. Some of the results are given below. The first figure in each series shows the normal rate of the pulse during the five seconds before the test begins. This figure is separated from the following figures by a stroke. These following figures give the pulse-rate during each successive period of five seconds throughout the performance of the test. Take, for example, the first line of figures in the first column—6/7.8.9.9.8.7. The 6 is the pulse-rate during the five seconds immediately before the test. The 7 is the pulse-rate during the first five seconds of the test. The remaining figures, 8.9.9.8.7, are the pulse-rates during the successive periods of five seconds until the test ends. In this way we obtain the character of the pulse while the person is undergoing continuous strain.

Pulse-rate in secs. during Endurance test.

Altitude in feet.	E.O.S.	B.B	G.B.	A.C.I.
7000 ...	6/7.8.9.9.8.7	6/6.7.9.9.9.7.6.6.6.5	5/6.6.8.6.5.4.5.5.5	8/9.11.10.8.7.6.6.6.6
14,300 ...	6/6.7.7.7.7.7	6/7.8.8.6.5	5/7.7.7.6.8.6.5.5	8/9.9.11.10.9.9.9.9.8
16,500 ...	6/7.7.8.7	6/9.9.9.3	6/7.8.9	8/11.10.9.7.6
21,000 ...	8/10.8.6	—	9/10.10.6	—

The chief points of interest in this experiment is the marked slowing of the pulse that takes place when the capacity of endurance is beginning to tell. At the commencement of the test the pulse first increases, but after a lapse of 15 to 20 seconds it begins definitely to slow up. This slowing of the pulse is more marked at the higher altitudes. There is an extreme case in the lowest line of figures of column two. The 6/9.9.9.3 indicates that on the commencement of the experiment the pulse immediately rushed up from 6 to 9 beats in the first 5 seconds, and after a lapse of 15 seconds suddenly fell back from 9 to 3. This occurred at 16,500 feet.

Nevertheless, in spite of these vagaries of the pulse, it is remarkable how well the strength is maintained at altitudes over 20,000 feet. This specially strikes us when we observe how animals can move so freely at

such great heights. Ravens and crows used to come to our camp at 21,000 feet. We saw lammergeyers circling round the mountain at 23,000 feet, and choughs followed the climbers to their highest bivouac at 27,000 feet. They moved through the air with perfect ease, though it must have required much greater effort to sustain them than when flying in the denser atmosphere of the plains.

Special Senses.—Changes in the function of the special senses have occasionally been noticed by mountaineers. They describe an impairment of vision, a diminution in hearing, alterations in the taste and smell. Most of our party noticed nothing in this respect, but two members were particularly emphatic in their loss of the sense of taste. One said that "taste was distinctly affected," that "things seemed to have less taste, though there was no change in the character of the flavour." He was unable to taste onions at 19,000 feet. Another found food "distinctly tasteless." At 19,000 feet he could eat a slab of peppermint without strongly appreciating the flavour. Their sense of taste returned on descending to the base camp at 16,500 feet.

Pain.—The only kind of pain which we could attribute to high altitude was the occasional occurrence of a slight headache. Most of the members never experienced it, but some of us noticed it on first reaching the plateau, though, after a few days' acclimatization, it completely disappeared. It usually commenced at the back of the neck, spread into a general mild headache, and disappeared after an hour's rest. Exercise, and particularly stooping, increased it. Lying down quickly brought relief. Our porters also suffered from headache. Many of them asked for headache tablets the first time we passed over into Tibet. Even the inhabitants of the plateau are not immune. It is common to see patches of plaster on their temples and black pigment smeared on their cheeks. These are remedies which they use to alleviate the headache caused by the altitude and wind.

Gastro-intestinal Symptoms.—Loss of appetite is a serious consequence of residence at great heights. Probably it is the cause of much of the wasting that occurs. There is much individual variation in this respect. Some of the climbers maintained that there was no loss of appetite. I found some dislike for food even at the base camp, though this disappeared on acclimatization. Bruce thought that his appetite was unimpaired up to 21,000 feet. At 23,000 feet he found a disinclination for meat, though he still had an appetite for cereals and sweets. At 25,000 feet he lost all appetite for solid food, but could still take coffee and to a less degree soup. Somervell at 27,000 feet found an absolute distaste for solids, though he enjoyed liquids and sweets and fruit. The general opinion seemed to be that sweet things were the most palatable and meat the least palatable above 19,000 feet. There was no suggestion of nausea or vomiting even at the highest altitudes reached.

Diarrhœa is not uncommon. It is usually of a transient nature, and

may be associated with much bile. Occasionally it may be more persistent, and refuse to yield to any treatment until a descent is made to moderate heights. Thirst is a far more important factor. It may be excessive at the end of a hard day, and, owing to the practical difficulties in obtaining water, may cause exhaustion of the climbers and failure of the climb. How best to relieve thirst at the high camps is a most important practical point. The craving for drink is not the result of perspiration, but of the loss of moisture in the respiratory passages from the excessive inhalation of cold dry air. This desiccation of the body at extreme altitudes may result in a great scantiness of urine. One of the climbers at 21,000 feet did not micturate for 16 to 18 hours; another on his descent from 28,000 feet did not do so for 24 hours.

Mental Effects.—High altitudes affect the operations of the mind. One member was confident of a dulling of the will power, a diminution in the strength of purpose, with less and less desire to reach the summit the further he made the ascent. Somervell describes a lack of observance at and above 25,000 feet. Bruce records an enfeeblement of memory. He found an effort in recalling previous events. Above 23,000 feet his ideas became increasingly inaccurate. It was necessary for him to record them immediately, as otherwise they would become forgotten or distorted. I think every one experienced some mental lassitude. Though the mind was clear, yet there was a disinclination for effort. It was far more pleasant to sit about than to do a job of work that required thought. We did not notice any peevishness or petulance, though I suspect that high altitudes would cause unsociability in a party less perfectly harmonious than ours. Though mental work is a burden at high altitudes, yet with an effort it can be done. One physiologist has said that sustained mental work is out of the question at anything over 10,000 feet. We certainly could not agree with this. Those who have read Norton's despatches to the *Times*, especially one dictated at Camp III., when he was burdened with anxiety and partially blind, will admit that this effort from 21,000 feet was not a bad intellectual performance. The main effect of altitude is a mental laziness which determination can overcome.

I made some mental tests on the members of the party. These tests were very simple. The first was a multiplication test. It consisted in multiplying the figures 123456789 by 7. The second was a division test, and consisted in dividing the same series of figures by 9. A record was made at successive altitudes of the time taken to do these sums. Probably these tests were far too simple. By an effort of concentration they could be easily done, and thus the effect of altitude was not properly shown. I give the results for what they are worth. They show no definite deterioration of mental activity. It will not please the members of the next expedition to hear that more complicated and worrying tests are required.

Multiplication test, showing time in secs. for completion of sum.

Altitude in feet.	R.W.H.	B.B.	E.F.N.	G.L.M.	T.H.S.	E.O.S.	G.B.	J.V.H.	A.C.I.	N.E.O.
0	20	—	—	—	—	—	—	—	—	—
7000	25	25	27	13	40	43	40	35	25	80
14,300	25	24	19	15	28	43	25	—	28	—
16,500	18	23	28	17	40	35	35	55	35	30
21,000	17	—	—	—	—	35	27	40	—	—

Division test. Showing time in secs. for completion of sum.

Altitude in feet	R.W.H.	B.B.	E.F.N.	G.L.M.	T.H.S.	E.O.S.	G.B.	J.V.H.	A.C.I.	N.E.O.
0	30		—	—	—	—	—	—	—	—
7000	20	20	30	10	25	55	15	35	15	45
14,300	28	20	13	23	20	45	17	—	17	—
16,500	13	27	23	17	40	38	23	43	20	50
21,000	15	—	—	—	—	40	13	59	—	—

The knee-jerks were examined at successive altitudes. In no case did they seem in any way affected by the height. Three of the party developed mild tremors: one a tremor of the eyelids at 14,000 feet, two a fine tremor of the fingers at 21,000 feet. This was an indication of nervous strain. It was a common sign of exhaustion and anxiety amongst those serving in the great war.

Sleep.—To my mind insomnia was an unpleasant feature. But there were others who suffered from no lack of sleep except when they happened to be cold. Bruce on two nights slept for more than ten hours at 21,000 feet. He had a fair, but somewhat broken, night at 23,000 feet. He had about two hours' sleep at the beginning of the night, then a long period of sleeplessness, then a few more hours' sleep in the morning, when at 25,000 feet. He always slept with his head raised, having learned the trick on the previous expedition. Somervell slept well at 25,000 feet, and had two good spells of sleep at 27,000 feet. Norton, however, takes the record. He slept well and had an excellent night at 27,000 feet. A point about high altitude sleeplessness is the fact that it is not associated with restlessness, nor does it cause weariness the next day. One lies awake, but does not toss about; nor is the sleep accompanied with irritable dreams.

Glacier Lassitude.—A distinct feature in the Mount Everest region is the very pronounced glacier lassitude which develops over tracts of ice. This was most marked on the Rongbuk glacier, especially when passing through a trough in the ice at an altitude of about 20,000 feet. The trough was a remarkable feature, being girt on either side with walls of ice in many places hewn into fantastic pinnacles and ornamented with pyramidal spires. In this trough there was a peculiar sapping of energy, a weakness of the legs, and a disinclination to move. It was not a breathlessness due to exertion, but a loss of muscular power. There was a feeling of prostration. One seemed to drag oneself along, instead of going with the usual strength. A profuse sweating was not uncommon. It was something like the oppression experienced when

marching through a hot moist jungle in the rains. The lassitude appeared immediately after stepping on to the glacier; it was as quickly relieved on again reaching rock or moraine. It was most noticeable in the absence of wind and in the middle of the day when the sun was strong. It was absent late at evening and in the early morning, and was less marked on cloudy days.

The cause of this lassitude is easily explained. The conditions for its development are a sheet of ice, a hot sun, and a still air. The sun melts the superficial layer of the ice. The lowest stratum of the atmosphere becomes saturated with moisture but does not rise owing to its being chilled by contact with the ice. Thus, when on the glacier, one is in a saturated atmosphere, and this, in conjunction with the high altitude, is sufficient to cause the unpleasant effects.

We did not notice that other atmospheric conditions had any special influence on these high altitude symptoms. This was different from my experiences in the western Himalaya. There, on two occasions, our party climbed the same peak to a height of 18,203 feet. During the first ascent the sky was clear, the air was free from moisture, and our disability was slight. On the second occasion the conditions were different. The sky was dark, stormy weather was imminent, and the atmosphere felt heavy and damp. Our distress on this second occasion was acute. Every few paces found us gasping for breath, and we had repeatedly to make short halts. The same explanation applies to this as in the case of the glacier lassitude. On the second ascent the atmosphere was laden with moisture. The free evaporation of perspiration was checked, and, as a consequence, the high altitude symptoms were increased.

Individual Variation.—The experiences of the party, as already detailed, indicate considerable individual variation with respect to oxygen want. It was obvious that some of us breathed more laboriously than others. One suffered from headache, another did not; one lost the sense of taste, another observed no such change; one was sleepless at comparatively low altitudes, another slept well at the highest camps. One member seemed particularly resistant to the lassitude that occurs over snow and ice. All were agreed that the Sherpa porters suffered, on an average, less than Europeans. Their power of carrying loads was extraordinary. They went with loads as fast as did the climbers without loads. It was not that they were muscularly more powerful than we. Probably their actual strength was less. It was their capacity to carry that was so much greater. This must be due to their permanent habitations being at altitudes of 12,000 to 14,000 feet, and to the fact that they habitually carry loads over passes of 16,000 and 18,000 feet.

Oxygen.—To what extent does the breathing of oxygen alleviate the symptoms already described? Theoretically we should expect an enormous benefit. We know of its great value in balloon ascents, which could not be made to extreme altitudes unless oxygen was breathed. But our

evidence on the subject is most unsatisfactory. The two climbers who could have told us most about it have perished on the mountain. Bruce used oxygen on his ascent to the North Col—that is, between 21,000 and 23,000 feet. He noticed scarcely any benefit. Odell used it at the same altitude and considered that it gave no relief. Later he used it between 25,000 and 27,000 feet. There the oxygen seemed to relieve the breathing and diminish the tiredness of the legs. He thinks it may have helped to keep up the temperature. Its use produced an uncomfortable drying of the throat which necessitated frequent swallowing and expectoration. He abandoned the oxygen at 27,000 feet and descended easily without it. It is remarkable how little benefit was obtained from the oxygen compared with the experiences of the previous expedition.

Acclimatization.—I pass to the problem of acclimatization. When we compare a rapid with a gradual ascent we see how powerful is this factor of adaptation to increasing heights. Haldane describes the condition of visitors after a rapid ascent of Pike's Peak to a height of only 14,100 feet. " Many persons walked or rode up during the night to see the sun rise, especially on Sunday morning, and the scene in the restaurant and on the platform outside can only be likened to that on the deck or in the cabin of a cross-channel steamer during rough weather." Now the altitude at which this scene took place was about the same as that of the Tibetan plateau. But our ascent to the plateau was gradual, and therefore accompanied by acclimatization. As a consequence we felt scarcely any distress. We were quite comfortable at a height where, if our ascent had been rapidly made, we should have been like the nauseated visitors on Pike's Peak.

But the contrast is more marked if we compare our progress with an air ascent. In the year 1875 Tissandier and his two companions made their famous ascent in a balloon from Paris. They were provided with oxygen but were unable to make use of it. Tissandier fainted at 26,500 feet, and when he recovered consciousness the balloon was descending and his companions were dead. The balloon had reached an altitude of 27,950 feet. This was a rapid ascent with no acclimatization. The result was death between 26,000 and 28,000 feet even when sitting quietly in a balloon. Compare this with a gradual attack on Mount Everest. Climbers without oxygen have ascended the mountain to 28,000 feet, somewhere about the same height where death occurred in the balloon. Yet at that altitude they were capable of strenuous effort; they showed no indication of fainting; they could sleep well at a slightly lower elevation, and were comparatively comfortable so long as they were at rest. The difference in the two ascents is due to acclimatization, without which any attempt to reach the summit of Mount Everest would be altogether out of the question. The fact is that balloon ascents and experiments in air-chambers are not at all comparable to the conditions of a prolonged climb.

A special point which the expedition of this year taught us is that persons who have once experienced high altitudes will acclimatize very much more rapidly than those entering them for the first time. Those of our party who had been on two expeditions were unanimous in the view that they suffered less on the second than on the first occasion. One said that his mind was much more active than it was in 1922, another that he reached Camp III. with much less difficulty, another that he had not to breathe deeply at night as he had found necessary on the previous expedition. Also it was obvious that the new members of the party were distinctly more affected than the old. This is a point of practical importance. It means that, other things being equal, old hands will acclimatize more rapidly and be in a fitter state to climb the mountain than will be a party of fresh recruits. Even aviators have noticed the same thing. Although their ascents are so quick and short, yet they say that they get accustomed to the height. The body seems, as it were, to become trained by one experience, and therefore to make the necessary adjustments more easily on reaching high altitudes a second time.

To what height can acclimatization continue? There seems to be no doubt of a steady improvement at 19,000 feet. Shebbeare spent over a month at that altitude in Camp II. At first he found the ascent to Camp III. very laborious, but at the end of a month could do it with ease, and on the last day did it in the record time of 1 hour 55 minutes. Odell remained for ten days at 23,000 feet, and said that he certainly felt better as a result of this. Somervell believed that acclimatization took place at 24,000 feet. But we must remember that while acclimatization is in progress there may be physical deterioration at the same time. Though the body is becoming more accustomed to the altitude, yet simultaneously it is losing both in weight and strength. Dr. Kellas puts the important question: "Is it possible to become sufficiently acclimatized to altitudes of 24,000 feet to 26,000 feet to enable one to climb to over 29,000 feet?" I think that most of our party would reply in the affirmative. Two of them have already reached 28,000 feet aided by no other power beyond their own natural capacities for acclimatization.

After-Effects.—A note as to the after-effects consequent on residence at the high camps. The climbers were examined before we left the mountain. All of them showed signs of dilatation of the heart; in two it was decidedly marked. All were debilitated. All had wasted considerably—probably as much as 1½ to 2 stone. The porters too had lost much weight. Barcroft observed the same effect on his expedition to Peru. Loss of weight occurred in all the members of his party, the most marked being a decline from 155 to 131 lbs. in twenty-seven days.

Those of the expedition who had been badly frostbitten required treatment for weeks after we had left the mountain. Frostbite showed itself in two varieties: the moist form with large blisters full of fluid and the dry gangrenous type. Snow-blindness also may need after-treatment.

A point of interest was that Norton developed a severe attack of blindness when at high altitudes though in the absence of snow. At 28,000 feet he was on bare rock. He thought it unnecessary to use his snow-glasses, and on the next day he was completely blind. The sun's rays in this thin air can cause a most acute attack of conjunctivitis even when reflected from bare dark rock.

Thus life on the mountain causes physical deterioration. Improvement followed on our return to the base camp, with increase in appetite and better sleep. Finally we descended into the Rongshar valley, where, at the pleasant altitude of 10,000 feet, all were quickly restored to health.

Conclusion.—A last word on the possibility of reaching the summit. In the year 1916, at an afternoon meeting of this society, Dr. Kellas showed an interesting dissociation curve of Oxy-Hæmoglobin in blood. On this curve he plotted the heights of some well-known mountains. From it he drew the following deductions. "The curve," he said, "is very suggestive. It shows that the strain on the climber is nearly negligible up to 10,000 feet, and at about 15,000 feet becomes appreciable; but one must pass above 20,000 feet before the steepening of the curve indicates that the mountaineer will have to adapt himself carefully to his aerial environment. At 23,000 feet the curve is getting much steeper, and the climber will obviously be put on his mettle above 25,000 feet, for the curve then attains its steepest. Every 1000 feet still higher must mean considerably increased difficulty, and the climber near the summit of Mount Everest will probably be on his last reserves in the way of acclimatization and strength." This deduction was made before the first assault on Everest, and I think that we can now safely say that our practical experiences bear it out.

I think that climbers will reach the summit of Mount Everest even without the help of oxygen. Though the physiological difficulties are undoubtedly severe, yet they can be overcome. But the condition of the weather must be more favourable than this year. The climbers must be in perfect health and in first-rate training; they must be men of exceptional powers of endurance, and their capacity for acclimatization must be complete.

Before the paper the PRESIDENT said: We open our session of afternoon papers with a statement by Major Hingston showing the effects which high altitudes have upon human physiology. These results, of course, are interesting, because the Mount Everest Expedition has reached greater altitudes than any expeditions which have preceded it, and any general conclusions which may be drawn from such results consequently must have an important bearing upon the whole question. I will now ask Major Hingston if he will give us his paper.

Major Hingston then read the paper printed above, and a discussion followed.

Air-Commodore MUNRO (Director, Medical Service, R.A.F.): I am pleased to have had the opportunity of hearing the paper; all the more so as

in some ways I had a hand in Major Hingston joining the Expedition, in that I was partly instrumental in getting the Government of India to allow him to leave 'Iraq, where he was serving with the Royal Air Force. The paper is of particular interest to us in the Medical Service of the Royal Air Force, of which I am the Director. Our problem, of course, is very different in that airmen go to great altitudes in very short spaces of time; in other words, we have not to deal with the problem of acclimatization mentioned by Major Hingston. But we do need in the Royal Air Force the same standards of physical fitness; men need to be in perfect physical condition. It is, therefore, of great interest to us to see the results of our own tests employed at these high altitudes, and I should like, on behalf of the Medical Service, to thank Major Hingston very much for so kindly undertaking to do these tests for us. I congratulate him very heartily upon the paper he has just read.

Professor J. B. HALDANE, F.R.S. (Oxford University): I think this paper is one of extraordinary interest to physiologists, and I beg to congratulate Major Hingston on its clearness and simplicity. He avoids—I have no doubt purposely—certain physiological points which are just now the subject of acute contention.

I should like to make one or two comments on the points raised. First, in regard to breathing at high altitudes. What is the cause of the enormous increase in breathing during work? Proportional increase is present during rest too, no doubt, but is not so noticeable. Is the cause of increased breathing when at work want of oxygen immediately? It is certainly want of oxygen in the long run; but there is no evidence that it is immediate want which causes it chiefly. Excessive panting is, I have no doubt, due to accumulation of carbon dioxide with the blood in the condition in which it is in an acclimatized person at high altitudes. During the process of acclimatization, as Kellas, Kennaway, and I showed, the blood loses alkali, so that in an acclimatized person the amount of carbon dioxide in it must be kept much lower in order to preserve the normal alkalinity. To keep the carbon dioxide low there must be greatly increased breathing, which during work causes much distress. It is possible to reproduce that condition artificially at sea-level by means which my son discovered three or four years ago, namely, by producing acidosis by the administration of ammonium chloride, and I shall not easily forget the experiment. When he was sitting at rest he was breathing deeply without discomfort; but when he went in the street for a stroll, walking about 3 miles an hour, he was panting as if he were running. He had to keep down the carbon dioxide. I was familiar with this effect in connection with the effects of carbon dioxide in the air of submarines, mines, and helmets of divers. The capacity for any considerable work is destroyed by excessive panting, as would exist on Mount Everest. If the person is unacclimatized oxygen has an enormous beneficial effect, which I can testify to from experiments in steel chambers. If he is acclimatized he will breathe not quite as much as before, but nearly as much, because it is not mainly want of oxygen which is worrying immediately, but excess of carbon dioxide. Hence the somewhat disappointing effects of oxygen on well-acclimatized persons.

The experiments on holding the breath are also very interesting, especially the time during which breath can be held. There is, I think, no doubt from physiological evidence that it is mainly want of oxygen that limits the holding of the breath at high altitudes. There is very little oxygen in the lungs, and it runs down very rapidly if the breath is held.

Mr. J. BARCROFT, F.R.S. (Cambridge University): I should like, first,

to add my congratulations and, still more, my thanks to Major Hingston for having given us the data which he has put before us this afternoon. It is really a great matter that on an Expedition of this sort reliable scientific data should be accumulated, and it is a great advantage to have had on the Expedition a person who has with such care and such evident exactitude brought us home definite information. I feel somewhat diffident in saying anything at all, because, of course, a little knowledge is a dangerous thing, and the little knowledge that I have on this subject has been gained for the most part at altitudes of about 15,000 feet or thereabouts, and therefore at altitudes which in Major Hingston's mind, if I could see right into it, are really quite low and possibly altitudes which I should not discuss at all. My only excuse is that I imagine some lower altitudes affect lesser men in the way the higher ones affect those best suited to compete with them.

There are one or two general matters most interesting to physiologists, and first, why in practice does oxygen not seem to be of more use? As Major Hingston said, in theory one would have thought—perhaps wrongly—that oxygen should have solved their difficulties. If one considers why it has not done so, a number of reasons come into the mind. Firstly, that their difficulties were not altogether in regard to oxygen, but were associated with cold and other such things. I take it that those difficulties have all been eliminated. And then there is another possibility about which I have no knowledge, namely, the extent to which the party were drilled in the use of oxygen beforehand. Of course, with all forms of respiratory apparatus of that kind drill is essential, because when you use it under difficult circumstances you will almost invariably come to grief if you have only used it under easy circumstances beforehand. One would like a little information as to how much oxygen the climbers got; whether their tubes froze up, and so on; and whether they were getting the adequate or calculated amount. Let me pass over that and assume they were; there comes the question, Why is it, if they were getting oxygen, it did not help them? That is very interesting and significant from the point of view of the physiologist, from the point of view of the doctor, and from the point of view of the next Mount Everest Expedition.

I think that probably we will all agree that the fundamental trouble at this altitude on Mount Everest is one of oxygen, but whether the cumulative effects of want of oxygen over days and weeks can be abolished by the immediate breathing of oxygen is, I think, really the kernel of the matter and is a question on which we have but little data. The information brought by Major Hingston appears to be extremely to the point and should be sifted very carefully.

There is another point of rather general interest, I think, in connection with the pulse, namely, that in the last column of a table of Major Hingston's tabulated observations there were some very irregular figures, showing that the pulse came back to its normal period rather rapidly at high altitudes, when one might have expected it to come back rather slowly. Those figures were to me of extreme interest, because the irregularities began to show about 7000 feet, and at about the same altitude I got the same results in the Andes. I am glad that I am not alone in getting those results. Also during the war, Dr. Hunt, Dr. Price-Jones, and Miss Dufton (now Mrs. Wilson) were working on gassed cases in this connection and doing exercises, and they got the quick return of the pulse to the normal figure and even below it, and then going up and down again, and so on, where one would have expected a slow and gradual return. That evidently was what we physiologists call a *vagal*

affaire, and rather significant, because the return of the pulse is used as a test for insurance data, and so on, and this seems to be a sort of anomalous condition in which that test is invalid.

Lastly, I wish to comment upon something which Major Hingston said. He found that there was very little difference in the power to do arithmetic at great heights as compared with low altitudes. He kept a record of the time taken to do multiplication tests, and it was shown that by an effort of concentration they could easily be done. That, indeed, is so, but he also said, " It will not please the members of the next expedition to hear that more complicated and worrying tests are required." I think Major Hingston will agree with me that that is just the point. Down here it would not " displease " us to know we had to do tests rather more complicated than simple division, but up there that sort of thing is most worrying.

Professor LEONARD HILL, F.R.S. (University of London): I would like to add my word of admiration of this paper. I think Major Hingston has put forward with extraordinary simplicity and clearness conclusions which have the greatest interest and value to us physiologists. One point which has come out is a confirmation of the value of the Air Force tests which were introduced by Group-Captain Martin Flack. I quite agree with Major Hingston as to his interpretation of the results of the expiratory force test; these are due to extraordinary development of the breathing muscles through training and going up to these great altitudes. The Air Force men who fail in the test through fatigue or after crashing are in a condition of nervous debility, and have not got that power which is developed by long training in climbing to high altitudes. That is why there is a discrepancy in this test. The other tests come out exactly as one would expect, showing diminished efficiency at great altitudes.

Another point that struck me as being of great interest was the immense increase in the number of red corpuscles coupled with the great increase in breathing power. By these two means compensation seems to be set up by which climbing can be done at great altitudes. Dr. Haldane, who is a great authority on all these matters, has suggested that the lung has the power of secreting oxygen into the blood. I do not know—he has not told us to-day—what he feels about the results in regard to that matter; whether he thinks it upholds his views or not. My own opinion is that by acclimatization, by the increase of red corpuscles, by the great power of increasing breathing through training, and possibly by loss of weight, which is so pronounced, the loss of weight lightening the body and making the load less—that by all these means the power to climb these altitudes is reached, and we need not bring in the supposed secretory power of the pulmonary epithelium.

Then another point which interested me very much was the loss of efficiency in that glacial trough where the members of the party were exposed to strong sun and a windless wet atmosphere which produced sweating. That is exactly what I expected. I have often read of such places in Alpine climbs where mountain sickness has been increased, and it has always been my view, and I am pleased to hear it confirmed, that this was due to the very conditions described by Major Hingston. The blood under such conditions is determined in much greater volume to the skin. One of the great points which enables people to climb to these immense heights is the great cold which constricts the blood-vessels, drives the blood into the internal viscera and muscles, and keeps it out of the skin. The skin as a radiator comes less into play; the heat-loss is taking place largely by evaporation from the lung, as Major Hingston showed,

and cooling of the body is brought about by convection, due to cold wind, without sweating coming into play and with the least quantity of blood in the skin. All that is very favourable to meeting the conditions. We have found, when working in hot places, that what fails is the heart. The pulse-rate goes up, and if it goes up much above 140 our man begins to fail and cannot go on with the ergometer test. In exposed places on Mount Everest we have the heart saved from having to send blood in large quantity to the skin in order to keep the body cool because the cooling is brought about without that means. But directly you get into the hot troughs described, with sun pouring down and the air saturated, then the sweating comes into play and more blood is sent to the skin, and the heart has to do the work of pumping it to the skin in order to cool the body as well as pump to the muscles in order to keep up muscular energy. That is why the failure takes place. If we could get pulse records made in those troughs I think they would be of great interest.

There is another point—the breathing of very dry cold air may make it easier for oxygen to diffuse through the breathing membrane into the blood, while the breathing of warm saturated air by making the film of moisture thicker on the breathing membrane may lessen the rate of diffusion. We know that the breathing of war gas poisons by increasing the exudation of fluid opposes the passage of oxygen through the breathing membrane.

Professor BOYCOTT, F.R.S. (University College Hospital): I am glad to have the opportunity of thanking Major Hingston very much indeed for this interesting and concise account of the symptoms produced by high altitudes. I will not detain the meeting by making comments on the various points, but I would like to make one suggestion that may possibly be practicable. The body evidently does a great variety of different things in trying to compensate for the strain entailed in reaching high altitudes. Among the compensatory processes is the increase of the red corpuscles in the blood, which has been shown by Professors Haldane and Douglas in the Pike's Peak Expedition to be due to the making of fresh red corpuscles in the body. That is a process that in man takes some little time to occur; it may take many days or perhaps several weeks before you get the result, and I take it it might be an advantage if you could accelerate that process so that it took place in a few days. As a matter of fact, if you give the body practice in reproducing red corpuscles you can increase the capacity to do so. If you take an animal and take away one-third of the red corpuscles it will replace them in about twenty days; if you do it again on the same animal it will grow the same number of red corpuscles at the end of six, seven, or eight days; and again you can still further accelerate the process. I take it that one may obviously produce exactly the same thing in man, and that he need not have practice by going to high altitudes because it can be done by bleeding a person in the ordinary way. That is to say, you might very much improve the capacity for going to these high altitudes by simply having an old-fashioned course of bleeding before you begin.

Dr. T. G. LONGSTAFF: Major Hingston has omitted all reference to the most remarkable of his achievements as medical officer to the Expedition of 1924. So soon as he heard that Colonel Norton was snow-blind on the North Col after his great climb, he just walked straight up to over 23,000 feet and fetched him down—blind. Now Major Hingston does not admit to being a mountaineer: but all mountaineers took off their hats to him when they heard of this exploit. They all realized the problem involved in taking a blind man down such a place as the North Col was this year: it was a proposition that the sturdiest climber might well have recoiled from. I do not think the lecturer

brings out the magnitude of the demands that must be made on will-power in order to overcome the mental and moral laziness from which we all suffer at high altitudes. This attack on our mentality is the complement of the attack on our vitality which is shown by reduced resistance to cold and fatigue. I feel that very few people at all realize the extraordinary degree of resolution and determination which is required to attain success. The man who at great altitudes succeeds in taking photographs, or collecting specimens, or in observing and noting physiological effects, possesses the supreme attribute of the successful mountaineer. You may safely back such an one as a winner.

Dr. MALCOLM L. HEPBURN: I should like, first of all, to thank you for the compliment you have paid me in asking me to join in this discussion. I feel it is a compliment which I do not altogether deserve, and any work I may have done on the subject was carried out between the years 1894 and 1902. I have not done any since, and thus I feel that I am in a somewhat false position. However, to justify myself in your eyes I should like to say one or two things which have come to my mind from studying work that has been carried on since 1902. In a paper in the *Alpine Journal* for that year I analyzed all the numberless symptoms complained of on the mountains, and came to the conclusion that many of them arose from ordinary fatigue due to either pathological or physiological causes, often aggravated by want of training, imperfect respiratory mechanism, inadequate or improper food, thus leading to gastric disorders. The cold, privations, anxieties, and exposure found in ordinary mountain climbing lower the resistance, as Dr. Longstaff has told you, and contribute to the onset of fatigue. I think few people realize how enormously they are accentuated in the attempt to conquer the highest mountain in the world. The amount of work measured in foot-pounds is probably greater than in any other form of muscular exercise, and cannot be undertaken by any one unless physically sound and after an amount of training which far exceeds what is necessary for the most strenuous work at sea-level, and not the least important of which is the ingestion of a proper and suitable form of diet.

I also analyzed in the same paper the symptoms complained of by sufferers from other forms of diminished atmospheric pressure. In addition to mountaineers there are three other classes of people who suffer, or may be made to suffer, in this way; they are workers in caissons, aeronauts, and those working in the laboratory at sea-level. I agree with Major Hingston that these are of very little value for the purpose for which we are gathered here, which is to inquire into the physiological effects of high altitudes. I think this subject should be treated alone.

A further conclusion I came to after a study of the work of other scientific observers was, that after eliminating the question of direct or indirect fatigue it was possible to isolate a set of symptoms which were definitely and constantly associated with climbing in the higher ranges. These are well known, but I will say briefly that they are: While at rest, a feeling of lassitude and disinclination for exertion, associated with excessive breathlessness and its accompanying discomforts on the slightest manifestation of muscular effort.

I have also pointed out the similarity between these symptoms and those complained of by patients suffering fron anæmia at sea-level. In the latter case we have poorness of hæmoglobin in the presence of a full supply of oxygen, as opposed to richness of hæmoglobin in the presence of a poor supply of oxygen in mountain climbing.

I would like to remind you, in further justification of my position here, that in a paper in the St. Bartholomew's Hospital Reports in 1895 I said that

provided (1) proper organization could be carried through, and (2) the weather would allow of sufficient time for the establishment of the necessary number of camps on the mountain; (3) the mountain to be ascended were relatively easy; and (4) the carrying of oxygen were rendered feasible, the physiological effects of high altitude would not prevent the highest point on the Earth's surface from being ascended by man. This opinion was gravely challenged at the time, and I still have private letters in my possession from high climbers—Mr. Edward Whymper, Sir Martin Conway, and Mr. Douglas Freshfield—sternly rebuking me for my youthful optimism.

As regards the means to be employed for overcoming the difficulties in the future: The men to be chosen must be physically sound and show definite signs of being able to take the fullest advantage of the opportunity for acclimatization so as to eliminate as far as possible the symptoms due to fatigue; but this can only be tested on the mountains at heights of 16,000 feet and over. Their individual power of increasing the number of red cells in the blood should be investigated; their capacity for accomplishing excessive muscular effort, entailed in climbing and carrying, in the most economical way should be encouraged. Special idiosyncrasies, such as sleeplessness, varying powers of ingestion and assimilation of food, variation in pulse-rate from the normal, should be noted, and all this with a view to making the symptoms of fatigue as remote as possible. The food most necessary for muscular exercise has been proved long ago to be of a carbohydrate nature and especially sugar. This again has been emphasized by Major Hingston. During the war it was found that large doses of acid sodium phosphate were especially valuable in increasing the capacity for muscular work. I do not know whether climbers have tried that.

Finally, we come to the efficacy or otherwise of the inhalation of oxygen on the mountains. No doubt, if it can be utilized effectively the benefit to be derived from it would be incalculable. There is no question that it is of value in attaining high altitudes, and in a position of rest a height of 40,000 feet has been safely reached by this method. It has also been definitely proved by Dr. Leonard Hill, Commander Martin Flack, and Mr. Just (in 1908) that it is of special value in the performance of muscular work, and particularly in postponing the onset of fatigue. At the same time, it is possible that the increase in the number of red blood-cells may so increase the oxygen-carrying power of the blood that it enables the blood to carry an indefinite amount of oxygen, though each individual corpuscle may not be saturated. In this case inhalation should be useful, since very little oxygen goes into solution. But against this, it is possible that the benefit in the performance of muscular work may be exactly counterbalanced by the increased effort entailed in transport. Thus we see, once more, the differences in individuality which enable some climbers to attain great heights without oxygen and others with its aid; but if it can be proved that it makes the ascent easier it ought to be used.

I consider I am justified in the optimism I felt thirty years ago, since Himalayan explorers, physically sound, properly trained and equipped have reached higher and higher altitudes, eventually attaining a record of over 28,000 feet, some with and some without oxygen.

Dr. PRICE-JONES (University College Hospital, Med. School): I have nothing special to say in a meeting such as this, but I am interested because I have received from Dr. Hingston some blood films which were taken at different altitudes. I am examining them, and I hope they will show some interesting results. What I think is the chief feature is the fact that Major

Hingston should have had the will-power and energy to have taken these specimens at the altitudes at which they were taken.

A FELLOW: Might I venture to add a word? In the Andean range there is a railway on which the trains leave Lima at 7 o'clock in the morning and ascend to Cerro de Pasco and other districts in that mountainous region. The train staff are to the last degree unaffected by any differences of altitude, but the passengers leave very palpable evidence alongside the line from hæmorrhage, and the more so when the train emerges from a tunnel which is above the snow-line. The suffocation in that summit tunnel is beyond conception, so that both passengers and staff have a very severe trial indeed. That bears out what Dr. Leonard Hill has said, that it is largely a matter of accustoming one's physiological condition. But the fact remains that this train leaves every morning at 7 o'clock, ascends to Cerro de Pasco, arrives there before 4 p.m., so that there is abundant experience of a very practical character. Very much the same is noticeable in Colorado, where on Pike's Peak the altitude of the tunnel is 14,442 feet, whilst the altitude of the tunnel on the Lima line is 15,212 feet above sea. At the former, however, there are evidences along the railway to a greater degree than on the Cerro de Pasco line.

The PRESIDENT: It only remains for me to express the gratitude of the Society to Major Hingston and to the other eminent speakers who have taken part in this afternoon's discussion. I was particularly interested in what was said by Professor Leonard Hill, because his remarks bear out to a great extent my own experience in these matters, namely, that the extent of the altitude is by no means the only factor in bringing about physiological changes in the system and consequent bodily discomfort. I have not climbed to any very great altitudes, but I have reached 19,000 feet in the west of Tibet without any discomfort of any kind. It is true that on that occasion I had undergone a pretty prolonged period of acclimatization, for I had been living at altitudes varying from 10,000 to 14,000 or 15,000 feet for a considerable time, and it may be that that accounts for the fact that I experienced no discomfort on climbing to 19,000 feet. On the other hand, in other parts of the Himalayan Mountains where there is a greater degree of humidity in the atmosphere, I have experienced considerable discomfort at very much lower altitudes; not only that, but I have found great variation in different places not very widely separated from one another. I think probably Sir Francis Younghusband may recall a certain spot in the north-east of Sikkim which has a particularly bad name for producing bodily discomfort in spite of the fact that its altitude is not very great, probably only about 13,000 feet, whereas the surrounding country runs up to a much greater altitude—16,000 to 18,000 feet—and does appear to affect one in the same way. It seems to me that these somewhat curious results are explained, to a great extent, by what Professor Leonard Hill said in the course of the discussion.

Let me, on behalf of the audience, in the first place express our gratitude to Major Hingston for the care which he has taken in compiling these results of his recent experience. I fully agree with those who congratulate him upon the will-power which enabled him at these great altitudes to sit down methodically and carry out these investigations, and I feel sure that the result of his labours will not only be of academic interest to physiologists, but will probably prove of great practical value to any subsequent expedition which may attempt to reach the summit of Mount Everest.

THE MOUNT EVEREST FILM OF 1924

IN presenting the kinematograph record of the Mount Everest Expedition of 1924, Captain Noel and his collaborators have been faced with the difficulty that whereas the expedition followed exactly the same route as in 1922, camped in the same places up to the North Col, and went the same—the only—way up the mountain, it was necessary this year to approach the subject from a different angle : not only to avoid repetition of scenes already familiar, but for the higher and paramount motive admirably expressed by him in his opening speech at the Scala Theatre on the evening of December 9. He was resolved that nothing should be done to vulgarize the tragedy of the last high climb.

The new record then lays most stress upon natural beauty : the marvellous ice-scenery of the trough in the East Rongbuk glacier, the exquisite effects of cloud shadow and sunset upon the glittering pinnacles. Through this cold unearthly scene we see the expedition passing, on its way to the high camps. From his eyrie on the North Peak Captain Noel photographed the climbing parties at long range with a mighty lens of great aperture and focal length, so that one may actually see the climbers moving on the mountain at somewhere near their extreme heights : a marvel of photographic technique. A few days later Odell at Camp IV. on the North Col laid out the signal of six blankets on the snow, to say that the search had failed, the camps had been found empty, and that hope must be abandoned. We follow his movements on the film from a great distance, as the party at Camp III. must have followed them through the telescope : and that is the nearest we come to the fatal accident. It is a sympathetic and moving record, and could not, we think, have been better done.

Most interesting and important are the pictures of the final pyramid, showing much more detail of its surface and its difficulties than we have seen before—no small triumph for the kinematograph camera in competition with the many cameras that have been turned upon that summit in the last few years. But indeed the photography is excellent throughout, and Captain Noel deserves our sincere congratulations on his success. In the discussion following Major Hingston's paper (published in this number of the *Journal*) all speakers agreed on the extraordinary difficulty of concentrating on a job to be done, and we may recall how Colonel Norton insisted on the extreme distaste they all felt for the simple operations of cooking and eating at the high camps. Let us imagine, then, what it must be to operate a complicated machine like a kinematograph camera with an electric drive and a lens as big as itself. As the product of supreme skill the film earns our respectful admiration. But that is a refinement, and not to be insisted upon, lest we miss appreciation of the subject in praising the technique.

The subject is worthy of the skill. In the film of 1922 we saw more

variety of incident, with exciting side-shows. The record of 1924 is deliberately more restrained, more artistic, and worthy of its title, The Epic of Mount Everest. We heartily commend these moving pictures to the notice of all our Fellows, and urge them not to miss the opportunity of seeing a film quite unlike the last.

As a prologue to the representation Captain Noel has brought from Tibet seven Lamas from a monastery near Gyantse, and one of the Sherpa porters, all in the care of Mr. John Macdonald, son of the British trade-agent at Chumbi. We see and hear the celebrated 10-foot trumpets in a little scene of Lama life that is designed to create the right atmosphere. The incidental music introduces some of the charming Tibetan airs that Mr. Somervell collected in 1922. We regret only the unavoidable absence of a lecture such as accompanied the first film, for which the sub-titles, with a touch of the professional jargon, are a poor substitute.

TWO ANCIENT MONUMENTS IN SOUTHERN KURDISTAN

C. J. Edmonds

THE Qara Dagh is a double range of cretaceous limestone, rising to a height of over 5000 feet. Between the two jagged ridges is a tract of elevated oak forest, about three-quarters of a mile wide, called Naokopi. Although between it and the line of the great Kifri–Kirkuk–Altun Kopri road, which divides Arab from Kurd, there is a belt some 45 miles across of exclusively Kurdish territory, it is at the Qara Dagh that the real Kurdistan seems to begin. For this belt consists, for the most part, of the most forbidding scenery imaginable—broken " bad lands " of clay, gypsum, and sandstone, crumbling and dusty in summer, slippery and treacherous in their narrow paths after rain. To the north of the range lies another world, park-like, oak-grown country, with blackberry hedges and orchards, running brooks, and tobacco gardens. Near its south-eastern end the Qara Dagh range contains two striking monuments of antiquity.

The first is out in the open at the southern foot of the Paikuli Pass, on the main migration road of the nomad Jaf, and is called by the Kurds *Butkhana,* the idol house. Its existence is well known, the ruin having been discovered by Rawlinson in 1844, and more recently examined by the German archæologist, Dr. Ernest Herzfeld, in 1911, 1913, and, under British auspices, in 1923. The original building, which stands on a natural hillock, has collapsed, and all that remains is a core of stone and mortar, about 12 feet high on the north, the highest side. But over the hillside are scattered numerous blocks of dressed stone, a few with mouldings, many with fragments of a third-century bi-lingual inscription in Sassanian and Chaldæo-Pehlevi (W. Geiger and E. Kuhn, ' Grundriss

to reach Bering Strait, and is probably once more frozen in near Lighthouse Island. Capt. Wisting says that the *Maud*, which had on more than one occasion been subjected to heavy ice pressure, had sprung a small leak, and also that there was only sufficient motor oil fuel left for a day and a half. An aeroplane was carried on the *Maud*, but little success attended its flights. Trials were made on 5 and 12 June 1923, but on June 22 it was damaged in attempting to take off, and on July 16 it was completely wrecked through a forced landing. Scientific observations have been carried out continuously and successfully, particularly with reference to the tidal currents.

GENERAL

The Seventeenth-Century Map-Maker, John Daniel.

The mention of this early seventeenth-century map-maker, of whom little appears to be known, in our note on Captain Smith's map of Virginia of 1612 (*Geographical Journal*, October 1924, p. 350) has brought us communications from two different quarters, in which attention is called to other scraps of information about him which we possess. Mr. William Foster points out that Walter Peyton, captain of one of the ships of the East India Co.'s fleet which conveyed Sir Thomas Roe to India in 1615, whose journal is preserved in the British Museum, refers (under date 25 March 1615) to "The platte of John Danyells making (being Mercators proiection)," as untrustworthy as regards longitude in the region of Cape Bojador. Mr. M. C. Andrews of Belfast writes, that in addition to the charts preserved at Florence mentioned by Dr. Wieder (two of which are dated 1637 and one 1639), he has lighted upon a chart of the Mediterranean by the same maker in the Library of Trinity College, Dublin. It bears the inscription: "This platt was made by John Daniell, dwelling in St. Katherens, near unto the Iron Gate by the Tower of London, A.D. 1642." It is to be presumed that the reference by Robert Evelyn in 1641 to "M. Daniel the plot-maker" is to the same individual, "M." probably standing for "Mr." It would be interesting if other contemporary notices of John Daniel's work could be brought together, for he appears to have been in business for a considerable number of years. Another little-known chart-maker of the time is Nicholas Comberford, who in 1646 brought out a nautical chart which is also preserved at Florence in the Biblioteca Nationale.

Gilchrist Studentship.

The Gilchrist Trustees again offer, for 1925–1926, a Geography Studentship of £80, tenable at any recognized school of Geography, with a view to the furtherance of improved teaching of Geography in schools. Applicants, who should be teachers with at least two years' experience, should send in their names to Prof. L. W. Lyde, University College, Gower Street, W.C.1, before the end of January 1925. They must give references and a full account of their previous work, and their application should be accompanied by three testimonials.

OBITUARY

J. F. Needham, C.I.E.

WE much regret to record the death, at Shillong in Assam, of Mr. J. F. Needham ("Jack" Needham, as he was affectionately called by his friends and colleagues on the Assam frontier), whose energetic attempts in the 'eighties to lift the

veil from the then unknown districts on the Tibetan border of Assam made his name a household word among a generation of geographers now rapidly passing away. A son of the Hon. F. H. Needham (third son of the second Earl of Kilmorey), Needham, in 1867, obtained an appointment in the Assam Police, and from his post at the frontier station at Sadiya made full use of the opportunities offered him of getting in touch with the wild tribes of the region beyond, and throwing light on its geography. In 1885 attention had once more been called to the problem of the Upper Brahmaputra, first by the publication of the results of A—K's journeys, and secondly by the appearance of Mr. Robert Gordon before this Society as a champion of the theory that the Sanpo of Tibet was the upper course of the Irrawaddy. This theory (held a century earlier by the French geographer D'Anville) was barely tenable in view of the explorations of A—K, who, coming from the Tibetan side, had traced the Zayul Chu of Tibet to the village of Samé, where the French priests Krick and Boury had been murdered when ascending the Lohit branch of the Brahmaputra from the side of Assam; so that, as pointed out by Sir Henry Yule, there was no possibility of communication between the Sanpo and the Irrawaddy unless the former were to pass athwart the basin of the Brahmaputra. But Needham was resolved to settle the matter by direct observation, and, in company with Captian Molesworth of the Assam Police, set out from Sadiya on 16 May 1885 to ascend the Lohit as far as possible. Pushing through the Digaru and Miju Mishmi countries, the travellers, after a march of twenty-four days, got within sight of the Tibetan village of Rima (a few miles east of Samé), where the two upper branches explored by A—K unite to form the Lohit. By thus joining his route to those of the native explorer Needham finally proved the impossibility of the Sanpo being in any way connected with the Irrawaddy. And as he ascertained that no important stream entered the Lohit from the north in the section examined, it was also proved that the Sanpo must find its outlet by the Dihong, though the actual demonstration of the identity of the two rivers was reserved for Majors Bailey and Morshead nearly thirty years later.

The results of this journey were published in one of the 'Supplementary Papers' of this Society (vol. 2, part 3) in the form of copious extracts from Mr. Needham's diary, prefaced by a review of his achievement by the Secretary to the Chief Commissioner of Assam; much new and interesting information on the geography and various native tribes of that region being thus made available. Though perhaps the most noteworthy of Needham's journeys, it did not stand alone: an interesting account of an excursion into the Abor country was contributed by him to the R.G.S. *Proceedings* in 1885, and in 1888 (being then Political Officer for Upper Assam) he led an expedition to explore the hill routes leading from Assam towards the Hukong valley on the side of Upper Burma. Although unable to reach their objective, the party explored a considerable tract of unknown country. But Needham's eyes were constantly turned towards the north, and he lost no chance of gleaning information on the unknown tract between the Sanpo and the Dihong. It was a deep disappointment to him that he was unable to take part in the Abor expedition of 1912. After his retirement in 1905 he had made his home at Shillong, where he died at the ripe age of 83, Six children survive him. He had been a Fellow of the Society for thirty-five years.

H. B. Cotterill.

The death of Mr. H. B. Cotterill, which occurred in July last in Switzerland, must be recorded with regret in this *Journal*, for though his early travels

were but an episode in a life given mainly to other pursuits, they brought him to the notice of geographers at the time, and he was for some years a Fellow of this Society. After graduating at St. John's College, Cambridge, in 1869, he was for a time a master at Haileybury; then, after some medical training at Edinburgh, he became connected with the Scottish Mission on Lake Nyasa, which included among its objects the encouragement of legitimate trade as an antidote to the pernicious influence of the Arab slave-traders. A wide area to the north of the lake, between Tanganyika and the east coast, was then a *terra incognita*, though some hearsay information about it, and especially about the influential native chief Merere, had been gleaned by Livingstone during his last journeys. When in 1877 the much-lamented Consul Elton determined on a journey of exploration by a route leading north from Lake Nyasa, he secured the co-operation of Cotterill, and bears witness in his journal to the value he attached to this addition to his party. The expedition visited the chief Merere, but in the further journey Elton fell a victim to the hardships of the route, and it fell to Cotterill to bury him in the African wilds and to complete the journey to the coast, taking with him his leader's diary, notes, and memoranda, which he afterwards edited and completed in the work brought out in 1879 under the title 'Travels and Researches in the Lakes and Mountains of Eastern and Central Africa.'

Cotterill never returned to Africa, but devoted himself to teaching, and, in the latter part of his life, to literature, his most important work being a translation of the 'Odyssey' into English Hexameter verse.

Miss Constance Gordon-Cumming.

It would be unfitting to allow the death of the well-known lady traveller, Miss Constance Gordon-Cumming, to pass unnoticed in this *Journal*, for although her travels led her over no positively new ground they were sufficiently varied and extensive to bring her prominently before the public, at a time when lady-travellers in outlying parts of the world were far less common than they are now. She was the twelfth child of Sir William Gordon-Cumming, Bart., of Altyre and Gordonstown, and, having been born in 1837, was thus in her 88th year at the time of her death on 4 September 1924. Her travels began in 1867 with a visit to a married sister in India, and during the next twelve years took her to Fiji and other parts of the Western Pacific, to Hawaii, California, China, the Himalayas, and Ceylon, being described in a series of narratives which attained considerable popularity. In recognition of the services rendered in this way to geography she was made a Life Fellow of the Society in 1914.

CORRESPONDENCE

The Death of Dr. Shelton.

THE interesting Memoir of the late Dr. A. L. Shelton of Tibet, reviewed in the *Journal* for December 1924, gives fuller details of his most grievous death than we had before, and from the information in that Memoir and further correspondence it is necessary for me to revise two statements I made in *To the Alps of Chinese Tibet* (1922, p. 209). It was there stated that Dr. Shelton was wearing Tibetan dress, which we are now told he never did. He was wearing a long khaki sheepskin-lined coat which may have been mistaken for Tibetan. The conclusion that the murder was not due

either to Tibetan or Chinese officials, but to local brigands, is fully confirmed; but I am told that there is no ground for the belief that he was shot deliberately. The Memoir remarks (p. 255), "It still seems strange that he alone was the target, and no one else harmed in the least." The tragedy that the first shot fired struck Dr. Shelton appears to have been a mere mischance.

J. W. GREGORY.

16 December 1924.

MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1924–1925

Second Evening Meeting, 17 November 1924.—The President in the Chair.

PAPER: The People of the Aures Massif. M. W. Hilton-Simpson.

Third Evening Meeting, 1 December 1924.—The President in the Chair.

ELECTIONS.—Major Robert Alexander; George Alfred Angus; Walter Snowden Birkett; Guy Houghton Blanchet, B.SC., A.M.E.I.C., D.L.S.; The Hon. Sir Edward Owen Cox, G.B.E., M.L.C., J.P.; Miss Kate M. Cropper, L.L.A., F.R.S.A.; Ernest John Cushion, M.A.; Edwin J. Dingle; Arnold Tiffany Dudley; William Scott Fell, M.L.A., J.P.; George Frederick Horace Girling; Charles William Goffin, B.A.; Harold Berwick Goodridge, B.A.; Alister Clavering Hardy, M.A., F.L.S.; Capt. W. R. Hay, I.A.; Frank G. Jackson; Miss Gwendolyn Peyton-Jones; Stanley Wells Kemp, SC.D.; Capt. Charles Robert Kettlewell; Merl La Voy; Thomas William Langdon-Bruce; Commr. C. H. Lightoller, D.S.C., R.D., R.N.R.; Mrs. Winifred McCalmont; Capt. Victor David O'Malley, M.C.; Lieut. Francis Poole, R.N.R.; Prof. Edgar Prestage; Mrs. Albert Pym; Sir Arthur Rickard, K.B.E., J.P.; Walter Theodore Tolley, B.SC.; Lady Norcot Warren; Leonard Alfred John Webber; David Williams; Miss Mabel Honorine Margaret Withers.

A Selection from M. Albert Kahn's collection of photographs in natural colours, was described by Prof. P. M. Roxby, Mr. E. A. Benians, and Mr. L. H. Dudley-Buxton.

Second Afternoon Meeting, 8 December 1924.—The President in the Chair.

PAPER: Irrigation in the Indo-Gangetic Plain. A. V. Williamson.

Fourth Evening Meeting, 15 December 1924.—The President in the Chair.

ELECTIONS.—Richard St. Barbe Baker; John Bourne; Major W. J. Bovill, O.B.E., I.A.; George Leslie Boyle; Frederick Anthony David Browne; Rev. R. Burges; John C. O. Burns; Charles Colegrave-Scott; Thomas Corlett Corris; Mrs. Jessie Mindele Dreshfield; Reginald John France, B.A.; Hugh Ingle Halliday; Edward George Hawke, B.A.; Robert Conway Hickson; Horace Alfred Hill, L.C.P.; Vernon Hinde; Miss Dorothy Jenkins, B.A.; Miss Winifred Lamb; R. E. B. Lee; Mrs. Margaret Irene Louisa Milward; Capt. Guy Douglas Clifford Money; Rear-Admiral Aubrey Clare Hugh Smith, C.B., M.V.O.; Major W. F. N. Vernon; Mrs. Katharine Longstaff Wedgwood; James Williamson, J.P.; Alexander Harris Zaradi.

PAPER: The Deserts of Jafura and Jabrin. Major R. E. Cheesman.

is conscious that he does not know exactly. That is what Palgrave did. There are various types of conscience, the scientific conscience, the nonconformist, and so on! Mr. Philby has the scientific in a highly developed form. Palgrave certainly had not. But he was not a downright liar. There is a great difference between the attitude of a downright liar and that of a man writing loosely about details which he does not very well remember. Palgrave had lost his notes in a shipwreck. But I do not fancy they would have been of very great value to him, when, arrived back in this country, he found he was expected to remember geographical matters to which he had given little attention on the spot. But, in any case, he was the kind of man who puts down as much as he can remember and then fills in more or less picturesque detail which, so far as he knows, may be right, reflecting that nobody else will be in a position to say it is wrong. The main facts Palgrave must certainly have remembered, and it is, I think, absurd to suppose that he invented visits to whole districts and fabricated long journeys; for example, his journey to the oasis of Hasa. Major Cheesman has borne witness that he had a good memory for general impressions. He went out, not for exploration, but on a secret anti-British mission from Napoleon III., and when he came back and found that he was expected to redeem his credit here by giving useful information about geography, he found himself in very considerable difficulty. He had paid no particular attention to the matter on the spot; and we all know how difficult it is, after a long journey and the sight of a great deal of country, to remember details. When you see the paper in its printed form, and read what has been omitted in Major Cheesman's speech to-night, you will agree that he has produced convincing proof that Palgrave actually went to Hasa and did, as a matter of fact, give a very good impressionist account of it. I congratulate Major Cheesman on a thoroughly satisfactory paper, full of different topics of great interest, and confined from first to last to things really seen and known.

The PRESIDENT: After what you have heard to-night you will have perceived how well justified your Council were in equipping Major Cheesman with geographical instruments. He has made the most excellent use of them and brought back a great deal of information which will assist in filling up the blanks in the map of Arabia. Not only that, but he has returned the instruments as well—a thing we cannot always say of all those explorers whom we have equipped! He has given us this evening a narrative of a most interesting journey, full of information, lit with delightful touches of humour that have really thrown a flood of light upon a very little-known corner of the world. In offering to Major Cheesman the grateful thanks of this audience for the evening which he has given us, I would venture to add the hope that this will not be the last of his encroachments upon the unknown quarters of the globe.

IRRIGATION IN THE INDO-GANGETIC PLAIN

A. V. Williamson, B.A., Assistant Lecturer in Geography, University of Leeds

Read at the Afternoon Meeting of the Society, 8 December 1924.

THE Indo-Gangetic plain covers an area of 300,000 square miles, and embraces most of Sind, northern Rajputana, the whole of the Punjab, United Provinces, Bengal, and half of Assam. Throughout this region the late summer and autumn—the period of the south-west

monsoon—is the season of heavy rainfall, but in parts economic importance attaches also to the winter rains. The plain is influenced by both branches of the monsoon, but the eastern or Bay of Bengal branch brings practically all the rain received. Only at rare intervals does the western or Arabian Sea branch penetrate eastwards beyond the line of the Jumna River to affect the Ganges valley. North of the Gulf of Cambay it is no longer moisture laden, for in these latitudes the reservoir of air-supply is the heated plateaux of Iran and Baluchistan; any moisture which the wind picks up in traversing the narrow sea *en route* to its goal in the barometric minimum over Sind is lost to the coastal fringe, and contact with the heated sands of the Indus basin only renders it increasingly desiccating.* Bikanir, with a monsoonal rainfall of 9·1 inches, is typical of the intense aridity prevailing throughout Sind, western Rajputana, and the western Punjab.† Over the eastern half of the plain rainfall decreases as one moves inland from the Ganges delta along a line parallel to the Himalaya (*i.e.* from east to west through Bengal and the United Provinces, then from south-east to north-west through the Punjab) and also from the mountain foot out over the plain. Thus :—

	Annual rainfall (inches).	*Monsoon rainfall (inches).*
(*A*) *E. to W. up the Ganges.*		
Calcutta . . .	62·7	50·8
Fyzabad . . .	43·6	40·2
Delhi . . .	27·4	23·5
Moving out over the plain across the Ganges Valley.		
Pilibhit . . .	53·4	48·4
Fyzabad . . .	43·6	40·2
Allahabad . . .	38·3	35·6
(*B*) *S.E. to N.W. through the Punjab.*		
Delhi . . .	27·4	23·5
Lahore . . .	19·7	15·1
Peshawar . . .	13·6	4·8
Moving out over the plain.		
Simla . . .	65·7	49·7
Sialkot . . .	31·0	23·0
Lahore . . .	19·7	15·1
Multan . . .	6·6	4·6

The winter rains though small in absolute amount are of great importance in connection with the rabi (spring) crops of northern India. From the

* This statement is adequate for our purpose, but see also Dr. G. Simpson, *Q. J. Met. Soc.*, vol. 47, July 1921, p. 168.

† Unless otherwise stated, rainfall figures given throughout have been computed from records extending over a period of forty-five years. Rainfall occurring during late September and October anywhere in India is most accurately described as belonging to the retreat of the monsoon. It is, however, only in peninsular India that the rainfall of the retreating monsoon acquires a distinctive character from an agricultural point of view. For us, therefore, the south-west monsoon embraces June to October inclusive.

centre of maximum precipitation in Peshawar—which receives over half its annual rainfall of 13·6 inches between December and April—the fall dwindles and the season shrinks as one moves towards the south, and although some rain occurs throughout the United Provinces during this period it is scanty away from the hills and far less reliable than further north. In the eastern half of these provinces it blends early in the year with the spring storms rainfall, which belongs to an entirely different order of natural phenomena and is of little agricultural importance outside the rice country of Bengal.

The extent to which precipitation over any tract is liable to deviate from the normal seasonal average may be held to determine its economic value. This is equally true whether the variation is positive or negative since a drowned crop spells failure just as much as a parched one. The character of the rainfall—whether heavy or light—its actual distribution in time, retardation of the rainy season or a premature cessation, are all factors which modify the value and require recognition in the study of conditions prevailing in any particular season or the agricultural history of a small tract. In general, the lower the rainfall the greater the variability. An analysis of the percentage deviation of rainfall at certain stations throughout India provides ample proof of this. Appended are a few of the results arrived at for the region under discussion based on records covering the period 1896–1915 :

Station.	*Season.*	*Average fall.*	*Per cent. variation.*
Peshawar	S.W. Monsoon	4·8	59·5 per cent.
,,	Winter (Dec.–Apr.)	7·4	37·8 ,,
Bikanir	S.W. Monsoon	9·1	42·8 ,,
Lahore	,,	15·0	38·0 ,,
,,	Winter (Dec.–Mar.)	3·3	36·9 ,,
Delhi	S.W. Monsoon	23·5 (1892–1911)	28·6 ,,
Fyzabad	,,	40·2	22·0 ,,
Calcutta	,,	50·7	16·4 ,,

A variability in excess of 20 per cent. implies great risk in farming. Where rainfall is less than 10 or 12 inches agriculture cannot be carried on save under irrigation, so that there is little attendant risk. Such is the case throughout the arid western half. In lower Bengal and Assam rainfall is both plentiful and reliable, and economic distress need not be apprehended. Elsewhere throughout the plain, embracing the most densely peopled part of India, natural moisture is normally sufficient to ensure the harvest, but such is the degree of uncertainty that in the absence of irrigation agriculture is reduced to a gamble. The history of famine in India is illuminative of the losses sustained.

What then are the facilities offered by nature for the practice of irrigation in this area? The Indo-Gangetic plain, as we know it to-day, is a vast level expanse of fluviatile material which has been accumulating ever since the upheaval of the Tertiary mountain periphery which delimits

it on the north and east. The great rivers to which it owes its creation have continued throughout to work their changeful will over its whole surface, and in many parts a decade is the measure of antiquity. The present main watershed between the Indus and Gangetic systems lies between Saharanapur, Ambala, and Ludhiana. Here the land stands at 900 feet, whence it falls imperceptibly to the deltaic areas at either extremity. The alluvium forms one continuous series throughout, but it is usual to distinguish between the Bhangar or older alluvium containing fossiliferous remains of Pliocene age, and the Khadar or newer alluvium in which occur fossils chiefly of living species.* The Bhangar is generally confined to the higher land lying above the annual flood-level of the rivers, and wherever it has been encroached upon the deposition of Khadar is proceeding. The older alluvium, being well consolidated and reinforced by nodular limestone (Kankar), rarely loses more than 10 feet a year at any point where exposed to river attack, but the newer material immediately adjacent to the rivers often sacrifices 300 or 400 feet in the same time. The hills skirting the plain are everywhere fringed with gravel slopes (Bhabar), in crossing which the rivers lose themselves to reappear in the clay (Terai) below.

The subsoil of the plain consists usually of alternate layers of sand and clay to an unknown depth, and the water-retaining powers are greater or lesser according as one or other predominate. In general it responds admirably to irrigation. There are, however, extensive alkaline tracts—great salt (Reh or Kallar) encrusted areas known in India as Usar land. It has been estimated † that in the United Provinces alone there are three million acres thus infected. The problem of how to reclaim such land has engaged attention for the last forty years, but success is still only in the experimental stage. The relationship existing between irrigation and Usar land is of first importance. The salts can only be brought to the surface when two conditions are present: first, water to percolate down to the subsoil and dissolve them; and, second, a strong evaporative force. Therefore wherever drainage is inadequate or over-irrigation is practised, the first of the required conditions is furnished. In the early days of pioneer irrigation failure to provide adequate drainage caused the land in the neighbourhood of the older canals (Jumna and Ganges) to become waterlogged, with the result that thousands of acres now lie outside the pale of cultivable land. British engineers soon learnt, however, that it is just as important to get water off the land as to get it on, but, as we shall see later, the cultivator has not yet grasped this truth.

The level surface of the plain commanded and traversed by the glacial-fed perennial rivers of the Himalaya offers every facility for the

* "Some Remarks on the Geology of the Gangetic Plain," F. Molony, *Jour. Asiatic Soc. of Bengal*, vol. 1, No. 9, N.S., pp. 231 *et seq.*

† 'Irrigation Works in India,' 1909, p. 277, J. Clibborn (Principal, Roorkee Engineering College).

construction of great canals, in contradistinction to the peninsular division of India, where the broken topography and feeble rivers sunk below the general surface militate against such works. Moreover, the absence of any marked surface irregularity further permits the rain to sink into the ground, while percolation from rivers and canals also contributes to maintain the subsoil water-table at a level which can be readily tapped by wells.

So much has been written concerning the canals of India that there is a tendency to think of irrigation throughout the continent in terms only of these triumphs of engineering skill. It is, therefore, often a surprise to learn that over one-half of the acreage under artificial watering is nourished by small private works of which the principal is that ancient aid to husbandry—the well. Over three-quarters of the area served by this type of work lies in the Indo-Gangetic plain, where, as already noticed, conditions are most favourable. The well reaches its maximum development in the United Provinces, where, with the exception of the rocky district of Bundelkhand, much clay is present, and the subsoil water-table lies close to the surface. Practically one-half of the well-irrigated acreage of India falls within these provinces. On the other hand, in the Punjab clay is often absent and pure sand extends to a great depth, so that wells can seldom be sunk to any advantage far from a river. The chief centres of well-irrigation in this province are Sialkot, Jallandar, Amritsar, and Gujranwala, *i.e.* in the coarse strata near the foothills of the Himalaya.

The importance of the clay in the Indo-Gangetic alluvium cannot be over-estimated. It is known generally as mota in the vernacular, and does not form one continuous layer, but occurs in beds which lie at varying depths, forming, as it were, islands in the sea of sand deposit. The mota acts as a beam to support the well, which is fed with water through a hole 6 to 9 inches in diameter bored through the clay to tap the saturated sand below. Wells constructed on a mota foundation are generically termed "spring wells" in contradistinction to that class of well which depends for its supply upon percolation through the sides and base. The latter type are characteristic of the submontane gravel zone. Wells—whether of the spring or percolation type—may be either phakka (permanent) or kachcha (temporary). The former involves masonry work, and is the chief well in the Punjab, where the great depth of the water-table renders strong walls necessary. The cost of such a well and the area it will irrigate depend upon a number of variable factors, but for the peasant the initial outlay always represents a considerable sum, and only the very fortunate become owners of one.

In the United Provinces, whilst permanent wells play an important part, the height of the subsoil water-level offers greater facilities than in the Punjab for the construction of the kachcha or temporary well. This is simply a hole dug in the ground. Where the mota exists the hole

is dug down to it and then narrowed to pierce the clay. In the absence of such beds the hole is dug to percolation level and then narrowed and lined with brushwood, the water being thus filtered as it passes through. The life of the temporary well is seldom longer than one season. It is essentially the poor man's well, seldom irrigating more than two acres, often only the fraction of an acre. Despite its brief life, however, it possesses several advantages apart from its small cost. Thus the crops requiring irrigation must change from season to season, according to agricultural necessity. When a permanent well is in use this often entails long feeding channels in order to bring the water to the fields, and loss from absorption and evaporation is involved. On the other hand, a temporary well can be placed in close proximity to the crop. Further, a kachcha well can be sunk in a few hours in case of immediate need, and if unsuccessful the loss at most is only one or two rupees expended in labour, whereas a phakka well is a much longer task, and when of the spring type often only satisfactory after several trial borings involving much expense.*

During recent years there has been a great deal of experimental work going on, particularly in peninsular India where wells are frequently of great depth, in connection with the lifting of water. There is no doubt that the native methods of bringing water to the surface, admirable and ingenious though they are, do not extract the maximum possible volume from the well. The old means employed are of various kinds, some involving animal, some simply man power. They persist with slight modifications throughout the East, and require no particular notice, being familiar to most people. The superiority of steam pumps and oil engines over such primitive devices has been amply demonstrated,† but it is admitted that the employment of such modern equipment could only be undertaken with profit on a well yielding 10,000 cubic feet of water per day over the greater part of the year. Expressed in terms of acreage, this means that to justify the application of scientific lifts a holding should be at least 10 acres in extent, and there are few holdings of this size in one block in India. The difficulty could, however, be got over by peasants combining into groups, each of which might possess and operate a large well served by machinery, and in view of the rapid development of co-operative societies in India the suggestion put forward may well prove to be of practical value.

The canals of northern India fall into two groups : (1) Inundation ; (2) Perennial. The former represent the survival of what must have been one of the earliest forms of irrigation, namely, the cutting of more or less shallow channels at right angles to the banks of a river in order that during the flood season a certain quantity might be drawn off to nourish

* "Wells in the Gangetic Alluvium," W. H. Moreland, Direc. Agric., United Provs., *Agric. Journ. India*, vol. 4, part i. 1909, p. 34.

† 'Lift Irrigation,' A. Chatterton, Director of Industries. Madras : 1922.

the land in the vicinity. On the other hand, perennial canals, as their name implies, sustain a constant flow, and involve large engineering works. Geographically the sphere of the two may be distinguished, for the limit of irrigation under an inundation canal is restricted to the lower land, and such canals reach their maximum development where the rivers of the Punjab begin to converge to form the lower Indus and the Khadar widens at the expense of the Bhangar. In Sind it is virtually the only form of irrigation in vogue. The drawbacks of such a system are apparent. Apart from liability to rapid silting, success depends upon the floods rising at the right time and being of adequate volume and duration. Thus it is usual in the Punjab to flood fallow land when the river is up—the area thus treated is normally almost equal to the irrigated land under crops at this season—and to raise wheat on the moisture retained during the winter months.* If the river begins to shrink prematurely the land is not sufficiently saturated and the wheat may fail, or at least it may necessitate restriction of the area sown. Again, if the flood is late (or the volume small), instead of the water overflowing from the canals on to the land by the middle of June, both men and cattle have to be kept employed in lifting it up on to the surface when they should by this time be engaged in the fields. After twenty years of commission and inquiry the Government have finally sanctioned the conversion of the main inundation canals of Sind into a perennial system, and to accomplish this the construction of a barrage across the Indus at Sukkur is now proceeding. What the change may mean in connection with one crop alone is worthy of note. "We consider that the experiments with Egyptian and American cotton in Sind, though they have for the time being ended in failure, show beyond doubt that these varieties can be successfully cultivated in the province. We are emphatically of opinion that the fundamental cause of failure has been the unsatisfactory character of irrigation. Provided a perennial supply of water can be assured we hold the view that there is no other part of India which offers such hopeful prospects of the successful cultivation of long-staple cotton. The climate and soil are in every way most suitable, and all that is wanted is water at the right time and in sufficient quantities." † Schemes for the improvement of the inundation canals of the Punjab have also received sanction.

The essential feature of a perennial canal system is a weir constructed in the bed of a river sufficiently high upstream to ensure that the canal (or canals) taking off from above the headwork can be aligned to command the area to be irrigated.‡ An endeavour is made to find a portion of the

* This practice is far less common in Sind, where 90 per cent. of the irrigation is devoted to Kharif crops. This is probably explained by the fact that the canals of Sind lie in much lower ground and more in soil than those of the Punjab, and hence irrigation has to be carried on by lift to a far greater extent than in the latter province.

† 'Report of the Indian Cotton Committee, 1919,' vol. I, part i. p. 81.

‡ On technical aspects 'Irrigation Works in India,' R. B. Buckley, first published 1905, remains the best single reference in the field.

river where the course is straight, the velocity uniform, and the sectional area of the stream fairly constant. A gorge may recommend itself, since, other things being equal, the narrower the stream the less costly the weir. But at such a point the depth of the river and its velocity may necessitate a particularly stout barrier involving great expense in the long run. On the other hand, a very wide reach must often be avoided because of its liability to silt up, since the velocity of the river is checked when an obstacle is thrown across its path. Further, the tendency of all rivers to alter their course—enhanced by the presence of an obstacle—must be carefully guarded against. This compels a thorough survey of the banks and reinforcement where necessary. The nature of the silt carried must be analysed to ascertain whether it is fertilizing or not, and what portion of it is to be admitted into the canal. Proximity to building stone is another point to be borne in mind.

Throughout the Indo-Gangetic plain the absence of any great irregularity of surface enables the main canal of a system to be brought to the backbone of the doab—the inter-stream watershed—with a minimum of delay and expense, whence lateral branches can be run off. The capacity of all canals and distributaries is determined by the duty * during a period of pressure. This varies of course according to the nature of the crop to be irrigated. The area nourished is naturally limited by the amount of water available, or, if the supply is abundant, by the area which can be commanded under the system. In Madras and Orissa where the supply is usually in excess of the demand little restriction is placed upon the distribution of water, but where, as in northern India, there is need for greater protection owing to a less reliable rainfall, it is customary to limit irrigation to a proportion of the area commanded. Briefly, the available supply is meted out over as large an area as possible in order that each district embraced within the command may have a certain percentage of cultivation assured. This does not promote farming on a commercial basis, but it has the great merit of keeping the maximum number of people above starvation level. These remarks apply particularly to that portion of the United Provinces lying between the Jumna and Ganges rivers. In this densely peopled tract—the hive of Hindustan—protection has been adequate for many years, but the rivers are unable to supply any greater volume, and schemes are now limited to increasing the efficiency of existing works and to assisting ambitious cultivators to sink deep tube wells. There remains, however, a wide field for development north and south of here, particularly in Bundelkhand, which suffers as much from an excessive and ill-distributed rainfall as from drought. When the Indian Irrigation Commission issued its report only one canal existed—the Betwa. The apathy of the Bundela cultivator, the presence of black cotton soil in various parts, and the few facilities offered by the physical features and rivers of the region—which is allied to the peninsula

* Duty = area of crop which can be matured by a given quantity of water.

—were held to explain the situation.* Since this time, however, apart from the three canals, the Ken (1906), the Dhassan (1911), and the Ghaggar (1918), several large tanks rendered possible by the broken nature of the country have been constructed and others are in hand. North of the Ganges, between that river and the submontane zone there is at present no canal, although well irrigation is carried on extensively. The rainfall is here more copious and reliable than to the south, but the winter rains upon which the important wheat crop depends are reaching their southern limit, and are not always to be depended upon. It has frequently been suggested to harness the Sarda River for the irrigation of this part of Oudh, but the landholders have persistently objected. Recently however they have suffered a change of attitude, and it is hoped to carry water to over $2\frac{1}{4}$ million acres. The numerous small canals actually within the submontane country form an exception to the protective nature of irrigation throughout the United Provinces. Their chief value lies in the benefit they afford to the rice crop; without them the best qualities produced for the market cannot be secured.

The development of irrigation in the Punjab has differed from that of the older province to the south-east. Here the quantity of water drawn off to protect the thickly settled districts of the east under the Bari Doab and Sirhind Canal systems only deprived the river network of the province of a very small part of its total water volume It has therefore been possible to extend irrigation into the lower doabs embracing the great plains of western Punjab, and to transform extensive arid tracts into flourishing agricultural colonies. Such country as that now served by the Lower Chenab Canal which feeds $2\frac{1}{2}$ million acres and the Lower Jhelum Canal nourishing over 800,000 acres, both of them in the Rechna Doab, and by the Lower Bari Doab Canal † which irrigates nearly 900,000 acres in the Montgomery Plain, is described as having been in pre-canal days a pathless waterless *terra incognita* of which every one stood in dread. The only inhabitants were pastoral nomads who sought whenever possible to swell their legitimate incomes by cattle stealing. To-day these same areas are the seats of model villages, large towns, and busy markets. The enormous output of wheat—rivalling in quality the famous hard red variety of Canada—has occasioned rapid railway growth, and excellent roads have been provided for in the elaborate system of land demarcation which has for its main object the maximum efficiency of water distribution. The original colonists were mostly picked men drawn from the congested areas of south-eastern and eastern Punjab, preference being given to those who were related by common descent and possessed not only experience in irrigation farming but also small means. Very soon, however, the nomads themselves came forward,

* 'Report of the Indian Irrigation Commission,' 1903, part ii. p. 183.

† The Lower Bari Doab Canal is the main feature of what is known as the "Triple Project," a work which undoubtedly represents the most ingenious scheme in India

and receiving every encouragement have proved among the best of the colonists. It is not unusual to read of an erstwhile nomad carrying off a first prize at one or other of the agricultural shows held annually at the various large centres throughout the Punjab. It may be mentioned in this connection that the Thal Project now under construction and designed to irrigate more than $1\frac{3}{4}$ million acres in the Sind Sagar Doab, between the Indus and Jhelum rivers, will afford a wide field for colonization after local requirements have been provided for.

There remains for brief notice the actual method of irrigating the land. Throughout India, with the exception of certain garden lands, water is almost everywhere applied by surface flooding. The land is divided up into compartments (kiari) on either side of the local water-channel, each compartment being defined by ridges of earth along its sides. The water is admitted to the compartment by temporarily breaking the ridges and placing the removed earth across the channel to form a dam. Usually two compartments—one on either side of the water-channel—are irrigated simultaneously. When the water has to be lifted to the surface in order to serve the local channel, as it has from wells and often also from inundation canals, little harm results from this method, for a man employing his own strength or that of his cattle does so sparingly. Unfortunately such is not the case under a perennial system. Here the water reaches the fields under gravity unaided by the cultivator. To him there appears to be an abundance of it, and since he is not charged according to the volume he uses but the area he irrigates, and is anxious to secure as much silt for his land as possible, no other fertilizer being available, there is every temptation to over-irrigate. To this temptation the great majority succumb, and it has been abundantly demonstrated that the cereal growers of northern India are using too much water to obtain the maximum yields.* But this is not the most serious of the evils consequent upon the general practice. The lesson that water is not everything is not an easy one either to teach or to learn in a country whose history has been one of constant distress occasioned by a lack of it. With plenty of water on his land the cultivator feels that little else matters. Drainage receives scant attention, and the surface is seldom worked over. Hence the spread of malaria, rust disease, and alkaline tracts are all assisted, soil aëration is destroyed, and the plants are forced to develop surface roots, thus requiring ever-increasing quantities of water to bring them to maturity. In addition to adequate provision for getting water off the land, success in irrigation depends upon preventing the tendency of soil particles to run together after the application of water, thereby forming a crust which excludes both air and moisture from penetrating

* ' The Saving of Irrigation Water in Wheat Growing,' Bulletin No. 4 (2nd ed.), Fruit Experiment Station, Quetta, 1919, by A. and G. L. C. Howard. Also ' The Irrigation of Alluvial Soils,' Bulletin No. 7, Fruit Experiment Station, Quetta, 1917, by the same authors.

deep down. Irrigation is not to be regarded as an alternative to dry farming. Wherever the need to make a little moisture go as far as possible exists, intensive surface cultivation should be practised. Finally, India presents a parallel to rural England as it was in the days before the enclosure movement. There is minute fragmentation of holdings, so that one man may possess a dozen tiny strips scattered throughout a village. This state of affairs results very largely from the Hindu law of inheritance, but the introduction of English conceptions of land ownership has assisted in no small measure. Such fragmentation involves a multiplicity of tortuous winding watercourses and inevitable wastage. If only holdings could be consolidated without arousing suspicion and causing distress it would permit of extensive remodelling of channels, and would, apart from increasing the efficiency of irrigation a hundredfold, remove the millstone which hangs about the neck of rural India.

Before the paper the PRESIDENT (the EARL OF RONALDSHAY) said: Our lecturer this afternoon is a member of the geographical staff of the Leeds University, a University which, as probably most of you know, is about to celebrate its coming of age. In these circumstances all members of the University staff are naturally much engaged, and we are all the more indebted, therefore, to Mr. Williamson for having managed to find time to come and give us this afternoon a paper upon irrigation in the Indo-Gangetic Plain. Mr. Williamson's attention was first directed to this subject, I believe, on his service in India during the war, and having had his attention drawn to what certainly is a question of very great practical importance, he has since been pursuing his studies in connection with it; and the paper which he is to give us this afternoon is the result of those further studies.

Mr. Williamson then read the paper printed above, and a discussion followed.

The PRESIDENT: Mr. Williamson has dealt with a very interesting subject of great importance, and I should be glad if anybody present would care either to make any comments upon what has been said or to ask any questions with a view to elucidating any points which appear to them to be obscure.

Sir CHARLES YATE: I should like to ask a question with reference to Sind and the map which has just been shown to us. We all know there has been a great deal of discussion on the question of the Sukkur barrage. It is to be built, as I understand, 3 miles below the gorge, and almost all the old experienced engineers in Sind who have spent their lives there in studying the Indus are of opinion that there is great danger of the water being so held up that the swirl above the gorge will break the banks of the river and send it round the outside of the gorge instead of through it to the utter ruin of Sind—the drowning of the people and the devastation of the province. The general opinion seems to be that this scheme has been sanctioned on the advice of a younger generation of engineers who have not had the opportunity of studying the question so carefully as the older men who have spent their lives over it. Can the lecturer tell us what is the state of affairs at the present moment, and what is the opinion in India on the subject?

Mr. A. V. WILLIAMSON: The question which Sir Charles Yate has put is, of course, an engineer's question, and I am not an engineer. But what he says is likely may very well occur according to the older school of thought; has,

in fact, already occurred in the past elsewhere. It happened conspicuously on two occasions along the older canals in the 'eighties of the last century. But this scheme to place a barrage across Sind at Sukkur is not a new one, and I should have thought that time would have allowed of very careful examination of engineering details. Objections have been put forward on many grounds ever since the report of the Indian Irrigation Commission in 1903, but I have seen no objections to the actual structural details. One objection was that if such a barrage was constructed it would be more or less a white elephant, as Sind is so very thinly populated ; that it would be far better to spend the money on more densely populated areas. I appreciate that that is not a direct answer to the question, but the point I want to make is that many have objected, and for many years, to the conversion of the inundation canals of Sind into a perennial system, but never has the objection to my knowledge been on the ground of structural details which, I believe, have been drawn up for many years.

Sir EDWARD INGLEFIELD : I think it would be interesting to know when that barrage will be completed.

Mr. WILLIAMSON : In about ten years.

Sir CHARLES YATE : At a cost of £20,000,000.

Mr. WILLIAMSON : That, I think, is one of the reasons—certainly very just—that it is a very expensive undertaking, and it is a question whether the money could not be spent to better advantage in some more densely populated parts, liable to famine.

The PRESIDENT : If nobody wishes to ask any further questions or to add anything to what has been said by the lecturer, I venture, on your behalf, to express the gratitude of this meeting to Mr. Williamson for his extremely interesting paper. He certainly has brought home to us the immense scale upon which irrigation works are carried out in India. Most people have a vague idea that a great deal has been done in Egypt by the irrigation engineer, but few people realize that in British India we have irrigation works before which the works in Egypt pale into comparative insignificance. As an example I might take the very case which has been discussed, that of the Sukkur barrage, the foundation stone of which was laid about a year ago by the late Governor of Bombay, Sir George Lloyd. It is estimated that this scheme, when completed, will bring something like 6,000,000 acres of country which are at present mainly desert under cultivation, and it is estimated that that will add something like 2,000,000 tons of grain and cotton to the present agricultural products of the Indian continent. That is a single irrigation project.

If you take the case of the Punjab, of which our lecturer has spoken a good deal this evening, in that province alone there is an area of something like 9,000,000 acres which has been brought under cultivation by Government irrigation schemes which come under the heading of productive schemes ; that is to say, irrigation schemes which within ten years of their inception will pay their own working expenses and a certain rate of interest upon the capital sunk in their construction. If you take British India as a whole you will find that some 67,000 miles of canal irrigate something like 28,000,000 acres of country, the value of the crops raised on those 28,000,000 acres being estimated at something like £156,000,000 per annum. Of course these schemes are being constantly added to. Schemes under construction and in contemplation will bring the acreage irrigated by Government works in the not very far distant future up to something like 40,000,000 acres. That gives you an idea of what has been done by Government.

Perhaps one of the most striking features of Mr. Williamson's paper was the statement that "over one-half of the acreage under artificial watering is nourished by small private works"; that is to say, by wells constructed by the peasantry. If, therefore, the peasantry are responsible for irrigating something like half the total irrigated land in India, that, I suppose, would approximately double all the figures which I have mentioned as applying to big irrigation schemes undertaken by the Government itself.

Mr. Williamson did not say very much with regard to the extreme eastern part of the Indo-Gangetic plain, which happens to be the part I know best personally, namely, Bengal. I might perhaps add, therefore, that in that part of the Indo-Gangetic plain the problem of irrigation is rather different from what it is in the parts with which Mr. Williamson mainly dealt. Eastern Bengal, for instance, is a country which is inundated for several months during the year. Immense crops of rice grow in this inundated country, but unhappily immense crowds of mosquitoes are also nourished in these waters, and one of the great objects of irrigation combined with drainage in Eastern Bengal is to try to kill off the larvæ of the mosquito, which carries malarial fever. Curiously enough, it is only the female mosquito that bites; but she is a particularly dangerous animal because she carries the malarial parasite and imparts it to man. The mosquito breeds in small stagnant pools of water rather than in great expanses of water. What happens in Eastern Bengal is this: When the rainy season comes to an end the waters begin to subside, and there remain immense numbers of small patches of stagnant water on the land. In these the mosquito breeds. The irrigation engineer, therefore, in Eastern Bengal has to try to prevent that happening. He can do it only by constructing irrigation works which are designed to keep the water on the land rather longer than it remains there naturally, so that when he is ready to let the water off the land it flows off with a greater rush, and thus is less liable to leave stagnant pools behind. That is a very big subject, and perhaps I ought not to have embarked upon it in connection with this particular lecture, but it shows not only the immensity of the problems which lie before the irrigation engineer in India, but also their variety and complexity.

Let me once more thank Mr. Williamson for having, as I pointed out earlier, come, at considerable inconvenience to himself at the present time, from the University of Leeds in order to give us this paper. We are most grateful to him.

THE DAKHLA-OWENAT ROAD

W. J. Harding King

NOW that the position of Owenat, with its permanent water supply, has been fixed by Hassanein Bey, it should, as Dr. Ball pointed out in his note on Hassanein Bey's map, prove a most useful base for the further exploration of this part of the Libyan Desert. But to reach it from either the Mediterranean coast or the Sudan by following Hassanein Bey's route would be rather a waste of energy, as these roads have already been surveyed. As Dr. Ball has suggested the route to Owenat from Dakhla as an alternative, a note on the subject may be of interest.

Starting from Dakhla oasis in the winters 1909–1911, I made a number

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ANIMAL LIFE AT HIGH ALTITUDES

Major R. W. G. Hingston, I.M.S., Naturalist to the Mount Everest Expedition of 1924

Read at the Meeting of the Society, 12 January 1925.

THIS paper is a condensed account of certain observations in Natural History made while serving with the Mount Everest Expedition. It refers to life on the Tibetan plateau, especially with regard to the struggle for existence in those bare inhospitable tracts above the limit of the Himalayan tree-line.

First a word as to physical features. Tibet is a desert, a high-altitude mountainous desert at an elevation of about 14,000 feet. This is a point we must thoroughly realize, for the life of Tibet is in many particulars the life of a desert waste. Compare it for a moment with a lowlying wilderness, such as the sweeps of open sand in Arabia, Sahara, or Sind. It differs from these in one particular: it has none of their intense heat. But otherwise Tibet is essentially a desert, empty, bleak, and bare. As we travel across it we see all the features of the desert, the wide tracts of brown and barren soil, the vast distances spread out before the eye, the fierce display of light. Here, as in the desert, we meet tracts of sand, often loose and crumbling and at the mercy of the wind. In one place we see how its surface is rippled, in another how it is covered with a saline incrustation, in another how it stupefies the scanty vegetation or piles itself into crescent dunes. Here too we observe the same cloudless skies, the same glare from the plateau soil, how the air rises in shimmering waves or clothes the surface in a true mirage. There is the great range of temperature characteristic of the desert, often 50 degrees between day and night. The rainfall is scanty. The atmosphere is so dry that it splits the skin and nails, and prevents the ordinary decomposition of flesh. Fierce winds blow across it from the main range, and these might be compared with the Sirocco or Shamal. Frequently they raise up vortices of dust which career over the empty plain. As in the desert, we observe the same scantiness of vegetation, the monotonous growth that gives no colour to the landscape, the absence of trees, the thorniness of the plants, the short active season in which flowers rapidly bloom and

as rapidly die away. These are some of the desert features which we meet with in our journey through Tibet.

Let us consider the life of this high-altitude desert. How do the creatures live? How do they protect themselves? By what means are they adapted to the conditions of the heights?

Any one who has travelled in a lowlying desert knows how important is protective coloration in the general scheme of things. It is exactly the same in Tibet. Examples are apparent on every side. Most of the common animals of the plateau are inconspicuous against the soil. But we must remember that the plateau is littered with stones, and, not like many lowlying deserts, an even layer of sand. This gives an additional advantage to the animals. For not only do their colours blend with the surface, but their shapes and outlines are often lost to view, being confused with the scattered stones.

I will give some examples of protective colour in Tibet. Everywhere on the plateau we meet with colonies of Pikas, delightful little creatures which sit near their burrows and blend with the sandy soil. In the gorges of the main range we find another species. Its surroundings are more gloomy; it lives amongst rocks, and in accordance with this its coat is darker so as to fit it to these special haunts. The marmots likewise blend well with the altitudes. They like to occupy the bare passes as high as 17,000 feet. The Tibetan hare is a good example of harmonization, especially when it sits amongst fallen stones. Some of the larger animals are protectively coloured. The Tibetan gazelle is the colour of the plateau, and a herd of burhel is inconspicuous against a hill.

The majority of the birds are protectively coloured. The different kinds of mountain finches, the Tibetan skylark, the short-toed lark, the calandra lark, the Mongolian sand-plover, are all coloured so as to harmonize with the soil. They all live on the open plateau where there is nothing to conceal them from view. Two of the birds have conspicuous markings, but these do not interfere with the concealing effect. The desert chat, for example, has white patches on its wings which disappear from view when the bird alights. The horned lark has black markings on its neck and breast, but these are sufficiently well concealed from a hawk or other enemy soaring overhead. The Tibetan sand-grouse is an excellent example of harmonization; so is the magnificent Tibetan snowcock when feeding amongst the boulders and crags. The cliffs and torrents also provide examples. The wall-creeper lives around the fort at Shekar, and as it climbs about the slaty rocks the colour of its back blends with the stone. The ibis-bill is a more striking instance. As it feeds amongst the boulders in the bed of the torrent it is lost to view in the midst of the stones.

Some of the birds are not thus protected. But in such cases they are able to defend themselves from enemies or have special places into which

they can escape. The raven, the steppe eagle, the kite, for example, are so powerful that they need no protection. Certain little birds, like the sparrows and accentors, are conspicuous, but they keep near villages or piles of stone amongst which they can escape from birds of prey.

We see numerous examples amongst other creatures. The lizards on the plateau are very variable in coloration. Some are uniformly sandy, others coarsely speckled, but all harmonize with the arid soil. There are different kinds of grasshoppers that haunt special situations. One, a large Central Asian migratory species, is rich green in colour and lives in patches of fresh grass. Another, a new genus minute and wingless, lives on the moraines and decomposing granite as high as 18,000 feet. It is finely mottled in grey and black, and difficult to see because it closely resembles one of the granite flakes. There is a third kind which keeps to tracts of coarse loose sand. In its colour scheme are patches of blue and red, and these harmonize with similar colours in the grit. Still another kind haunts the water-worn pebbles on the banks of the Chiblung Chu. This little grasshopper is a uniform blue colour, and exactly the same shade as the layer of stones.

It would be tedious to mention all the other examples. But I must refer to the high-altitude moths which frequent the moraines at 17,000 feet. These resemble a species of tiny *Anarta*. Their under surface is very conspicuous, but is concealed when the insect alights on the rock. Their upper surface, on the other hand, is a mottled grey, which blends with the granite and the decomposing grit.

Thus we see how important is protective coloration in the struggle for existence at these great heights. It is in the vast and open tracts, the deserts, the snows, the elevated wastes, that we have this principle most lavishly displayed. The reason for protection of this kind is clear. In the wilderness hiding-places are seldom available. There are no trees, no scrub, no profusion of grass in which the animals can conceal themselves when enemies approach. To avoid destruction they must seek evasion of some sort. Their only chance is to resemble their natural surroundings and escape by being passed unseen.

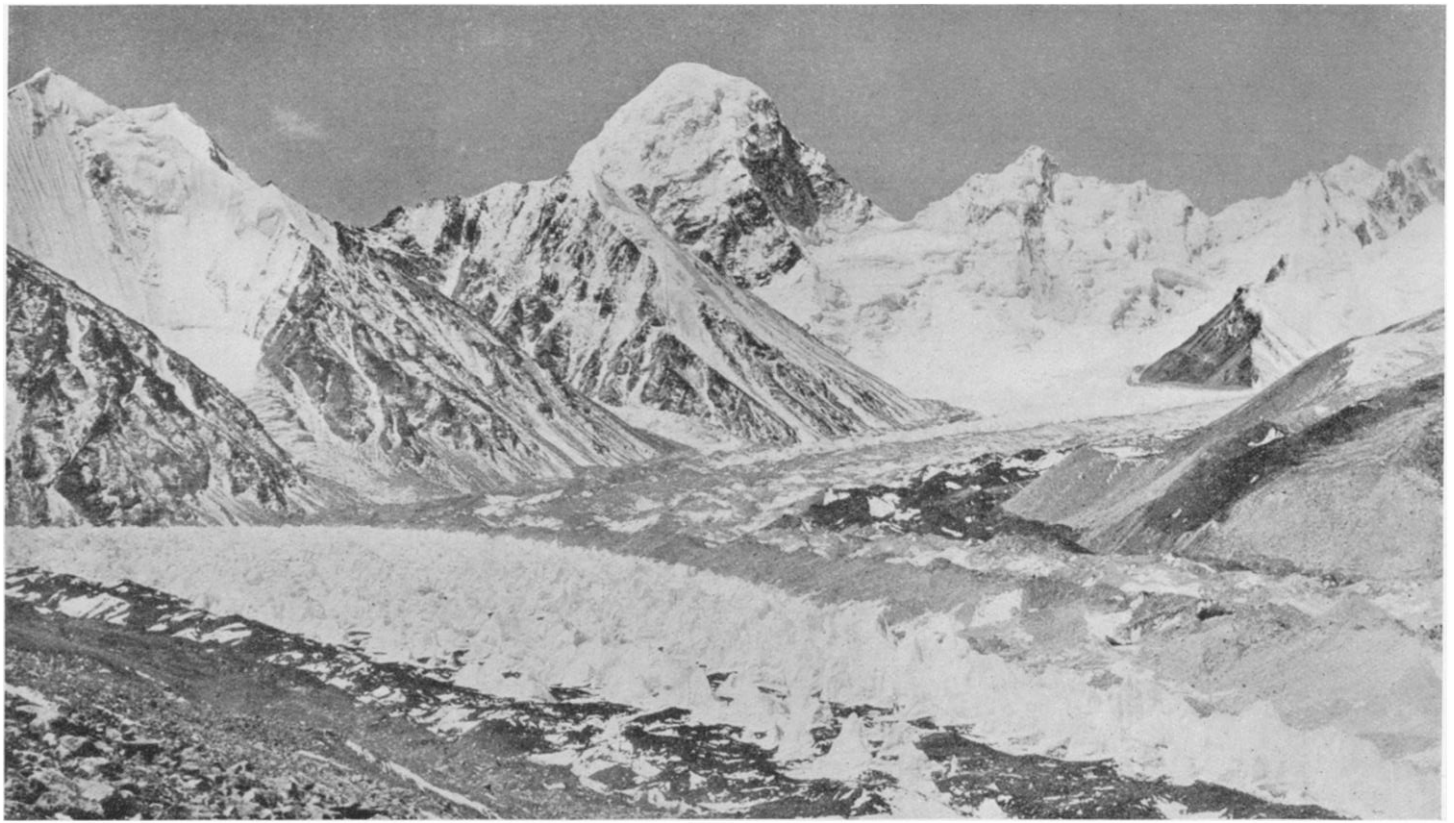
I pass to another problem. How do the animals of these high altitudes adapt themselves to the physical conditions that exist? Consider first their reaction to the wind. Tibet is notorious for its fierce winds. The morning sun heats the surface of the plateau, the hot air rises, and in order to fill the deficiency the wind sweeps down from the main range. Near our base camp we saw an excellent example of its force. The camp stood in a contracted gorge through which the wind poured down from the mountain to the plain. Round about the camp were piles of boulders which the Rongbuk glacier had deposited in the gorge. These boulders were remarkably eroded by the wind. Deep pits and furrows had been eaten into them; they were polished, and broad grooves had been cut into their surface, in places an inch in depth. They were com-

posed of granite and recently deposited, yet from their windward side they looked like lumps of coral while their sheltered surface was ordinarily smooth.

Let us see how the animals react to a wind which can eat into the granite rock. The mammals are often clothed in thicker coats of hair. We see this in the herds of domesticated goats, delightful little animals with long hair that hangs down like a kilt around their legs. The Tibetan dogs are often thickly clothed. Sometimes we may see them in the early summer shedding large patches of winter wool. Near Gautsa I saw pigs at 12,000 feet, and they were covered in a thick rusty-coloured hair quite different from the half-naked animals of the plains. The Tibetan hare has a dense coat, and it ascends to 17,000 feet. But the ordinary yak is the best example. Next its body is a layer of wool. Over this is a hairy coat which hangs down like an apron from its huge body, especially around its legs. Its neck is provided with a strong mane, and behind it supports a large tail of thick and bushy hair. When the yak is grazing we see the value of this coat. The animals like to feed with their backs to the wind. The thick tail then acts as a kind of wind-proof screen; the long hair around the hind legs adds to the shield, while the head, being kept low, is sheltered by the body and protected above by the hairy mane.

Everywhere we see the birds adapting themselves to the wind. The little birds escape it by getting behind obstacles. Thus we often see the larks, the finches, the ground choughs feeding on the sheltered side of villages and walls. When in the open they persistently face the wind; if they stand across it they may literally be lifted off their feet. The larger birds follow a similar habit. The choughs face the wind when feeding on the pastures; the ravens do likewise when scavenging for refuse; the lammergeyer always heads it when descending for bones; the kites persistently come round to windward before swooping down to take garbage from the ground. Those birds that live around rocks and habitations creep into some shelter when the wind blows. We see the sparrows hiding in the holes of the houses, choughs getting into the lee of rocks, rose-finches nestling under ledges and stones. A great number of the birds make their nests in holes, and in this way shelter their offspring from the wind. The mountain finches and the ground choughs place their nests in pika-burrows, often at a great depth. The magpie builds an enormous nest. I think it serves the parent birds as a permanent shelter in addition to serving as a home for the young. The birds that build on the ground place their nests behind tufts. The short-toed lark showed in one case an interesting modification: it built a rampart of pebbles on the exposed side of its nest so as to protect the structure by an artificial wall.

Certain of the butterflies show interesting adaptations. The Parnassius or Apollo butterflies are characteristic of high altitudes.



RONGBUK GLACIER

SLANDS OF MORAINE IN TROUGH OF GLACIER FREQUENTED BY SPIDERS

In Tibet they haunt the passes up to 17,000 feet where the wind sweeps furiously across the range. They are capable of only feeble flight, and are easily carried along by a gale. They escape being swept away by their unwillingness to fly, except when the air is comparatively still. Moreover, when disturbed, they make but short flights ; also when they settle down they choose sheltered nooks, and their resting attitude is to spread their wings, pressing them down close against the ground so as to offer the least resistance to the air. Furthermore, their wings are stiff and rigid and not likely to be torn when being battered about. Also their bodies are clothed in fur, which must serve as a protection against both cold and wind.

The Swallow-tails and Vanessidæ also haunt the plateau. They used to come about our base camp at 17,000 feet. But these butterflies are particularly powerful fliers, and by their strength alone can contend with the wind. Other kinds live at slightly lower altitudes. There is a *Melitea* on the plateau which has the habits of the Apollos. It escapes the wind in the same way by flattening itself tight against the ground. The Lycænids like to keep in sheltered places. One kind gets into the tufts of vetches, another conceals itself in coarse grass. The high-altitude moths that resemble *Anarta* adapt their habits to the fierce winds. They haunt the tracts of fallen rock, the bare hills and deposits of moraine. They fly about by day, alighting on the sand. When the wind is strong they enter clefts in the rocks or else shelter between the stones. Their flight is swift and of short duration. When they alight they behave like the Apollo butterflies, flattening themselves with outstretched wings against the rock, thus offering the smallest obstruction to the wind.

The Diptera that haunt the cliffs at 16,000 feet like to keep close in amongst the stones and rocks. Moreover, they make only short quick flights. Their actions are more like the leaps of a grasshopper than the ordinary movements of a fly. There is one kind, a *Tachinid*, which haunts boulders at the edge of the rivers. It has a black hairy body, a spined abdomen, and grayish speckled wings. Now this fly seems almost incapable of flight, so reluctant is it to take to the air in a wind. Its habit is to seek for shelter beneath boulders, and, when these are upturned, it can be taken in the fingers, allowing itself to be captured rather than escaping by flight. There is another kind of the genus *Gonia* which likes thorny bushes. It comes out on sunny mornings when the air is calm. But its flights are short, only a few feet, as if it feared to trust itself to any distance in the air. Moreover, it strives to keep within the shelter of the scrub, flitting about from twig to twig or coming to rest on the sand beneath. Thus it manages to evade the wind, partly by reason of its short flights and partly by keeping within the scrub.

Some of the digger-wasps avoid the wind in the same way. They have learnt to keep close in amongst the boulders, also to make only quick short flights in order to avoid being swept away. Many of the

insects on the plateau are wingless. Numbers find continual shelter under stones. Grasshoppers ascend to 18,000 feet. But at this altitude they are minute and wingless and escape the wind by their inability to fly. The *Pseudabris* beetles provide an interesting example. These beetles are conspicuous and brilliantly coloured with alternate bands of black and red. They usually hang in clusters on the vetches, where they feed on the young shoots and flowers. Watch them when a strong wind suddenly springs up. They let go their hold and throw themselves to the ground. There they lie, all apparently dead. Each is on its side; its head is bent at right angles to its body; its antennæ are turned downwards; its legs are collected into a cluster and thrust out like lifeless tags. They all lie in the attitude of death like a crowd of corpses strewn over the ground. When the wind lessens they quickly revive, they run over the soil, regain the vegetation, and climb back to their places on the vetch.

Thus we observe that the animals of high altitudes contend with the wind in many different ways. Some grow denser coats, others seek sheltered places, and there is a great tendency to burrow in the soil. Certain butterflies and moths flatten themselves on the ground; many insects make only quick short flights; certain flies keep in amongst stones and bushes; high-altitude grasshoppers and other kinds are wingless; certain beetles throw themselves for safety to the ground.

Let us pass to another phase in the struggle. How do the animals at high altitudes contend with the scarcity of food? The domestic animals show us how severe is the struggle. It is wonderful to see a herd of yaks grazing on the hillsides. To all appearances the mountain is absolutely barren, yet the animals manage to pick up some food. When snow is on the ground they dig through it to the vegetation. The Tibetans said that they scraped up roots. I have seen them eating the fresh dung of a pony which had been well fed on grass and grain. In April, when the grass is just commencing to appear, the sheep struggle hard to obtain food. With their fore feet they dig into the soil and shuffle aside the superficial sand in order to get at the buried blades. When food is scarce, the ponies do likewise. I have seen them cutting up the ground with their hoofs in order to expose the hiden roots. Also they wade into icy lakes, where they feed on the water-weed that grows up from beneath. The mules and donkeys will sometimes eat quantities of yak-dung, which does not seem to do them any special harm. The pikas show an excellent example of husbandry. They store up quantities of seeds in their burrows to serve as a winter supply of food.

The bills of certain birds seem specially suited for penetrating frozen soil. This is of importance for the insectivorous species, since in winter, when the ground is hard, all insects are hibernating underneath stones or in the superficial layer of the earth. Compare the bill of the chough, an inhabitant of high altitudes, with that of its allies,

the rook and crow. The chough's bill is proportionately longer and sharper and better fitted to penetrate the frozen soil. It is also used as a kind of lever with which the bird upturns the lumps of dung in order to reach the good things underneath. The ground chough is a delightful Tibetan bird of a sandy colour that harmonizes with the soil. It is about the size of a lark, but is supplied with a long and powerful bill, slightly curved like that of a chough. Now this bill fulfils an important purpose. The bird is an insect-feeder, and must find great difficulty in securing food during the cold months of the year. All insects are then in a state of hibernation. But the ground chough can dig them from their places of retirement. We may often see the bird boring in the soil, driving its stout bill into the hard plateau until it finds the insects hidden underneath. Unless it had this special instrument of excavation it could scarcely exist through the winter months.

The larks supply another example. In India there are two kinds of Calandra larks: one the Eastern Calandra lark, which lives on the plains; the other the long-billed Calandra lark, which occupies the plateau of Tibet. They are powerful birds of heavy build, and utter a loud call-note when in flight. Compare the bills of these two species. That of the plain bird is comparatively small, about $\frac{4}{5}$ inch in length. That of the Tibetan bird is distinctly longer, its length being $1\frac{1}{5}$ inches. The longer bill of the Tibetan bird is explained by its environment. It ploughs into the ground after the manner of the ground chough, hammering the surface with its powerful bill and securing its food by boring into the soil. And since the soil is often frozen and difficult to penetrate, this species of the plateau must have a sharper bill than the closely allied species of the plains.

That remarkable bird, the ibis-bill, provides an excellent example of how the bill of a bird is adapted to its method of securing food. It is a high-altitude wader with a long hard and slender bill curved something like that of a curlew. This bird is met with in the mountain torrents that pour from Tibet into the Himalayan range. It specially likes those places where the stream is broad and meanders through a bed of stones. There it runs about upon the layer of boulders, sometimes wading into the torrent up to its breast, thrusting its long bill under the stones in the hope of finding insects beneath. Sometimes it curves its bill around the front of the stone, sometimes inserts it from one side. The bill is an excellent instrument for this purpose. Were it straight, it would not suit the roundness of the pebbles. The curve is a necessary feature of the implement and is excellently adapted to the habits of the bird, for it is curved in such a way that it fits neatly around the boulders when the bird is probing for food.

The peculiar environment of the Tibetan plateau has caused some of the high-altitude birds to change their customary habits of life. Some

kinds, owing to the absence of trees, have become almost exclusively village birds. Thus the tree-sparrow is to be found near every habitation. The accentors, which usually haunt bushes, in Tibet live amongst houses and in streets ; also the rose-finches, which naturally like jungle, are frequently seen on the village walls. The magpies are like house-crows in the way they keep to the villages, and, like choughs, they frequent precipitous cliffs. Many of the wildest birds have lost their sense of fear. The ruddy sheldrake and the bar-headed goose, which in India are amongst the most timid of birds, in Tibet swim about the ponds near the villages as fearlessly as in a city park. The hill pigeons fed as boldly at our Everest base camp as if they were the tame birds in a London street. We observe the same tameness in the case of some of the mammals. Wild sheep, for example, are naturally very timid, yet at the base camp they came within 20 yards of our tents, and they are said to visit the caves in the mountains, where they take food from the hermits' hands. Thus we see how pliable is animal instinct. This unusual tameness must be due to the absence of persecution, and shows that the sense of fear is not altogether innate, but is developed as a result of persecution by man.

Certain birds of the plateau have formed communities with other animals, this being a help to them in securing food. The most interesting of these is the mouse-hare community. The mouse-hares are most engaging little animals about the size of a large rat. They live in burrows on the open plateau, where they are usually seen feeding at the entrance or running from hole to hole. A number of birds associate with these mouse-hares. Amongst them were three kinds of mountain finches, and Elwes' horned lark. All these little birds were remarkably tame ; there was a perfect confidence between them and the mouse-hares, the whole making a charming society of protectively coloured mammals and birds. What is the object of this friendly association ? It is one of the ways in which the birds of the plateau contend with the scarcity of food. For these birds are seed-eating species, and find special attraction near the mouse-hare's holes. The mouse-hares possess an instinctive forethought. They store up a winter supply of seeds, which they carry into their dens. But where storage takes place there must certainly be some refuse. Little seeds will lie about in the vicinity of the burrows, and it is these waste fragments that attract the birds. Very possibly the birds also pillage the mouse-hares, for we often observed them entering the holes.

At greater heights, on the almost barren mountains, a less conspicuous society may occasionally be seen. This is an association of choughs and wild sheep. The chough sits on the wild sheep's back, where it searches for insects in the animal's hair. The sheep seems pleased with the bird's attention, and remains still while being explored. It is an interesting association at the highest altitudes. I have seen it on the crumbling

snow-clad slopes as high as 17,000 feet. Thus the stress of food at these elevations drives certain birds to associate with mouse-hares, others to keep company with wild sheep. The wild sheep at high altitudes are continually displacing small rocks and stones. At different times my notice was first attracted to the animals by the clatter of stones falling down the slope. It is thus likely that these animals play no small part in the denudation of high altitude cliffs.

I pass to another point. How do the animals escape the cold of winter? A number, of course, migrate to lower altitudes; but of those which remain, most go into hibernation and sleep the winter through. When we reached the plateau early in April, we found it almost destitute of animal life. Everything was hibernating underneath stones or in clefts of the rock or in the surface earth. The ants were hidden in subterranean galleries. Under stones were weevils quite motionless, also Carabid beetles so torpid that they were scarcely able to move. We found centipedes rolled into motionless coils, spiders lying dormant in the interior of snail-shells, earwigs in a sluggish state with their antennæ thrust back along their sides. Under some stones were numbers of dead insects, as though many had sought concealment in the autumn and died during the winter cold.

Hibernation must be a valuable protection to the animals. At the base camp I made an artificial burrow like that in which the pikas are accustomed to hibernate. At a foot beneath the surface its temperature was almost uniform. From 8 a.m. to 9 p.m. it remained at 33° F., while during the same period the temperature of the air varied through 19° F. Thus by burrowing the animals gain great advantage. They escape extremes of temperature and find uniform conditions. In winter they gain it even still more when they hibernate in the soil under thick snow. The conditions under a stone are also favourable for hibernation, though not to the same extent as a burrow in the soil. At an altitude of 17,000 feet the temperature beneath a stone varied through only 12° F. during the twenty-four hours. In the same period the temperature of the air varied through 44° F. Thus the beetles, the spiders, and many other creatures gain more equable conditions by hibernating under stones.

The hot springs of Tibet supply a place of refuge in which animals can escape the cold. In one place we found these springs bubbling through the soil and flowing away in warm streams. The temperature of the water was 60° F. A varied life inhabited these springs, chiefly crustacea and different kinds of shells. The only snake from the Tibetan plateau that I know inhabits the hot springs. In my original report on the fauna of the plateau mention was made of small leeches found at a height of 16,000 feet. It was found, however, on more careful examination, that these little animals were in reality planarians.

In the struggle for existence at these great altitudes many animals are driven to extreme heights. It indicates how relentless is the force of

Nature to spread into every habitable corner of the Earth. The wild sheep and mountain hares struggle up the ranges even to the barren slopes at 17,000 feet. There is a little redstart which places its nest at the same inhospitable height. We found grasshoppers at 18,000 feet, near the furthest limit of vegetable growth. We frequently saw the magnificent lammergeyer soaring round the mountain at 20,000 feet. We found bees, moths, and butterflies at 21,000 feet, spiders at 22,000 feet, choughs at the immense height of 27,000 feet. We found traces of a permanent animal existence far above the Himalayan snow-line and 4000 feet above the last vegetable growth. These were small spiders, and are the highest existing animals on the Earth. They live in islands of broken rock surrounded by snow and ice. There is no sign of vegetation or living creature near them, and for food they eat one another.

Nothing illustrates better this high-altitude struggle than the manner in which animals secure a livelihood on tracts of snow and ice. We found an interesting fauna on the Rongbuk glacier at an altitude of 17,000 feet. The surface of this glacier was deeply fissured and to a large extent covered with broken rock. It seemed at first sight utterly barren, yet some grass grew amongst the rocky fragments, and patches of lichen appeared on the stones. Certain animals found existence in this desolation. I have seen a herd of wild sheep sitting on the glacier surrounded by pinnacles of ice and stones. Certain birds used to frequent the icy tract. The snowcock came down to it from the sides of the gorges, perhaps to find a little food on the surface moraine. I saw Guldenstadt's redstart high up on the glacier where nothing existed but *débris* and ice. A little stint, while migrating through the gorge, halted for a rest near a glacier pool. A tortoiseshell butterfly was sometimes seen on the glacier at 17,000 feet. A number of protectively coloured moths used to live on its surface moraine. Beetles and small spiders found a shelter on it. It was the home of some minute flies. Even in the deep blue pools on the surface of the ice some creatures managed to secure a place. These pools were so cold that, after sweeping them with a net, the gauze remained frozen into a rigid bag. Yet in these pools were the larvæ of both stone flies and mayflies, and other equally delicate kinds skated on the surface of the water.

We may sum up with the impression that the struggle is fierce in the high altitudes of the Mount Everest region. We have seen that numbers escape death through protective coloration ; that many kinds have devices for escaping the strong winds; that at certain seasons the struggle for food is intense ; that some birds are specially equipped to dig into the soil ; that other birds are forced to change their habits of life, and some to form communities with mammals ; that burrowing and hibernation are the great resorts by which animals escape the extreme cold ; and finally that the ceaseless and relentless competition has driven animals to

extreme altitudes, where they live above the snow-line and on the surface of the glaciers in one of the most inhospitable regions of the Earth.

Before the paper the PRESIDENT said: Our lecturer this evening requires little introduction to an audience of this Society, for he is well known to you as the Medical Officer and Naturalist of the last Mount Everest Expedition, and uppermost in our minds, no doubt, will be that outstanding exploit of his when he conducted Colonel Norton, after he had become incapacitated by snow-blindness, safely down from the North Col of that formidable mountain. Many of you will also recall with interest the technical paper which Major Hingston gave to us at one of our afternoon meetings upon the effect of high altitudes on the human organism. He had already studied that subject when he attended as Medical Officer, I think, the survey expedition which carried out a programme of triangulation upon the high peaks of the Pamirs in 1913. It was no doubt their appreciation of what he had done in this direction that induced the authorities to release him from his command of the Royal Air Force hospital in Mesopotamia in order that he might join the Mount Everest Expedition. But besides these qualities for the post he has always been also a keen naturalist, and it is of the geography and its accompanying fauna of the high plateau of Tibet that he is going to speak to-night. The distribution of animal life in these high and inhospitable regions and the methods which that life adopts for its protection is well calculated to provide a fascinating story in competent hands, and it is with complete confidence in the power of Major Hingston to do justice to the subject that I now call upon him to give us his paper.

Major Hingston then read the paper printed above, and a discussion followed.

Dr. A. W. HILL, F.R.S. (Director of Royal Botanic Gardens, Kew): Major Hingston has told us a very interesting story of how the animals and birds have mastered the problem of protection at inhospitable heights. We at Kew now possess, through the kindness of the Joint Committee, all the plants that have been collected on the expeditions to Mount Everest. With the plants, of course, the problem of how to protect themselves in the adverse conditions under which they grow is as important as that with which the animals are faced.

I happen to have travelled in the Andes among the mountains around Lake Titicaca and collected plants growing at between 13,000 and 17,500 feet, and there, I fancy, from what we have heard to-night, the conditions must be very similar to, though rather less severe than, those in Tibet. In the Andes the plants are, of course, entirely different from those of the Himalaya, yet the methods of protection assumed are very closely similar. In the case of all high alpine plants the great thing to be aimed at is reduction of the transpiring surface; the leaf area is reduced to the smallest possible dimensions; the plants are very slightly raised above the surface of the soil, often not more than 1 inch, and they generally have a dense woolly protective covering. One of their chief characteristics is that they possess a long tap-root which goes deep down into the soil and thus enables them to get the necessary moisture from the ground below the level affected by frost. As Major Hingston has pointed out, the difference between day and night temperatures is very great, and the upper layers of the soil are often frozen. The leaves are closely imbricated and protected by the fibrous remains of

older leaves. Plants belonging to totally different families and genera show very similar adaptations; some of the Crucifers, such as the Drabas, the Androsaces belonging to the Primulaceæ, the Saxifrages, and the Gentians, to mention a few, are so alike in their vegetative characters that without flowers it is impossible to tell to which natural family or genus they may belong. I have no doubt that Major Hingston, in making his remarkably fine collection of plants, which contains some five hundred specimens, had considerable difficulty in discovering those minute plants, and, especially at the higher altitudes, in distinguishing them among the stones and gravel in which they were growing.

Major Hingston has referred to life at the highest altitudes he reached, but I do not think he collected plants from quite some of the highest points to which he climbed. The highest-growing plant that we know from Mount Everest is *Arenaria muscosa*, collected by Mr. Wollaston at 20,400 feet on the first expedition, and that we believed until quite recently was the highest recorded plant. But I find that the Swiss naturalist, Dr. Jacot Guillarmod, collected *Delphinium glaciale* at 20,600 feet when he was on Kangchenjunga in 1905.

In addition to the interesting Alpine herbaceous plants collected by Major Hingston, which included *Gentiana amœna*, also found by Mr. Wollaston, *Androsace sessiliflora*, and the beautiful new Primula, which the late Sir Isaac Bayley Balfour named after Mr. Wollaston, *Primula Wollastonii*, all from about 17,000 feet, there were also several dwarf shrubs. Three of these are dwarf Loniceras (Honeysuckles) one being probably an undescribed species, and there are also two Rhododendrons, *R. setosum* and *R. anthopogon*. The Rhododendrons are interesting because they afford a striking morphological contrast. We are apt to make definite statements in regard to plants and to say that those from high altitudes are characterized by being covered with woolly hairs, and this is commonly the case, but of the two rhododendrons I have mentioned, one is densely woolly while the other has no protective hairs at all, though no doubt it has a well-developed cuticle. These two plants form an interesting parallel to the unprotected human beings and the hairy animals who inhabit this region.

The genus *Pedicularis* is richly represented by some ten species in Major Hingston's collection, and it is interesting to find so large a number of these semi-parasitic plants at these high altitudes.

Another feature of interest in the collection, especially in association with human habitation, is the occurrence of several common weeds at these high altitudes. *Brassica campestris* was found at altitudes from 12,000 to 14,500 feet. The common Shepherd's Purse (*Capsella*), a common weed in our gardens, was found up to 14,500; whilst a weed of American origin, *Galinsoga parviflora*, occurred at 10,000 feet, and the ubiquitous Dandelion was found at 14,500 feet. *Glaux maritima* was also collected at 14,500 feet, and this, as botanists know, is a plant confined to the seashore in this country; *Polygonum viviparum*, a plant which at high altitudes has the flowers replaced by bulbils, was also found on the slopes of Mount Everest at 14,500 feet.

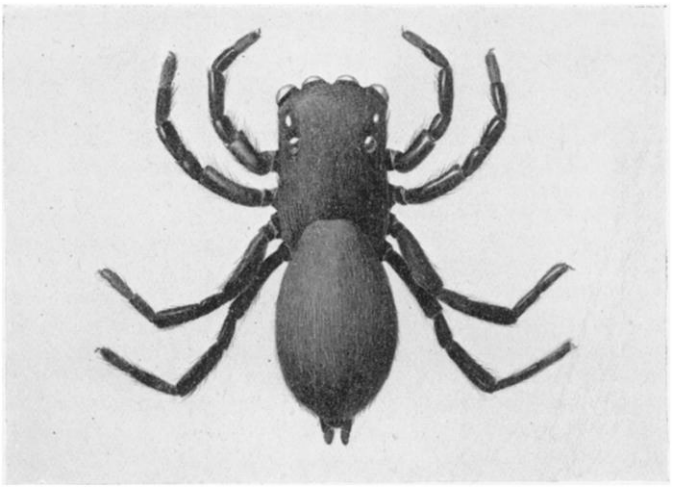
The highest plant brought back by Major Hingston is the common alpine Edelweiss from about 17,500 feet.

All these plants form a very interesting addition to our knowledge of plants from high altitudes. Taking into consideration the difficulties that must have been met with—and the same can be said of the earlier collections

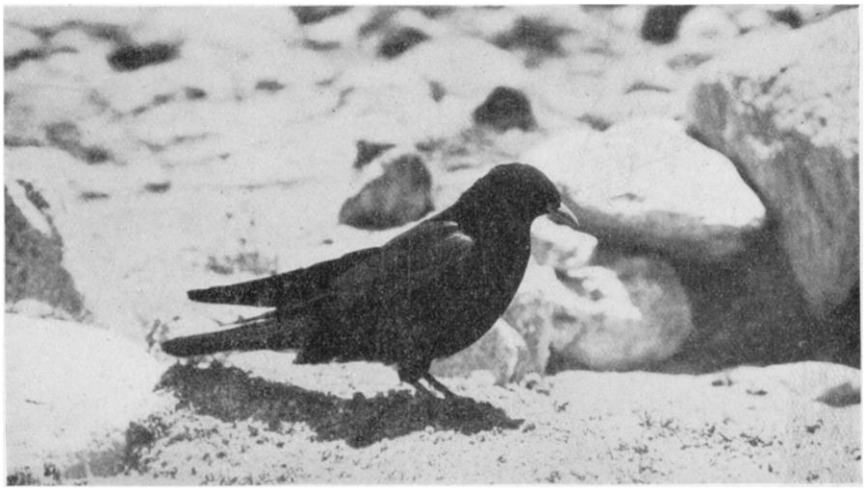
YOUNG OF TIBETAN SNOWCOCK

BURHEL ON CLIFFS NEAR BASE CAMP

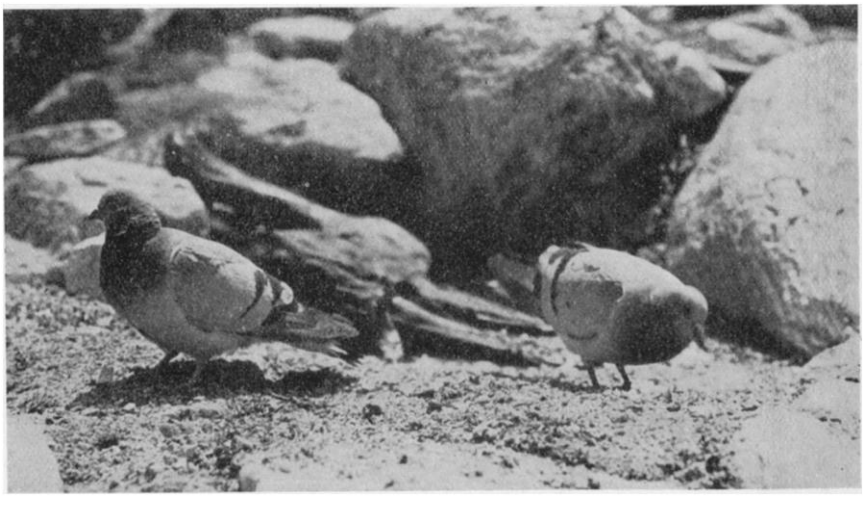
A YAK



ATTID SPIDER FOUND AT 22,000 FEET



YELLOW-BILLED CHOUGH IN BASE CAMP



BLUE HILL PIGEONS IN BASE CAMP

—the condition in which they were preserved and sent home has been remarkably good, and it has been possible to name them without any very great difficulty. A few of the plants probably represent undescribed species, but at the moment we have not had time to work through them critically. They will however be carefully determined and a full list published in due course.

Mr. A. F. R. WOLLASTON: I have listened to Major Hingston's lecture with intense interest. He makes me very much ashamed of the scanty observations and collection we brought back in 1921. Listening to his account of the ways in which animals protect themselves and are protected against the rigorous climate, one is struck by a very important omission. The dogs, the yaks, the sheep, the pikas, the very little pigs themselves have their fur coats, but nothing is said of man! The Tibetan is a singularly hairless creature. His only protection from the weather is the dirt that he accumulates. He has not contrived any kind of protection. It is a serious reflection this, that we are really such very recent upstarts in the order of things!

Talking of that same cold weather, I think the bird population in the plateau is very small in winter. When we were at Kharta in October we found at the altitude of 12,000 feet, which is well below the high regions, tens of thousands of desert forms crowding down the valley, and I have no doubt that in a week or two they would have gone still further down, so that I think the bird population in the plateau is very small in the winter except about the villages. Many of the mammals hibernate, so they have no trouble.

One of the most interesting observations that Major Hingston mentioned is that of the choughs following the mountain-climbers up to 27,000 feet, which is exactly what they do in the Alps; they follow climbers up to the tops of peaks, hoping for some crumbs from luncheon. I only wish Major Hingston had seen the lammergeyer flying over the top of Mount Everest. I have no doubt they do. We saw them fly certainly 26,000 feet, and surely they can go higher.

There is one small point in which my experience differs from that of Major Hingston. He thinks that fear is not innate in wild creatures. I think fear of man is innate. For instance, I have been in high regions in the middle of Africa in Ruwenzori and in very high regions in the snow mountains in Dutch New Guinea where certainly no man, white or black, had ever been seen before, and it was noticeable how very shy and how very difficult to approach were the small birds in both those regions. I think when a small bird first sees a man it is necessarily frightened. The birds and mammals in Tibet have learned by association with the Buddhists that they are not going to be molested and so they lose fear. But I believe fear is innate. I may be wrong.

A year or two ago I had the privilege of reading a paper to this Society on the natural history observations which were made in 1921 on the first Mount Everest Expedition. As I left the meeting I walked down the street in front of two Fellows of the Society. One said to the other, "That is not the sort of thing I expect at the Geographical." The other said, "I think I shall write to the Secretary." I do not know whether he did write to the Secretary nor what the Secretary replied to him. But with all deference I venture to differ very strongly from those two Fellows. I think that if a traveller is only a geographer and not in some part a naturalist he misses, I should like to say, almost half the pleasure of travel. I have no further observations to make, except to congratulate Major Hingston on the most interesting discourse to which we have listened.

The PRESIDENT: I offer, on your behalf, our sincere thanks to the lecturer for the pleasure which he has given us this evening. It is only too painfully obvious, I suppose, to every one that the struggle for existence at these high altitudes is extremely severe, and it was extraordinarily interesting to learn of the various devices which these different forms of animal life evolve in order to meet the severity of the conditions under which they live. One thing that certainly struck me was the patent futility of all such devices. The small birds, apparently, evolve protective colouring to protect them from the larger birds which habitually prey upon small birds, yet the larger birds appear to be as successful as they generally are in living upon the smaller birds, for the lecturer told us of lammergeyers, ravens, and other large birds of prey flaunting themselves in their arrogance in non-protective colours across the range of his vision. Again, the smaller birds appear to develop specially constructed beaks which enable them, in their turn, to defeat the efforts of the insects to get away from them. It really seemed to me that the futility of life is even greater at these high altitudes than it is at more normal levels. And surely the height of futility was reached in the case of the spider which, according to the lecturer, lives at so great an altitude that there is nothing for him to live on except his father. Can you conceive a greater degree of futility than being born and struggling to exist in order that, in due course, you may become food for your son? And for your son to be born and to struggle to exist in order that, in due course, he may become food for your grandson? It seems to me that in that case we really have reached the height of futility. Finally, Major Hingston has given us much food for thought, and one of the outstanding features of his lecture, I think, though probably it was an entirely unconscious one, was the extraordinary industry, determination, and perseverance which the lecturer himself showed in making these interesting and minute observations under conditions which must have been extremely trying and in many cases involved no small degree of hardship. We are grateful to men of his type in general who are prepared in the interests of science to undergo these discomforts and hardships, and we are grateful to him in particular for the extraordinarily interesting story which he has told to us to-night.

THE ROSS BARRIER AND THE MECHANISM OF ICE MOVEMENT

C. S. Wright

Read at the Afternoon Meeting of the Society, 19 *January* 1925.

THIS paper on the Ross Barrier and the mechanism of ice movement is based on the Glaciological Report of Capt. Scott's last Antarctic Expedition, but extends to a slight extent certain views of the mechanism of ice movement dealt with in that Report, which was a joint work with Major R. E. Priestley.

The Ross Barrier is the name given to the huge mass of ice which fills the southern end of the Ross Sea. It was discovered by Ross in 1841, and the northern boundary was surveyed by him from the *Erebus* and *Terror*. The Ross Barrier is thus bounded on the north by the Ross Sea, on the west by Ross Island and the steep coast of South

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NEPAL

Brig.-General the Hon. C. G. Bruce, C.B., and Major W. Brook Northey, M.C.

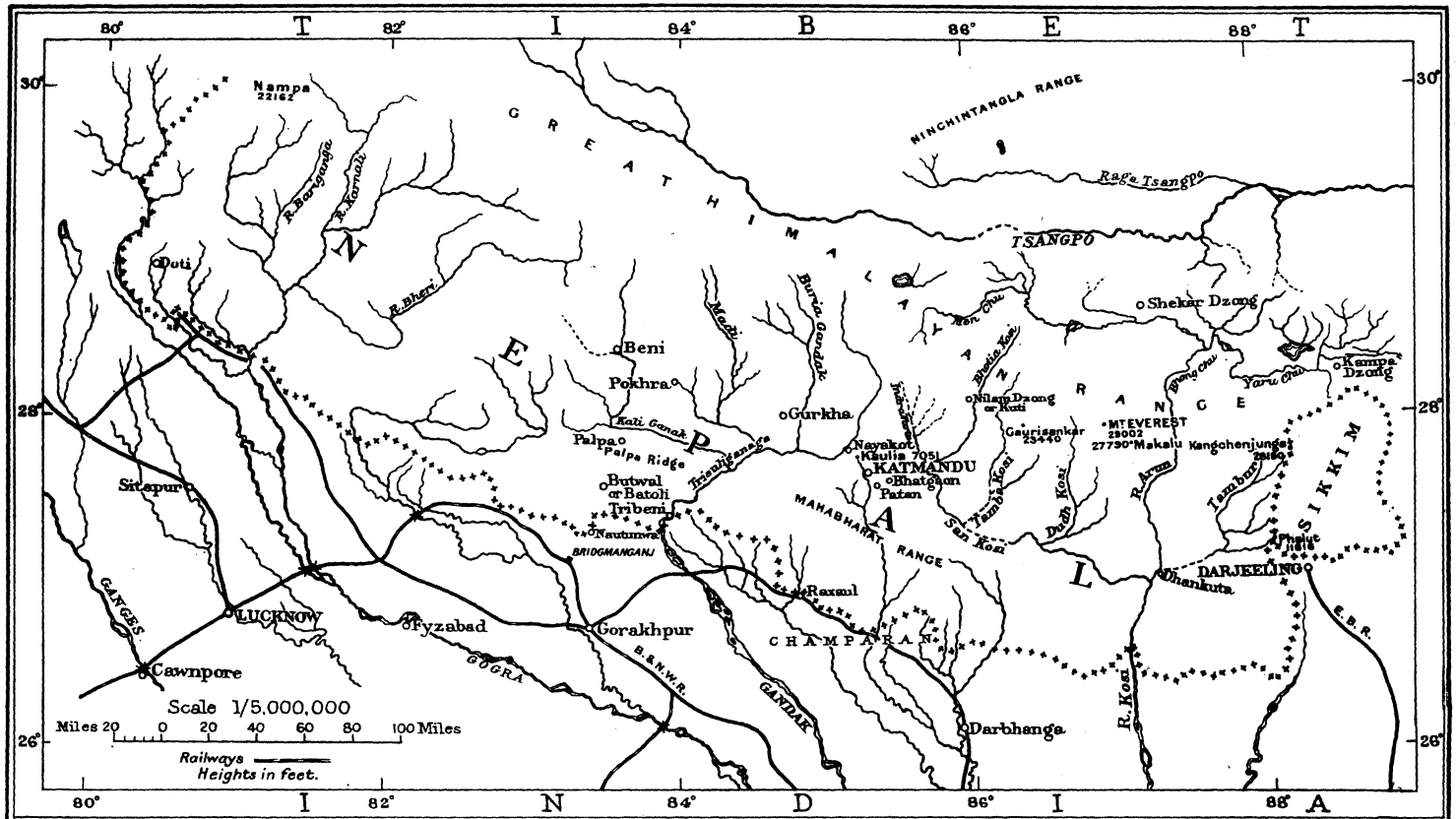
Read at the Meeting of the Society, 26 January 1925.

PART I: GENERAL BRUCE

WHEN Major Northey and I undertook to give a lecture on Nepal we both had at the back of our minds the idea of bringing out the relationship of the present Gurkha Raj with the Imperial Government, and of showing more clearly the position, and possibilities, and some of the present difficulties with which our relations with that country are faced. But in order to do this it is necessary to give a very short sketch of the history of Nepal, and the rise of the present reigning Gurkha dynasties. With this question is very much wrapped up the geographical aspect.

That part of the Himalaya between the Singalela ridge on the east and the Mahakali on the west is almost as little known as any part of Asia. Between these two boundaries lies the territory known as the Kingdom of Nepal—a name which has been given to it only as being the most convenient, and as representing the boundaries of the kingdom as fixed by Treaty. The name Nepal itself is, and has been for innumerable centuries, confined to the valley of Nepal, or, as it is called in Nepal itself, " The Country contained within the Four Passes " : to the east, the Saga pass ; to the south, the Phar Ping (through the Mahabarat Range) ; to the west, the Panch Mané ; and to the north, the Pati pass. Within these four passes lies the historic and true valley of Nepal, and these four passes separate Nepal from the outer world.

For many centuries the valley and the lowland, especially to the east, were in the hands of what are now looked upon as among the original inhabitants of Nepal, the Newars—a race distinctly and clearly of Mongolian origin and speaking a language also Mongolian in origin. Their country has been a religious centre for untold generations. It is called, after a great Hindu Rishi, Ne Muni, Ne Pal—the beloved abode of Ne. It went through all stages from early Hinduism, and then was for many years the sanctuary of Buddhism, visited by the great



SKETCH-MAP OF NEPAL, TO ILLUSTRATE THE PAPER BY GENERAL BRUCE AND MAJOR NORTHEY.

The northern frontier of Nepal runs along the Great Himalayan Range, but not always on the line of the highest peaks.

Saint Manjusri, who probably was Shri Manchu, the Illustrious Manchu. Latterly it has been the home of Hinduism and Buddhism flourishing side by side. To the Newars are due all the culture, the arts and crafts of Nepal, and under them a considerable civilization must have been developed in this curious hidden land. From far back beyond the historic period the country has had a succession of dynasties, almost more confusing than Asiatic dynasties usually are. It was from them that the present Gurkha rulers of Nepal in the eighteenth century conquered and annexed the heart of the country.

Let me now roughly sketch the geography of the country. The region included under the term the Kingdom of Nepal is contained from east to west between the Singalela ridge, which divides it from Sikkim on the east, and the Mahakali, or Sarda, which divides it from Kumaon on the west—about 500 miles in a straight line. On the north its boundary is usually the main axis of the main Himalaya, but by no means altogether, as there is a certain amount of country, especially in central and westerly Nepal, beyond the first great snowy range. Its greatest breadth is from Mustang on the north to Makwanpur on the south, about 140 miles. In many parts it is a good deal less than that. Within these narrow confines one can pass from the wonderful tropical jungles of the Terai to the eternal snows.

To describe the country, possibly more as it is understood in Nepal, we may say that from east to west Nepal is divided up into four regions. The first is the Kosi system of drainage, known as the Sapt Kosis—the seven Kosis—which drains the whole of the eastern Nepal Himalaya, not only carrying off the waters from the southern slopes, but also from the northern slopes, *viâ* the Arun and the Bhotia Kosis, etc. This system is composed of the seven great tributaries of the Kosi river : the Tamor, the Arun, the Dudh Kosi, the Thama Kosi, the Sun Kosi, and the Bhoti Kosi. To which may be added the Indra Vati and the Likhu Kosis.

Then comes the valley of Nepal, included between the four passes as before stated, and principally drained by the sacred Bagh Mati.

Leaving the valley of Nepal we meet another great drainage system known as the Sapt Gandakis, which drains the main central Himalayas ; from Gosain Than to beyond the Kali, and the great mountains of Dwalagiri and Mackhapuchri and Jhib Jhibia. The Sapt Gandakis consist of the Tirsuli, the Buria Gandak, the Marsiangdi, the Seti, the Chépé, the Madi, and the Kali (also known as the Krishna Gandaki), to which may be also added the Dharmadi.

To the west again we find the drainage system of the Karnali, with its great affluents the Bheri, the Buri Ganga, and the Seti Ganga ; and then to the border, the Mahakali, which itself is an affluent of the Karnali. Many of these rivers, notably the Arun, the Bhote Kosi, the Kali, and the Karnali, rise beyond the main axis of the Himalaya. Doubtless as our knowledge advances we shall find many more breaks through it.

As a matter of fact these very bald geographical facts have a great bearing on the distribution of the population, and the valleys down which these different rivers flow have generally their own human characteristics. It may be said that the system of the Sapt Gandakis is the original home of the Gurkhas, and of the old military tribes of Nepal.

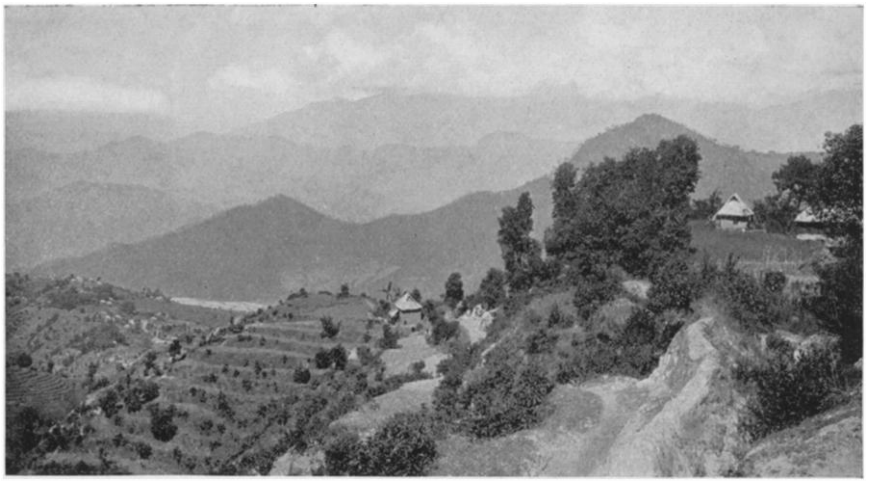
The whole of this very wonderful mountain country may be described as unknown. Reports brought by our native surveyors, who have been allowed into Nepal or have travelled in that country; the primitive maps of Nepal, of which there are a few; information collated at the Residency in Nepal or at our recruiting offices; and measurements made by our Survey officers, either from outside Nepal or from the valley and its neighbourhood, really supply all we know of this interesting country, which contains in itself some of the most magnificent scenery on the face of the globe. The most glorious panorama—a view I have hardly seen surpassed—was that which spread out before me one February morning, after bad weather, as I stood on the Chandragiri pass and looked down into the Nepal valley. Opposite to me lay the entire range of the Nepal Central Himalaya, deep in fresh snow, and appearing on that gorgeous winter's morning, in its sparkling white radiance, to be completely dominating the lower hill country which lay in the blue valleys immediately below me.

Nepal itself, the historic heart of the whole country, the ancient centre of culture in a sea of mountains, is the one considerable piece of flat ground, or, I should more truthfully say, *flattish* ground, to be found on the southern slopes of the Himalaya until the far greater western valley of Kashmir is reached, to which valley, however, it bears but little resemblance, being far more accidented, and being only some 15 miles in length by 7 in breadth. It is very thickly populated, and contains several towns of great antiquity and of great architectural interest.

In aspect these towns, their buildings, and surroundings are curiously un-Indian. The dominant impression one receives is Chinese, this being due to the Pagoda-like character of the architecture of all, or nearly all, the old temples and buildings. It is stated in Silvain Levi's book on Nepal that the Chinese got the idea of the Pagoda from Nepal, but I cannot vouch for the correctness of this theory.

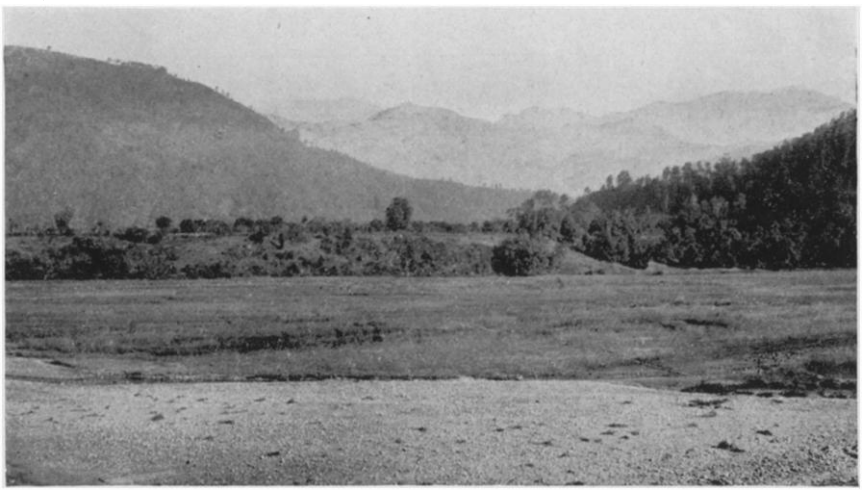
Before I deal with the extraordinary mixture of peoples contained in this strip of the Himalaya, it will be necessary to trace briefly the establishment of the present dominant race and the rise of the Gurkha dynasty. As I have already said, the only seat of culture in this district for many hundred years lay in the valley of Nepal. This valley and the neighbouring districts were ruled over by many and various dynasties, dating back into prehistoric times. Notwithstanding the authority of the book popularly called the "Bangswali," we may neglect for the present purpose all those previous to the Newar kings.

It is clearly evident from buildings and roads that the Newars

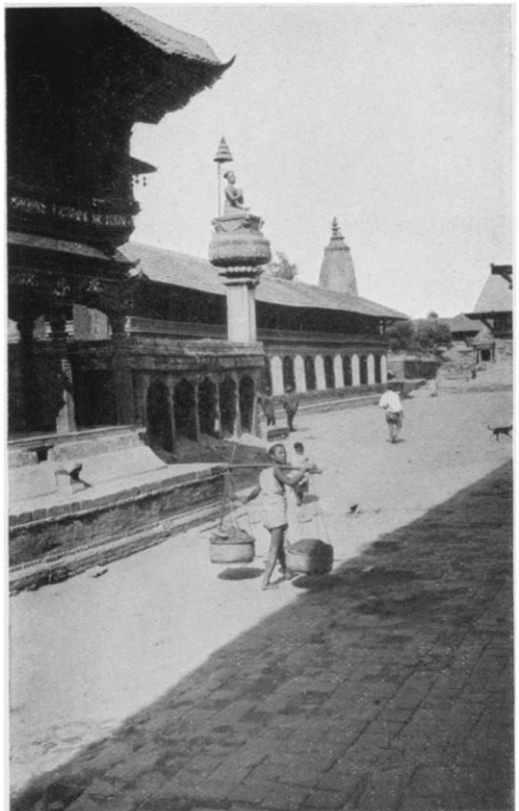


LIKHU AND NAYAKOT VALLEYS

ROAD TO KATMANDU: KARRI RIVER

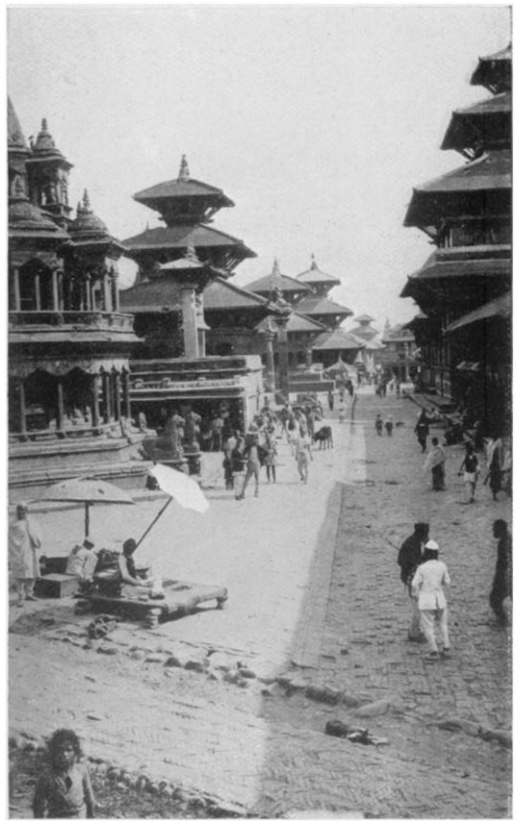


CORNFIELDS, LIKHU VALLEY



DURBAR STREET, BHATGAON

GOLDEN DOOR, DURBAR



PATAN, NEPAL VALLEY

influenced greatly, and probably entirely controlled, the low-lying hills as far as the Ilam to the east, and even Tansing to the west; otherwise the whole mountain country was ruled by little hill chieftains, every valley being a law unto itself.

But another influence made itself felt as well during the course of centuries. Dating from the first and continuing throughout the subsequent Muhammadan invasions of India, there was a great movement of Brahmins and Rajputs from the plains into the mountains, far beyond the present Nepal Kingdom. Thus was the mixed Khassia race formed; that portion of it, now the Khas, or Kshettriya class, being a mixture of high-class and aristocratic Hindus from the south with Mongolian barbarians from Nepal. The only difference between the Khas of Nepal and those hill tribes further west was, that although they had the same fathers they had different mothers.

Tradition has it that in the fourteenth century, after the fall of Chitor, certain scions of the house of Chitor fled northwards, entering the mountain country at Batoli, where their prestige assured them a welcome. Two hundred years later we find their descendants in the kings of numerous little hill states. But what a change has come over the high-bred, intensely aristocratic features of the Rajput! Their faces have broadened and flattened. Can it be that the aristocratic Rajput type has demeaned itself by blending with the barbarian Mongolian? That is undoubtedly what happened.

The whole of the country drained by the Gandakis was thus divided up into little kingdoms known as the Chaubissia Raj (the twenty-four kingdoms). One of these is the little state of Gurkha. Its inhabitants, Gurkhalis, followers of the King of Gurkha, are themselves precisely the same as those of all the neighbouring kingdoms, that is, they consist of the priestly class; the Khas, or Kshettriya, the ruling class; the Mongolian military tribes; and a large number of inferior classes all of whom show Mongolian extraction.

At this period, about 1740, nearly the whole of the inhabitants of the mountains had been obliged to accept the Hindu ceremonial laws, thus coming more and more under the domination of the ruling classes. The then King of Gurkha was Prithwi Narain Sah, a man of ambition and a soldier by instinct. He was strong enough in 1742 to invade the Nepal valley, and for over twenty years he continued his attempts to conquer the three Newar kingdoms of Katmandu, Patan, and Bhatgaon. By 1768 the whole of the Nepal valley and the lands previously ruled by the Newars were in his possession, but so serious was the opposition that he had encountered that the Newars were never forgiven, and though becoming subjects of the King of Gurkha, they have never been allowed the title of Gurkhali.

I must explain what the title of Gurkhali means to a Nepali purist. It merely signifies a follower of the King of Gurkha, and is not a racial

term. So much so is this the case, that although the many neighbouring kingdoms, such as the Chaubissia Raj, and others which were rapidly incorporated with the Gurkha conquerors without fighting, received the title of Gurkhali, neither the Newars nor the many Mongolian classes to the east, who at the present time furnish us with many of our very best Gurkha soldiers, are allowed by the Gurkha purist the title of Gurkhali. There is, however, one striking exception. Those Newars, the traders of the country, who had for generations been living in the town and district of Gurkha, were, and still are, permitted to call themselves Gurkhalis.

Prithwi Narain and his army, having established themselves in Nepal, quietly annexed the states immediately right and left of the valley, his successors pushed further to the east and west, and after considerable fighting, engulfed the whole of what is now called Eastern Nepal, including the military tribes known as Kirantis, or Rais, and Limbus, as well as other tribes in the great valleys running down from the main chain.

The Gurkhas were now full of ambition. They had, in fact, the lust of conquest, and besides that, were prodigiously swollen-headed. They acquired and incorporated into themselves the many hill states of the Sapt Gandakis, including the most powerful, the King of Palpa, who was in 1803 disposed of in true Oriental fashion, by poison, having been invited over to discuss the situation at Katmandu.

They then pushed west, acquiring all the hill country of Humla, Jumla and Baghang and Doti, and finally, crossing the Mahakali, overran and acquired Kumaon, Garwhal, and Jaunsa Bawar, etc., pushing their outposts up and through the Kangra Valley as far as the present hill station of Bakloh. Even this sweeping conquest did not suffice, and an attempt was made to acquire also a dominating influence in Tibet, and especially to acquire the two main routes, *viâ* the Kerong Pass at the head of the Tirsuli, and the Kuti Pass beyond Nilam, and high up on the Bhotia Kosi. They even extended their expeditions, though little better than raiding parties, through Tingri to Shekar, and as far as Shigatse.

This brought upon them condign punishment from the Chinese, who rapidly collected a force superior in arms and numbers, and not only defeated the Gurkhas but followed them into their own country, to within two marches of Katmandu itself. The Gurkhas claim that 70,000 Chinese drove them back, but it is extremely doubtful whether the Chinese army numbered even 20,000. Nepal, of course, in those days, neither in organization nor power, could compare in any way with what it is at the present time, and it is unlikely that the Gurkhas had even 10,000 men to oppose the Chinese. At all events a treaty was entered into by the Chinese general, who effected his retreat before the winter snows. The most notable factor in the treaty was that the Nepalese

should send a Tribute every five years to Pekin; this continued without a break until the establishment of a Republic in China a few years ago.

After this escape from China the Gurkha mentality went from bad to worse. They still held their advanced posts to the west, but naturally their forces were very attenuated, and the Sikhs, who then held the Kangra Valley, very soon obliged them to pull in their horns. Their conduct, too, all along the British Frontier was so arrogant and so provocative, that in 1814 war was declared between the Gurkhas and the British Government. This war was remarkable for a great deal of hard fighting on the part of the rank and file, and the failure of many British generals, redeemed however by Jasper Nicholls and Ochterlony, Nicholls in Kumaon, and Ochterlony at Bichia Koh on the main road, threatening Nepal. The Treaty of Segowli was shortly afterwards signed, the confines of the Nepal frontiers fixed, and a British Resident established at Katmandu. By this treaty, also, the Nepalese allowed their subjects to be enlisted for service in the Indian Army, and, it is specially stated, to be officered by British officers.

About this time another most important fact arose in Nepalese history. The descendants of Prithwi Narain had rapidly degenerated in character, and the power had been placed in the hands of regents, passing thence into the hands of prime ministers. Thus was established in Nepal, and still continues to this day, a system similar to that of the Roi Fainéant and the Maire du Palais of French history. It is not necessary to follow very closely the political history of Nepal from this time. It became chiefly a fight for power among the different clans and their leaders, who aimed at becoming prime minister. It is moreover a history of continual murders and treacheries—now, we may confidently hope, a thing of the past. At first the power was in the hands of the great Thapa faction, its most distinguished representative being the Prime Minister Bhima-Sena Thapa, who was finally murdered.

In 1845 the great Jung Bahadur came on the scenes—the great outstanding figure in all later Nepal history. He was a very remarkable character; he rose to power, first of all, by the murder of his maternal uncle, the then Prime Minister, Mat Bar Singh, following it up by taking a leading part in the great massacres at the Kot, where the Thapa faction was completely wiped out. From that time forth he was supreme, and his family furnish the hereditary prime ministers up to this day. Jung Bahadur must not, in spite of his lurid youth, be too severely judged. He proved himself later to be far superior to his surroundings. To him is largely due our friendship with the Nepal Government—so clearly demonstrated when Jung Bahadur headed a large contingent from Nepal to assist us during the Mutiny. He also, at about the same time, conducted a successful war against Tibet. But beyond that even he made himself felt in every department of government, enormously ameliorating the Criminal Codes of Nepal, and attempting in many

ways to advance his country. In fact, he is remembered in his country as much for his civil reforms as for his reputation as a soldier. He was also, during his whole life, a man of great daring, of great bodily activity, and a fabulous hunter of big game.

I will read, without comment, an appreciation of Jung Bahadur taken from his Biography :

" Looking back at the career and character of Jung Bahadur, the reader feels irresistibly tempted to compare him with one or other of the world's greatest heroes, Cæsar or Charlemagne, Cromwell or Frederick the Great, Napoleon or Wellington.

" But the attempt is soon found to result in dissatisfaction. The parallel is never complete. And the only character in all History towards whom the comparing mind, in its persistent efforts to find out a type or prototype, is bound to turn back to with equal persistence, as the only character fit to challenge comparison with Jung Bahadur, is Jung Bahadur himself.

" And so the stately figure of Jung Bahadur stands out in bold relief among the deified spirits of the world, peerless, matchless, unique."

The modern history of Nepal doubtless dates from Jung Bahadur's visit to England, before the Mutiny.

He passed the succession on, not to his sons, however, but to his brother, and in fact, up to the present, that arrangement has more or less held good. After his death, in 1877, he was succeeded after a short interval by his nephew, Bir Shamsher, an even more enlightened ruler, who in his turn was succeeded by his brother, the present Maharajah, Chandra Shamsher, our very good friend and ally, and by far the most enlightened ruler Nepal has had. They were both the sons of Jung Bahadur's younger brother, Dir Shamsher, who had seventeen sons himself, some of whom still survive.

To pass on now to modern Nepal and its present conditions ; it is entirely a military state, and almost, but not quite, a complete Despotism. It is governed by the Maharaj Adhiraj, known as the " Five Governments "—the head of the Reigning Family ; and by the Maharajah, the hereditary Prime Minister, known as the " Three Governments "—the head of the Ruling Family ; and by a theoretical Council of State. The only other official, however, who may be said to have any real power, is the Raj Guru, the " Archbishop of Canterbury," so to say. The country is still isolated from India. That, up to the present, has been a settled policy.

There is only one main road into the kingdom, and even in that there is a hiatus. This road runs from Raxaul in Bengal, through the great Terai jungles, to the foot of the Mahabharat range of mountains which divides the Nepal valley from the plains of India. Crossing them, it descends by two passes of about 7000 feet into the valley of Nepal. A motor road has now been made to the foot of the hills at Bhimphedi,

and I hear rumours of motor lorries being provided, and aerial rope ways are in course of construction. Having descended no less than 2300 feet from the last pass, the Chandra Giri, by stone steps, a short motor drive brings one to the British Residency, the seat of the British Envoy.

Other communications throughout Nepal are little better than mule tracks or riding paths, that is, beyond the valley of Nepal itself.

This valley, as I have stated before, is the actual hub of the whole kingdom. It contains three towns of first-rate importance and of the greatest interest: the capital and seat of government, Katmandu, and the capitals of two previous Newar states, Patan and Bhatgaon. Both of the latter are remarkable for their temples and palaces, their brass work and carvings, but they do not show a progressive spirit in other ways.

The whole life of the country centres in the capital, Katmandu. Here are the palaces of the reigning and ruling families and of their relations; here are situated all the great Government offices, mostly in the ancient palace of the Thapatali, while in the centre lies probably the most picturesque parade ground in the world, the Tunikhel, large enough to manœuvre 25,000 troops at a review. Here is also situated the Darera, a great minaret, and near it the very spirited equestrian statue of Jung Bahadur.

The Police Department of the Government is entirely run on military lines. All the civil police and the judiciary have military titles; I am sorry to say that the District Judges are, however, only given the title of Lieutenant. The Civil and Criminal Law has been coded, but it is almost entirely based upon ancient Hindu religious statutes, for the Gurkha Raj poses as being intensely ancient and orthodox in its Hindu outlook.

The Gurkha, *par excellence*, is the ruling Khas, or, as he now prefers to be called, Kshettriya. When a Gurkha of high position refers to any custom, saying "the Gurkhas do this or that," he always and invariably refers to the ruling classes.

I have in my possession a geography book lately published under the auspices of the Nepal Government. In dealing with the inhabitants of Nepal and their religions, it divides them into the Brahmin classes, the Kshettriya, some followers of the religions of Buddha, and Sudras—the Sudras being the lowest class in the Hindu hierarchy. That is to say, this geography book, issued under the authority of the Nepal Government, classes all the Mongolian military clans with not only the lower types of hillmen, but with all the menial classes as well. This doubtless is more or less a settled policy to tighten the ceremonial hold of the ruling class over the hillmen.

But in order to make things clear I must classify the inhabitants of the present Nepal Kingdom. Contained within its borders is a great strip of the Plains analogous to our Bengal and United Provinces, the

people of which are of the Plains type, and doubtless supply a good revenue to the State. I am now, however, treating only of the hill populations.

First there are the tribes included under the term Gurkhali ; Brahmins of two great classes, the great Kshettriya clans, providing all the nobility and ruling classes of the entire country—military classes *par excellence.*

Then there are the pure Mongolian military clans, Gurungs and Magars from the Sapt Gundakis, Sunwars, Rais, and Limbus from the Sapt Kosis, with a heterogenous crowd of Mongolian clans and menial classes, still called Gurkhalis, many of whom make excellent soldiers.

There are then the pure Tibetan clans, living on the southern side of the chain, from whom we drew our excellent Sherpa porters on the Mount Everest Expedition. Finally—for slavery is an established custom in Nepal—there are the very large class of hereditary slaves, known as Kamaras. Both the Prime Minister, Bir Shamsher, and his brother, Chandra Shamsher, the present Maharajah, have suggested methods for ameliorating this custom, and for its final abolition ; but public opinion has been too strong, and such measures have had to be dropped. A new attempt is now being made at this very time with much greater prospect of success.

Ordinarily speaking, we draw from the subjects of Nepal twenty battalions of Regular infantry, and numerous military and armed Police battalions, quartered in Assam, Bengal, and Burmah. Here I must draw attention to the effort of Nepal during the War, and the number of men supplied. I do not think I am underestimating if I place the inhabitants of all classes of the kingdom at 4½ millions of people. From that 4½ millions it would be very much overestimating to say that the military classes of all sorts numbered 2 millions ; but the normal 20 battalions were expanded to 38, and were kept up to strength, 56,000 recruits being enlisted for regular units. The Police battalions were kept more or less up to strength, and besides that, the Government of Nepal provided a contingent of 12,000 Nepalese troops for service in India.

I should like for a few moments to describe what manner of people these hillmen are.

The upper classes, grouped around the Court, certainly live curious lives. There are a very large number of relations of the reigning and ruling families, and these have to be provided for. They occupy very nearly all of the higher civil and military appointments. It is a very curious thing, among a people whose lower orders are really devoted to field sports, how weak their sporting instincts, compared to members of the same classes in India, appear to be. They seem to devote themselves almost entirely to the parade ground, and to have the same attachment to drill, as such, as is characteristic of the ordinary Gurkha soldier.

The other clans, or classes, from which soldiers of the rank-and-file are drawn are all peasants, cultivators of the soil, shepherds, etc. They all evince a great attachment for shooting and fishing—for " the Chase," in fact, although the accomplished shikari is as difficult to find among them as in other races. Owing to the complete lack of good roads away from the main routes, all transport is very scarce throughout the kingdom, agricultural produce, merchandise, and so forth, being carried on men's backs. Even in the case of the well-to-do and the plump, if travelling on bad roads, this was also very often the only means of travel. They used to have to ride on the backs of slaves, who carried a little saddle and stirrups, on which the owner rode.

One of the great characteristics of the country, and of village life in the mountains, is the weekly fairs, usually held at the junction of several valleys, where the hillmen barter their produce for other commodities, and where usually a gentle revel is enjoyed. Indeed, singing and dancing are a great feature of the life of the people. There are many types of songs and dances, several of them having their special times and seasons, such as sowing and reaping time, and especially at the transplanting and dividing of the rice crop. There are also long semi-religious dances, taken from stories from the Ramayun, or from other Hindu classics, and numerous folk-songs, differing greatly according to the clans. They often, too, have singing competitions, singing backwards and forwards against each other, exactly in the same manner as Welsh Pennillion singing. Some of them, such as the Limbus of the east, have to sing for their brides. They compete in song with the young woman they want to marry, and unless they can outsing her are not supposed to win her.

Many of their folk-songs, indeed, although very primitive, have quite interesting sentiments. A couplet, to be a good couplet, should have its first two lines in slight metaphorical relationship to the second part. Here are instances :

" In the heavens above are more than nine lakhs of stars.
I cannot count them.
Thus the words of my heart surge up into my mouth,
But I cannot utter them."

" O my elder brother, who is gathering crab apples,
Don't break the boughs ;
But if you break the boughs they may grow again—
Don't break your love for me."

" The swallow builds his nest under the eaves of the house.
My soul has arisen and arrives in heaven.
My body is soaked up in the earth."

One may get half a dozen sentimental ones, but it is quite beyond the

Mongolian to remain sentimental for long, and the next verse may run like this :

> " After seventeen years of married life a son was born to me,
> But unfortunately he was eaten by the cat.
> I searched for him all over the house
> And finally found his head in the pantry."

This is considered very funny.

In conclusion, I must point out that the Rulers, taking their cue from the Raj Guru, exact from all military classes, and from all others too, for the matter of that, implicit obedience to Hindu ceremonial laws laid down for their observance by him. Any man travelling abroad has to carry out on his return the ceremony of Panipattia, for which he also pays a small fee. From the Nepal Government's point of view this is a good arrangement, as it becomes a kind of ceremonial passport, a re-entry to the national life.

PART II: MAJOR NORTHEY

As General Bruce has already pointed out, the country of Nepal is closed to Europeans, and none but the British Envoy, the Legation surgeon, and one or two other persons, such as the British officer who is generally detailed annually to supervise the training of the Envoy's escort, an occasional engineer in the employ of the Nepal Government, and their friends, are permitted to reside in the country, and even they are confined to the limits of the valley of Nepal. Hence it follows that the only inner parts of the country of which Europeans can claim any intimate knowledge are the Nepal valley and the main road leading to it from British India which has as its starting-point Raxaul, a small station on the Bengal and North-Western Railway, a picturesque but exceedingly arduous journey of some 70 odd miles from Katmandu.

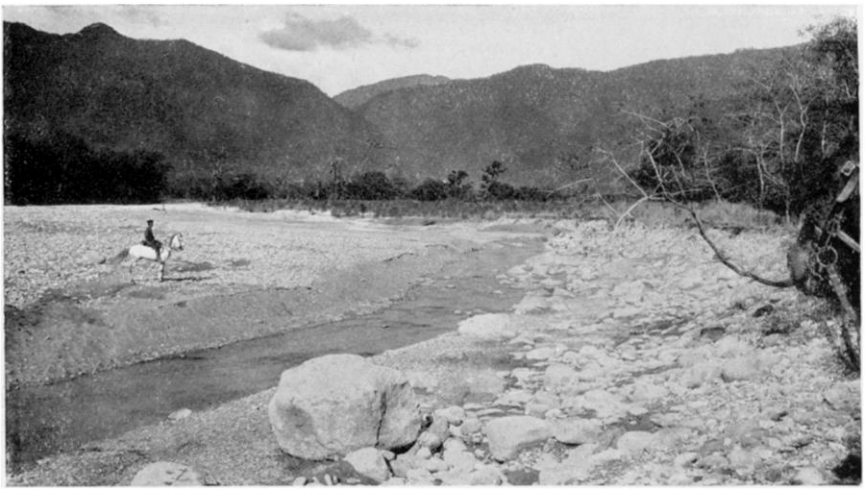
The Terai or lowlands of Nepal, celebrated for its magnificent big-game shooting, is comparatively well known nowadays, as many Europeans—notably the planters on the northern frontier of the provinces of Champaran and Behar, whose estates in many cases adjoin Nepal—obtain passes to shoot or fish or are invited to join the shooting camps of the Envoy, who leaves the valley of Nepal for the cold weather, making his winter quarters at any convenient place near the frontier.

It has been my good fortune, during my service in a Gurkha regiment, to be brought much into contact with the Nepal Government. Such appointments as British Officer supervising the training of the escort, a year's service with the Nepalese Contingent, and finally four years as Recruiting Officer for Gurkhas (which entailed annual visits to Katmandu) afforded me facilities for acquiring a knowledge of the country not granted to many. As a result, the Prime Minister very kindly gave me permission

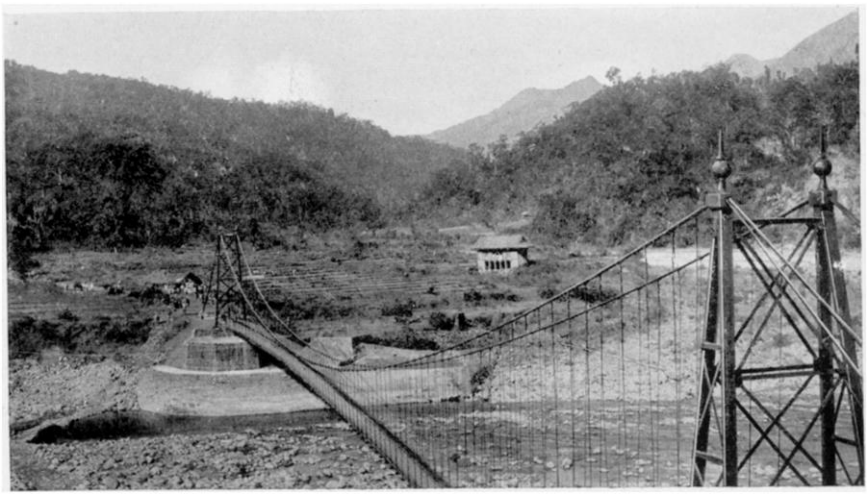
BATOLI, WESTERN NEPAL

TANSING AND PALPA HILLS

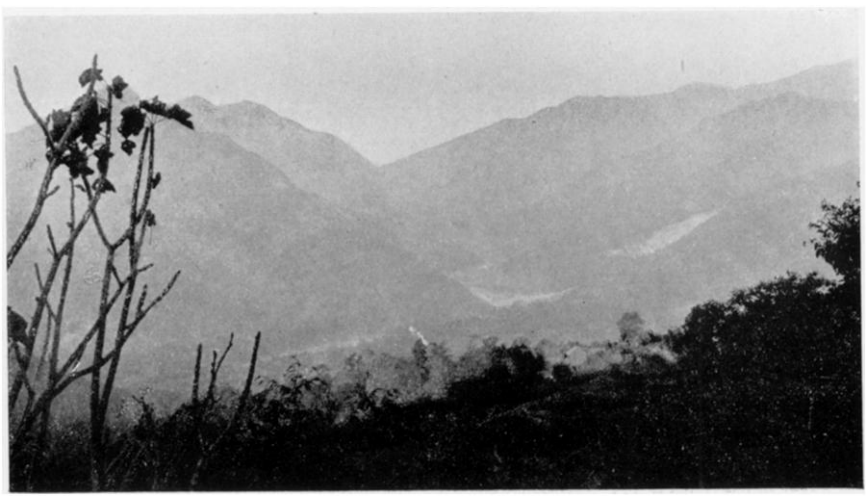
PALPA HILLS, LOOKING EAST



APPROACH TO BATOLI



DHOBAN RIVER, BATOLI HILLS



TIRSULI NAYAKOT, AND PASS TO GURKHA

to make several short trips which gave me a glimpse of the unknown and mysterious country which lies off the beaten track I have previously mentioned. Three of these trips I will attempt to describe: one into the Palpa Hills in Western Nepal; one to Devi Ghat and the town of Nayakot, due north of the valley of Nepal; and lastly, for a few miles across the border into Eastern Nepal, over the Tonglu–Phalut boundary road in the Darjeeling district.

The town and valley of Nayakot and Devi Ghat are not entirely unknown to Europeans, as occasional Residents or their surgeons have visited it, but their number must be exceedingly limited, and beyond a description—and that, too, none too accurate—by Doctor Oldfield in his book on Nepal, and another by Brian Hodgson in one of his many pamphlets, there is little if any modern information, and certainly no illustrations which have any bearing on the subject.

On leaving the Residency, a march of some 10 miles, the first part through the ricefields that skirt the town of Katmandu on its northern side, the latter up a steep and winding mountain path, brings us to our resting-place for the night, the pleasant well-built rest-house of the Maharajah on the top of the Kakanni ridge, which forms with Manichur, Sheopuri, and Kaulia the northern boundary of the valley of Nepal. From here on a clear morning a magnificent view of the snow range is obtained, including Mount Everest, Dhaulagiri, and Gosainthan. In the foreground are numerous minor ranges, between which lie several large fertile and well-watered valleys, the most prominent being the Likhu, Tadi, and Nayakot valley. The Tadi and its tributary the Likhu can be clearly seen, as they thread their way through the fertile valleys that bear their names, and away to the south-west the red bricks of the buildings of Nayakot stand out clearly in the morning sun. From the rest-house the path falls steeply and in some parts precipitously, to the south-west. We descended rapidly for several miles through rough scrubby country, with occasional cultivated patches of Indian corn, and with villages nestling amongst groves of Nim and Pipal trees, until we reached the first large valley, seen clearly from the top of the ridge just to the left, the Likhu valley. Passing through fields upon fields of corn, and leaving on our right the Government gardens of Khinchat, we gain the valley of Nayakot and cross the well-built suspension bridge over the Tadi. Then after threading our way through ricefields we ascend through fine groves of Saul trees to our camping-place, the little Thunri Khel or parade ground of Nayakot.

Nayakot consists of a single street, with two durbars and a temple to Bhairavi in the Chinese style of Katmandu. Once the favourite residence of the Regent Bahadur Shah, and also for a long time the station of Prithwi Narain's court, the little town has lost all the glamour and importance of its bygone days, and is now but rarely visited by any member of the ruling house, except when used as a halting-place for a

journey into the western provinces. The valley of Nayakot, some 2000 feet below the valley of Nepal, is intensely malarious from March to November. It is extremely fertile, and some seventeen different kinds of rice are grown in large quantities. Of fruits the chief is the mango, and next come the oranges, reputed to be second to none in the world. After these come the tamarind, jack-fruit, guava, custard-apple, and all the ordinary fruits of India. Forest trees not found in the valley of Nepal and peculiar to the district are the Saul, Pipal, Semal or cotton-tree, Neem, and pines; but generally speaking all the trees and fruit, as well as the superior Cerealia of North Behar and the Terai, can be found there. The lowlands, owing to the malarious climate, are but thinly peopled, the permanent dwellers therein being races of Nepalese that are not otherwise encountered, bearing such names as Dari, Kumha, and Kuswar. The higher grounds, such as the ridge on which the town stands, being above the malaria zone, are peopled by Nepalese of the ordinary castes, such as Newars, Khas Magars and Gurungs, Bhatias. The town is on a spur descending south-west from Mount Dhaibung or Jibjibia, about a mile above the Tadi river on the south and flanked on the west by the Tirsul or Tirsûl Gandaki. This last is a deep blue beautiful stream, that conducts not only the pilgrim to the sacred lake of Gosainthan, a lake reputed to be not less than 15,000 feet above sea and lying immediately beneath the peak which bears its name, but also the trader and traveller to Tibet. Skirting the town on the west, it joins the Tadi at Devi Ghat.

The scenery at Devi Ghat is of the wildest, most romantic kind, both rivers rushing over stony beds, bordered by stupendous rocks, and the waters of both being blue and perfectly transparent. Devi Ghat itself is a very holy spot under the protection of the goddess Bhairavi, whose temple stands in the town of Nayakot. Three miles up the Tersuli from Devi Ghat the river is spanned by a bridge, over which no European has ever crossed, on the high-road to Gorkha.

From Devi Ghat the Tersuli flows south-east towards the plain, forming the eastern boundary of the province of Gurkha, and is joined in its course by several feeders from the western side of Nepal proper; eventually, after joining at Deo Ghat the great Gandaki river, it flows nearly due south and quits the hills at Tribeni through a pass in the sandstone range to the west of the Someshwar ridge. I will ask you to imagine that we too have followed the course of the Tersuli from Devi Ghat to this intensely picturesque border village of Tribeni, for this will bring us closer to the scene of the little trip into the Palpa country.

If the high-road to Katmandu is well known to Europeans as the main, if not the only, means of entry to this inaccessible country, it is unknown to many thousands of Gurkhas who leave their hill villages to seek service under the British Raj. For the bulk of the recruits for our Gurkha regiments—in fact, eight out of ten regiments—are recruited from

Western and Central Western Nepal, and for these the main road or track into British India is *via* Butwal and Nautunwa. In former days, when recruiters used to smuggle their recruits into British territory, a favourite route was across the Cheryaghat range into Tribeni, but nowadays when recruiters by arrangement with the Government of Nepal bring their recruits through openly, fully 90 per cent. of the Gurkha recruits for the Gurkha regiments that come into the recruiting Centre at Gorakhpur pass through the Nepal town of Batoli, entering British India at Nautunwa and entraining at Bridgemangany on the Bengal and North-Western Railway.

On two occasions I was able to visit the town of Batoli, and on the last occasion the Prime Minister kindly gave me permission to proceed to the Massiang ridge, some 10 miles into the Palpa hills due north of the town, a country in which no European had ever before set foot, save possibly Jesuit missionaries who are reputed to have journeyed in Western Nepal at the beginning of the seventeenth century.

Leaving the train at Bridgemangany station, I travelled some 22 miles over a flat and exceedingly uninteresting country on a rough unmetalled road till I reached Nautunwa, a large village on the frontier and formerly an outpost for the Gorakhpur recruiting depôt. Nautunwa has little if anything to recommend it from a picturesque or interesting point of view, save, in the winter months of the year—like many other places on the northern frontier—a magnificent view of the snows. From Nautunwa to Butwal or Batoli the track leads for some 15 miles over country which differs little if anything from the plains of North Behar, save for occasional large and rather solidly built residences of Nepalese officials to be seen here and there. After this, and for the remaining 5 miles, the track—and it is so small and indistinct a path that neither coming nor going could I possibly have followed it by myself—leads through country that is less cultivated and becomes more akin to the ordinary scrub jungle and long grass of the typical Terai. Batoli itself is a large and important Nepalese town at the foot of the Palpa hills, the winter headquarters of the Governor of the province and winter station of the garrison of Tansing. Here I will interrupt the journey by a very brief reference to the system of government in Nepal. The whole country is, for the purpose of administration, divided into some forty districts or provinces, each of which being under the control of a Hakim, or governor. These governors are usually officers of military rank, and in the case of the larger provinces, such as Palpa and Ilam in the east, are often connections or relations of the ruling family. Though the power these officers possess is very large, the whole system of Government is very much centralized at Katmandu, and little if anything can be done even in the most outlying provinces without previous reference to the Prime Minister. Enormous progress in the shape of schools, medical and veterinary facilities, and so forth, have been made during

the tenure of office of the present Prime Minister, Sir Chandra Shamshere, who has worked untiringly in promoting the welfare of his subjects.

To resume our journey. My camp was pitched on both occasions on pleasant open ground in the village of Kasauli, on the other side of the river Sindhu from Batoli, where the winter barracks of the garrison are, away from the bustle and noisy atmosphere of the town. The larger buildings of Batoli have the same distinctive Nepalese appearance noticed in other parts, and the Governor's palace is a large handsome building surrounded by a pleasant garden; otherwise there is nothing very picturesque about the town save perhaps its site, nestling at the foot of thickly wooded hills.

On commencing the ascent up the steep rocky bridle path that leads past the palace of the Governor to the hamlet of Nawakot, an entire change of scene, inhabitants, and surroundings is experienced. The sudden transition from the plains with their Aryan inhabitants to the rough mountain bye-ways and villages of an entirely different kind, with sturdy mountaineers of obvious Mongolian type, is very striking, and in crossing the spur of the hill on which Nawakot stands one bids farewell, as it were, to India, for thence on not a trace of it is discernible. Passing over the fine suspension bridge that spans the Dhoban river, the path leads through picturesque and wooded scenery to the customs outpost of Morek, then up for several miles along a small clear stream, the Siswa river, till by a steep ascent the goal, the Masyang ridge, some 4500 feet above sea-level, is reached. From here, a magnificent view is obtained of the Palpa country, the home of many of the Magars, a tribe which forms so important a part of the Gurkhas enlisted in our Gurkha regiments. The hand camera I had with me was unfortunately quite insufficient to reproduce satisfactorily the panorama that was unfolded before me, a scene made more interesting by the fact that no European, certainly of modern time, had ever witnessed it before. The houses, chiefly of a red hue from the clay with which their walls were coloured, and surrounded by a patch of garden or field, looked comfortable and cheerful, and there was no sign of poverty or discontent amongst the local inhabitants.

Before us lay the Palpa ridge, to the west of which the white roof of a Palpa temple was clearly visible; while to the east, some 3 miles from where we stood, the town of Tansen could be seen with its parade ground, its few large buildings, its durbar, and its temple. On the further side of the Palpa ridge, unseen from where we stood, runs the river Kali, on the banks of which lie Riri to the west, the valley of Andikhola to the east, and numberless places known by name to officers in Gurkha regiments, but never visited. Beyond are tier upon tier of lofty mountains, flanked and crested with groves of black firs, terminating in snow-sprinkled rocky peaks. The intense pleasure I felt at this glimpse of unknown country was only equalled by a craving to proceed to the next

ridge, the Palpa ridge, which became almost intolerable ; but I retraced my footsteps with the satisfaction that I had seen much and that it was well to let it rest at that.

Before leaving the Palpa country a few words should be said of the Nepalese army of Nepal, which is represented in this district by three regiments, stationed in Tansing in the summer and Butwal in the winter. The Nepalese army, numbering some 45,000 men, is composed of material which in point of view of physique is superior to that of our Gurkha regiments. Three contingents of Nepalese troops came down to India during the Great War, where they rendered valuable assistance both by internal defence and in active operations on the frontier. Their old-time picturesque blue cotton uniform with its distinctive head-dress has very largely given place to the more serviceable khaki, and though there is a tendency to revert again to the purely formal pre-war training, the army has, in common with many other departments, made great progress in instruction and efficiency in the last few years.

To turn for a few minutes to Eastern Nepal : the traveller who has made the Tonglu–Phalut trip in the Darjeeling district along the Nepalese border, will doubtless often have looked down with curiosity and interest into the deep-forested valleys and distant villages lying in forbidden territory, and perhaps in many cases he will have felt an intense desire to penetrate into the unknown and mysterious country that lies outside his reach.

It can be well imagined, therefore, with what delight I was granted a pass to travel in Nepalese territory some 7 miles from the border, staying the nights either at the Dak Bungalow on the Tonglu–Phalut road, or at any convenient village in Nepal. Though I had selected a time which in ordinary circumstances should have been propitious, even for a climate so variable as that of Darjeeling—namely, early May—with the exception of the first day, the elements fought against me with all their power, the thickest mists often accompanied by drenching rain preventing my seeing much more than a very few yards ahead. An escort of a Subadar, Jemadar, and five or six soldiers of the Nepalese army met me at Tonglu Bungalow, and under the most favourable auspices we descended the Myong valley to the village of Jamuna, the first village Sir Joseph Hooker visited on his memorable journey through Eastern Nepal. The scenery and vegetation are similar to those met with in the Darjeeling district, and the proximity to the frontier results in the type of houses, inhabitants, and general cultivation not differing greatly from what is seen on the British India side. Unfortunately, heavy mists set in the day after our arrival in Jamuna, and continued practically without a break for the next six days. As a result I was unable to take any photographs, and, despite the excellent arrangements made by the escort and their unfailing good humour, the trip from a sight-seeing point of view was a failure.

A word in conclusion as to the extent to which militarism prevails

in Nepal. On the various occasions on which through the kindness of the Prime Minister I have made these few journeys off the beaten track, I have had great opportunities of observing the extraordinary power that is accorded the representatives of the army and the deference with which they are treated. The peaked cap of Lieutenant Ganesh Bahadue Regmi, my companion to Batoli, and the gold crest on the head-dress of Sub-Barbahadur Gurung were always the means of producing anything I wanted, access to everything and to everybody. This implies a complete domination of the civil population by the army, but such is the queer military spirit which imbues all classes, that it is not particularly resented. A matter however that is causing the Maharajah the gravest concern at the present moment is the ever-growing desire of the Gurkha to emigrate and seek service in any country, as it were, but his own. This condition of affairs is very largely a result of the War, which has produced a feeling —a feeling which is by no means confined to Gurkhas—of restlessness and craving for new scenes and spheres, and which is further enhanced by one or two factors, one being the great demand from all parts of India, and even from countries as far afield as the Malay States, for Gurkhas to be employed as watchmen, overseers, and any positions where a sturdy frame and an honest mind are required. Another and not less important factor is the unauthorized recruitment, very often on a very large scale, of Nepalese for coal-mines, rubber planting, and work generally under conditions that can but be the reverse of beneficial to the hillman. Prompt measures are needed to prevent this emigration becoming a real menace to the future welfare and prosperity of the nation. When we reflect upon the hundreds of thousands of little hillmen who during the last hundred years have helped to fight the Empire's battles, I think we must endeavour to assist Nepal to our utmost capacity.

Before the papers the PRESIDENT said: To-night we are to have papers by General Bruce and Major Northey upon the country of Nepal. Nepal, owing to its being closed to the ordinary traveller, is a country which is very little known. It is, nevertheless, a country which is in close relations with the Indian Government, and a country whose ruler did yeoman service to this country during the trying days of the War. Indeed, the magnitude of that service, upon which possibly General Bruce will touch this evening, is very little realized in this country. General Bruce is certainly qualified to tell us of Nepal, for he is a close personal friend of His Highness the Maharajah, and has on more than one occasion visited the capital of the country. General Bruce will be admirably seconded by Major Northey, who for some years was recruiting officer for the Gurkha regiments, and was consequently brought by his duties into close touch with the authorities of Nepal. He has, indeed, been fortunate enough to have travelled over considerable parts of that country which have never been visited by any other European, and we may look forward, therefore, with feelings of the keenest interest to all that he will have to tell us of this unknown land. I now have much pleasure in calling upon General Bruce to give us his introductory description of the country, and Major Northey will then follow with a description of those parts of Nepal over which he has travelled.

Brig.-Gen. the Hon. C. G. Bruce and Major Northey then read the papers printed above, and a discussion followed.

The PRESIDENT: I had hoped that Colonel Kenyon, a former representative of Great Britain at Katmandu, might have been present this evening, in which case he no doubt would have been pleased to have added something to the discussion. Unfortunately he has not been able to come, and I have some doubt, therefore, whether there is any one who is competent to say anything on the subject of this very little-known country. General Woodyatt is present, and he might care to say something; he has a wide experience of military matters in India.

General WOODYATT: I came here to-night to enjoy myself, and had done so to the full, until I now find I am required to talk about Nepal without any preliminary forethought at all. It is quite true, as Lord Ronaldshay said, that I have had a good deal of experience of Gurkhas. As we have heard a great deal of what the Nepalese did during the War, I might tell you something about them when they came over to India in the early part of 1915. Very soon after war was declared the Maharajah, the Ruler of Nepal, Sir Chandra Shamsher, volunteered to raise about 50,000 men, and sent a proposal in regard to the matter to the Government of India. The latter did not quite know how to deal with so large a contingent, and it was eventually arranged that the Maharajah should send over a much smaller number so that it might be seen how they would assimilate with our troops, for it was difficult to decide whether the units should be put into our brigades, or form separate formations of their own. There came at first 4000 men, who were stationed at Dehra Dun, where I happened to be commanding a brigade. The men were not trained quite on our methods. They were very good at ceremonial, but had had no experience whatever in what you might call barrack or camp life, in parading together, or in any kind of field manœuvres. It was rather difficult to arrange their discipline, and they had all sorts of strange rules and regulations to which we are not used.

During the first months we had an outbreak of cholera, about which I was much concerned, because the Nepalese—and indeed Gurkhas in general—are particularly susceptible to this scourge. I therefore issued very stringent orders, particularly regarding a river my medical officers considered the probable source of infection, which no man was to approach. I went the next morning to see the Nepalese parading on their exercise ground which overlooked, in one corner, this very stream, and to my horror saw about a dozen men bathing there. Sending for the senior General, I asked if the necessary orders in conformity with my injunctions had been issued. He said he had done so, and I then asked why the men were there. He said, "There are no men there." But when I took him to the corner and showed him the bathers, he was very upset and rode rapidly away. He came to my house about 3 o'clock and said, "I have had those men flogged." "I did not think you would do that," said I. "I only wanted you to make sure they would obey orders in future, and especially never bathe there again." I gathered they had undergone a species of bastinado, and I am not sure he did not contemplate having them shot! That was their way of dealing with their men, and showed their keen desire to instil good discipline. I may mention that on learning of the outbreak of cholera the Nepalese Inspector-General came down from Simla immediately and encouraged and visited the patients himself.

From Dehra Dun I was moved to a station called Abbottabad, where there were 6000 more Nepalese troops, commanded by a General Padma, a very

fine specimen indeed of the royal family. He is a son of the present Commander-in-Chief of Nepal, who is a brother of the Maharajah. I formed a strong friendship with this officer, almost as strong as with the Inspector-General of the Nepalese contingent, General Sir Baber Shamsher, the second son of the Ruler and a most able officer, from whom I often hear. General Padma and two or three other generals were accommodated in very poor quarters, for it was all we had to give them; but to preserve their privacy and incur less heat they preferred these quarters to tents. All these officers, with occasional moves, owing to the exigencies of the service, remained in those quarters for considerably over two years, and I never heard one single word of complaint.

There is one little incident in regard to General Padma which I thought showed a very gallant spirit. For some time he had been anxious that I should have a ceremonial parade, which was finally arranged. The troops were concentrated —about 6000 of them—on the Abbottabad parade ground some 4 miles from their camp. No sooner had they finished the march past than we had a most terrific and torrential downpour of rain, which came on without any warning whatever. So heavy was it that in about two minutes we were drenched to the skin. My wife was at the saluting post in a car, and when I told General Padma that he should dismiss his troops to run into some adjacent barracks, and gallop home himself to change, he only smiled and said, "I must first pay my respects to Mrs. Woodyatt." Off he went at full gallop on the slippery turf to the car to say how-do-you-do to my wife, because he thought it was the right thing to do. I said to myself, "Blood will tell."

The PRESIDENT: I should like to say that I am very glad of this opportunity of bearing my witness to the loyalty and friendship of His Highness the present Maharajah of Nepal. I know little of the actual country, as I have travelled only over the small eastern corner of it to which Major Northey made some reference towards the close of his lecture. But I have the honour of being acquainted with His Highness, who came as the guest of the Government to Calcutta during my tenure of office and found life, presumably, so agreeable there that his projected visit of a few days prolonged itself into one of some four weeks. He was always a most courteous gentleman and a most thoughtful guest. I am delighted to have this opportunity not only to pay my tribute of admiration to him as a gallant ruler of a gallant people and a loyal ally of this country, but also as a courteous gentleman.

Let me conclude by expressing to General Bruce and to Major Northey the gratitude of this audience for the admirable pictures which they have been able to give us of this little-known land. I am sure what they have been able to tell us to-night must have stirred in us the desire to know more, if possible, both of the land and of its people. It is with feelings of profound regret that I have learned from Major Northey, who is *persona grata* with the people of Nepal, that the serious wound which he received in the late war has disabled him from returning to his particular duties in connection with the Gurkha regiments, and that he will probably not have further opportunities of extending his studies in that particular field. I am sure you would wish to convey to him, as I do, our profound sympathy in what must be to him a matter of much disappointment. But we are grateful both to him and to General Bruce for the great pleasure which they have given us this evening.

Balsera has generally been read as Basra, which is confusing; on the map of Natolia there is a frontier town, Passera (the first *s* long), which may well have been the spot. In the general descriptions of countries, Miss Seaton says that without exception every non-classical name can be found in the Theatrum. Having shown Marlowe to be more exact than was generally assumed, Miss Seaton is able to explain the confusion over the line "The Terrene main wherein Danubius fals." Previously he has made the Danube flow to Trebizond, and it seems likely that he regarded the Danube's current as parting in the Black Sea, so that part flowed towards Trebizond and part through the Hellespont.

GENERAL

The Black, White, and Red Seas.

In *Le Globe* (*Mémoires*, 1924), M. Léopold de Saussure puts forward an explanation of the terms Black Sea, White Sea (Mediterranean), and Red Sea, as used by the Turks, basing it upon the early difusion of Chinese cosmological conceptions among the Tartars, Persians, and Turks. The Chinese, regarding the universe as a whole, divided the Earth into five regions, one central and four outer; these outer regions were identified with the cardinal points, with the movements of the sun, and with the elements of the universe. In the centre, like the Pole Star in the firmament, was placed the Emperor, ruler of the Middle Kingdom, corresponding to the element earth, and represented by the colour yellow. Similarly, like the Pole Star, he would face the south: thus his back would be turned to the north, the region of darkness and cold, represented by the element water and the colour black: before him would be the south, the region of heat and light, corresponding to the element fire and the colour red; on his left would lie the east, the land of the morning and the spring, represented by the element wood and the colour green; to his right, the west, the region of autumn and decline, represented by the destructive element, metal, and the colour of mourning, white. In the same way, the ruler of each outlying region would be the centre of his own smaller cosmos. Similar conceptions are met with in Iranian cosmography, and even in the Apocalypse. M. de Saussure thus argues plausibly that when the Turks reached Asia Minor, they would naturally call the Pontus Euxinus the Black Sea, the Indian Ocean the Red Sea, and the Mediterranean the White Sea. Herodotus remarks that the Persians were wont to call the South Sea the Red Sea, but in time the name came to be confined to its present area. A further trace of this idea is to be found in the Mongol name for the Emperor of Russia—the White Czar. M. de Saussure recognizes that the Turkish term applied to the Black Sea, *Kara*, may mean black or great, and that the mediæval Italians knew it as the "Mar Maor" or "Mar Maior"; but he holds that the application of the name White Sea to the Mediterranean shows that the foundation of the whole nomenclature is the Chinese cosmological system.

OBITUARY

The Rt. Hon. the Marquess Curzon of Kedleston, K.G., F.R.S.

WE deeply regret to record the death of Lord Curzon, Past-President and Trustee of the Society, on March 20.

At their Meeting on March 23 the Council resolved to place on record the profound regret of the Society at the untimely death of Lord Curzon, to whom it owes so great a debt for conspicuous services rendered to the cause of

Geography, and in particular to the Society during his Presidency; and to convey to Lady Curzon and the members of his family its deep and respectful sympathy.

At the Evening Meeting of the Society the President said:

Before calling upon the lecturer this evening you will desire me to give expression to the feeling of deep sorrow which must be uppermost in our minds at the untimely death of Lord Curzon, one of the most distinguished of the many eminent men who have served this Society as its President. All who knew Lord Curzon personally, as I myself was privileged to do, must often have marvelled at the amazing industry and capacity for work which he displayed; and there is little need for me to remind an audience of this Society of the time and labour which, despite his many and more exacting preoccupations, he devoted to the science with which we are concerned. The great ability and thoroughness with which as a young man he prosecuted an extensive series of journeys in various parts of Asia, from Persia to the Far East and from Indo-China to the frozen highlands amid which lies cradled the source of the Oxus river, won for him so far back as 1895 the Gold Medal of the Society —a distinction which it is common knowledge he rated very high among the honours which throughout a long and strenuous public life were showered upon him. His term of office as President of our Society from 1911 to 1914 was made memorable by the disposal of our old habitation in Savile Row and the acquisition of our present home. For many years some such move had been thought of and debated; but it was as a result of the comprehensive grasp of the Society's needs displayed by Lord Curzon, seconded by his immense driving power, that the difficulties in the way were solved and the project became an accomplished fact. It is not too much to say that in the Society's building at Kensington Gore there will be recognized by the geographical world an abiding monument to the services which he rendered to the cause of geography and to the unflagging zeal with which he laboured in the interests of this Society. As some small token of the gratitude which the Society felt for services so ungrudgingly rendered, it paid him the unique distinction of causing his portrait to be painted by Sargent and hung in a conspicuous position over the chimneypiece in the council room. In many spheres of public activity his commanding figure will be sorely missed, in none more sincerely than in that of the Geographical Society. And you will wish to endorse the resolution formally placed on record by your Council this afternoon deploring his untimely death and conveying to Lady Curzon and the members of his family its deep and respectful sympathy in their loss.

A portrait and memoir of Lord Curzon will be published in the May number of the *Journal*.

Mr. John Bolton.

The Society has lost an old and valued member in Mr. John Bolton, who died on February 22, after only an hour's illness, at the advanced age of 82. Simple and unassuming, he had endeared himself to all his friends and associates by his warm-heartedness and cheery good nature, and the regard they felt for him was more than ordinarily sincere. As a regular attendant at the Society's meetings for many years (he had joined it in 1877) he was a familiar figure to more than one generation of the Fellows, though latterly, owing to advancing years, he had been less often seen. He had also frequently attended the meetings of the British Association, serving on the Committee of Section E (Geography). As a competent and painstaking cartographer, he

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INNERMOST ASIA: ITS GEOGRAPHY AS A FACTOR IN HISTORY

Sir Aurel Stein, K.C.I.E., F.B.A.

The First "Asia Lecture."

Delivered at the Meeting of the Society, 3 November 1924. Map of the Lop Desert follows p. 472. The general map will be published with the second part of the lecture in the June Journal.

IT was last spring, in the course of a holiday wandering through Northern Syria, that I received the letter conveying your Council's kind invitation to deliver the first of those lectures on Asia which a benefactor of the Royal Geographical Society has endowed. I was much gratified by the distinction, but at the same time somewhat embarrassed. On previous occasions during the last twenty-two years when I had the privilege of addressing you, it was my good fortune each time to give you an account, condensed indeed, yet, I hope, not too dry like some familiar "extracts," of a journey of exploration successfully accomplished. Each of them had taken me into that great region of drifting sands, bare wind-eroded steppes, and barren mountain ranges which may in its present condition well be called the dead heart of Asia. This time I do not enjoy the good fortune of being able to tell you of fresh travels and discoveries made there. The abundant harvest of surveys, geographical observations, and archæological "finds" I had brought back from my third Central-Asian expedition was, alas, bound to exact its penalty in the shape of years of labour at the desk, such as the publication of adequate records demands. This duty to research, together with the sad realities of present Eastern politics which bar access for me to my lifelong goal across the Indian North-West frontier, has denied me since 1916 the eagerly desired chance of another Central-Asian expedition. Yet my thoughts, whether in the condensed humanity of London, or in the peaceful solitude of my Kashmir mountain camp, never cease to turn to scenes of past work in that vast desert region of innermost Asia.

This may suffice from a personal point of view to explain the choice of subject I have made for my lecture to-night. But it may be justified even more by the appeal which that region must make both to the geo-

grapher and to the historical student. That region is singularly fitted to illustrate on the one hand how geographical features may invest even the least attractive parts of our globe with very real importance for the history of civilization, and on the other hand to show how helpful the evidence of the traces left on such ground by past human activity can be for throwing light on various aspects of much-discussed physical changes.*

The region to which I wish to take you to-night may be roughly described as comprising those vast basins, elevated and drainageless, which extend from east to west almost halfway across the central belt of Asia. Their longitudinal rim is well defined by the big rampart of the Tien Shan, the " Celestial Mountains," in the north and the snowy Kunlun ranges in the south which divide those basins from Tibet.† The eastern border of the region may be placed where the Nan Shan, itself a continuation of the Kunlun, forms the watershed towards the drainage area of the Pacific Ocean. In the west it abuts on the mighty mountain mass of the Pamirs, the *Imaos* of the ancients, which joins the Tien Shan to the Hindu Kush and on its western flanks gives rise to the headwaters of the Oxus.

If you look at the map which is put before you on the screen it might well seem as if this vast region of which I have just indicated the borders in the broadest of outlines, had been intended by nature far more to serve as a barrier between the lands which have given to our globe its great civilizations than to facilitate the exchange of their cultural influences. For within this area, measuring some 1500 miles in a direct line from east to west and close on 600 miles from north to south where it is widest, the ground capable of settled life is strictly limited to strings of oases, and of them only a few in the extreme west and east offer enough arable soil to support a population of some size. The rest of this area is occupied by huge stretches of desert. Whether they extend over high mountain ranges, or wide barren belts of foothills with their gravel

* For essential details of the topography of this great region reference may be made to the maps of 'Chinese Turkistan and Kansu, from surveys made during the explorations of Sir Aurel Stein, 1900–01, 1906–08, 1913–15,' published by the Survey of India, 47 sheets, scale 1 : 500,000, 1918–22.

In my 'Memoir on Maps of Chinese Turkistan and Kansu' (Trigonometrical Survey Office, Dehra Dun, 1923), chapter ii., I have briefly discussed the chief physical features determining the geographical character of the several main divisions of this region.

For archæological facts illustrating the cultural past of this region, as well as for observations on its historical geography and ancient civilization, see my detailed reports, 'Ancient Khotan,' 1907; 'Serindia,' 1921 (Clarendon Press, Oxford).

† An endeavour has been made in this paper and the two maps intended to illustrate it to spell all local names according to the latest decisions of the Permanent Committee on Geographical Names.

Chinese local names are spelt as in the Chinese Postal Guide; other Chinese names have been spelt according to the Wade system of transcription.

glacis, or over plains overrun by moving sands, these deserts are almost everywhere devoid of water.

It is this extreme deficiency of water which invests by far the greatest portion of the area we are considering with the character of what I may call " true desert." Let me lay stress on the word " true " in this expression in order to make it quite clear that the ground over which I shall have to ask you to follow me to-night in tracing historical movements, differs greatly indeed from those deserts with which biblical stories, descriptions of Arabian or South African scenery, and the like have made many of us familiar in a certain sense. These " tame deserts," as I should venture to call them for the sake of distinction, may indeed impress the town dweller, especially if he comes from our centres of congested humanity, with their sense of solitude, emptiness, and, let me add, peace. But deserts in which whole tribes can wander about for long periods sure to find water and grazing for their flocks, at least at certain regular seasons, deserts in which populations driven out from their seats or harassed by foes can safely seek refuge for a time, are not such as face us in most parts of the huge basin between the Celestial Mountains and the Kunlun.

By far the greater part of this basin is filled by the dune-covered Taklamakan and the wastes of hard salt crust or wind-eroded clay of the Lop Desert which stretch almost unbroken for a total length of over 800 miles from west to east. In them the absence of moisture bans not only human existence but practically also all animal and plant life. Conditions are almost as forbidding in the high mountains and plateaus of the Kunlun. There vegetation is to be found only at great elevations where the proximity of glaciers provides moisture and allows vegetation to grow for a few months in the year under quasi-arctic conditions, or else in the extremely confined space which the streams fed by those glaciers leave at the bottom of deep-cut narrow gorges. It is solely to the water carried down by these streams that the oases scattered along the edges of this and the basins adjoining eastwards owe their existence ; for nowhere is cultivation of any kind possible unless irrigation is provided by canals. It is, of course, clear that the almost total absence of atmospheric moisture which such conditions imply directly results from the geographical position of the basins. A glance at the map is enough to show us how vast the distances are which separate them on all sides from the seas and their life-giving vapours.

Where nature has been so stingy with those gifts which create resources for human existence and favour close occupation, it is obvious that the ground, however extensive, and however important for the great historical movements it has witnessed, can offer but little scenic attraction by diversity of natural features. I wish I possessed the gift of making, by a few striking word-pictures, those who now hear me visualize all the essential aspects of those barren regions through or along which there

moved for centuries the currents of trade, conquest, and cultural intercourse linking the Far East with the West and with India. But this gift, so graphically displayed in a great poet's scenic descriptions for a drama dealing with momentous historical events—I think of Thomas Hardy's *Dynasts*—is not within my reach. So I must be content to give you a summary survey, a bird's-eye view as it were, of the several zones into which that great region is divided by main geographical features, and to hope that slides, all of them brought back fron my journeys, will to some extent help to enliven them.

It will be best to start on our rapid survey from the west, not merely because it was from that side that the earliest influence of the classical world, of India and of Persia passed into innermost Asia and thence into China, but also because the mountain barrier to be crossed there has attracted more interest among us than the rest of the encircling ranges. I mean the great meridional range which from the series of high open valleys adjoining it westwards may conveniently be referred to as that of the Pamirs. It joins the Tien Shan on the north to the ice-clad Hindu Kush on the south, and was known already to the Ancients by the name of *Imaos*. Ptolemy in his Geography quite correctly describes it as the range dividing the two Scythias, *intra* and *extra Imaon*. These terms closely correspond to the Inner and Outer Tartary of our grandfathers' geography and to the more appropriate ones of Russian Turkistan and Chinese Turkistan of our own. On this range lies the watershed between the drainage areas of the Oxus and the Tarim rivers, and this watershed has been rightly enough accepted in practice (though scarcely in a formal diplomatic way) as the frontier between Russian and Chinese territory on these inhospitable high uplands. But it is of interest to observe that the line of greatest elevations, culminating in the ice-clad dome of Muz Tagh Ata (24,388 feet; Pl. 1) and in the still higher chain of Qungur, with one if not two peaks rising well over 25,000 feet, stretches to the east of the watershed.

To the high plateau-like valleys of the Pamirs which extend to the west of this line and for the most part are drained by the headwaters of the Oxus and its main tributaries, it is unnecessary to make more than passing reference; for all their geographical and historical aspects have been long ago analysed in a masterly publication of your late President, Lord Curzon. Nor do those bleak uplands properly fall within the limits of the region which concerns us here. Only to two points may special attention be called here. One is the very slight amount of precipitation which those bleak uplands receive. It explains their continuous occupation all through the year by small scattered camps of nomadic Qirghiz, notwithstanding their great elevation between *circ.* 11,000 and 13,000 feet and the rigorous climatic conditions. It stands out in conspicuous contrast to the great extent of the glaciation to be found on the previously mentioned line of high peaks. We shall have occasion to note the same

1. MUZ TAGH ATA PEAKS, SEEN FROM SOUTHERN SHORE OF LITTLE QARA KOL

2 KUNLUN RANGE, WITH GLACIERS ABOVE QASH VALLEY,
SEEN FROM BRINJAK PASS, S. OF KHOTAN

3. LOOKING S. ACROSS UPPER SULO HO VALLEY TOWARDS SNOW RANGE N. OF QARA NOR, CENTRAL NAN SHAN

4. ERODED RANGES OF OUTER KUNLUN, LOOKING N.W. FROM ABOVE YAGAN DAVAN, S. OF KHOTAN

curious contrast in the case of the northernmost Kunlun range and to consider an interesting question of climatic change that it raises.

The other point concerns the lines of communication which lead through or past the Pamirs into the Tarim basin. Importance attaches to these, as they must be assumed to have served in ancient times as arteries for the trade and cultural relations which linked the Tarim basin with the Oxus region. This comprised Bactria and Sogdiana, great flourishing territories occupied from an early period by Iranian populations and permeated by influences both from the Hellenistic Near East and from Buddhist India. Though the general east-to-west direction of all the Pamir valleys would seem distinctly to favour their use for such intercourse, yet geographical conditions make it clear that only two routes could lay claim to serious importance in this respect.

One of them lies to the south, leading from Badakhshan up the open valley of Wakhan to the head of the true main feeder of the Oxus. Thence it crosses either by the Wakhjir Pass or the passes approached over the Little Pamir, into the habitable portion of Sariqol, south of Muz Tagh Ata. From Tash Qurghan, which I have proved to have been already in ancient times the capital of this small mountain territory of Sariqol, the Hopanto of the Chinese, difficult tracks through very confined gorges in the main chain of the great meridional range lead down to the utterly barren foothills on the side of the Tarim basin, and so on to the oases of Kashgar and Yarkand. It is this southern route up the main Oxus and through Sariqol which Marco Polo followed on his ever-memorable journey to Cathay in 1273. Before him it had served Hsüan-tsang, the great Buddhist pilgrim whom I am accustomed to claim as my patron saint, when he returned to his Chinese home A.D. 644, laden with sacred Buddhist texts and relics after seventeen years' travels in India and the adjoining lands. In 1603 it saw again a pious traveller, in the person of Benedict Goës, the Jesuit lay brother. He had set out from India "to seek Cathay," and after spending years on his way "found heaven" instead and rest from all earthly troubles when reaching Suchow on the borders of true China.

But far more important for trade was the northern route which started from that ancient centre of Bactra, corresponding to the modern Balkh. It ascended the Qizil Su or Surkh Ab to the big Pamir-like valley of the Alai, and thence crossed the saddle above Irkeshtam to the headwaters of the river of Kashgar and thus down to the oasis itself. This route, of which in 1915 I was able to follow considerable portions both on the Russian Pamirs and through the Qarategin hills of Bukhara, offers particular interest to the student of the historical geography of Central Asia; for the researches of two great scholars, both closely connected with this Society, Sir Henry Rawlinson and Sir Henry Yule, have made it certain that it corresponds to the road which, as Ptolemy in his Geography tells us, was used by the ancient caravans once bringing

the silk of the Seres, *i.e.* of the Chinese, down to the Oxus basin and the great city of Bactra.

Ptolemy derives his account of this ancient trade route from his predecessor, the Greek geographer Marinus of Tyre, who himself had drawn his information from the "agents of Maës the Macedonian," men actually engaged in the silk trade with far-away China about the first century of our era. It is a most interesting glimpse of those early commercial relations which brought Syria and other parts of Western Asia permeated by Hellenistic civilization into contact with the silk-producing Far East. This contact, as we shall presently see, was a direct sequel of the events which caused Chinese trade, political control, and military power to expand into the Tarim basin after the end of the second century B.C. It accounts for the remarkable part which this basin has played for close on a thousand years as the main channel for the interchange of cultural influences between China, India, and the Near East.

If we follow eastwards the routes just briefly sketched or their few possible but distinctly more difficult variations, we reach through tortuous arid gorges (Pl. 7, 10) the western margin of the huge trough, appropriately known as the Tarim basin. Before we proceed to visit the great drift-sand desert of the Taklamakan which fills most of it, we may pass in rapid strides along the big mountain chains enclosing this basin; for were it not for the water which their glaciers send down into it and which the Tarim river gathers before it gets dried up in the Lop Nor marshes, the whole of this vast area would be barred to life.

On the southern flank of the basin there extends in an unbroken line the mighty mountain rampart of the Kunlun. Starting from the side of the Pamirs we find it buttressing, as it were, in several high parallel ranges the great glacier-clad watershed which the Karakoram forms towards the Indus drainage. Through them they have cut their way the Yarkand river and its tributaries, the main feeders of the Tarim. What grazing there is to be found high up at the heads of their valleys is of the scantiest kind and barely suffices for the flocks of a few scattered Qirghiz camps. The routes which lead up these valleys, like those further east crossing the outermost snowy range above the little oases of Kilian and Sanju, all converge upon the Karakoram pass. Some 18,600 feet above sea-level, it is the only practicable line of communication giving access to Ladakh and the uppermost Indus valley. The great elevation of the pass and still more the difficulties of transport implied by the utter barrenness of the high plateaus over which it is approached, sufficiently explain why this route, until its quasi-artificial fostering through political conditions in quite recent times, has never been of much importance for trade or any other relations between the Tarim basin and India.

Further to the east the Kunlun raises a practically impenetrable barrier to traffic of any sort (Pl. 2). The two rivers watering the Khotan

oasis, the Qara Qash and Yurung Qash rivers, break indeed through the northernmost main range (Pl. 9), which maintains from here onwards a crestline of close on 20,000 feet for a distance of at least 300 miles. But their passage lies largely in extremely deep-cut and for the most part quite inaccessible gorges (Pl. 5, 6). Even where less confined ground can be gained at the head of their valleys, the extremely rugged character of the northern slopes of the glacier-clad range would suffice to close the way to any but expert mountaineers. The explorations carried out by me at the head-waters of the Khotan rivers in 1900 and again in 1906–8 sufficed to show the formidable nature of the obstacles to human intercourse raised here by the Kunlun. But quite as great a barrier is represented by the utter want of resources on the drainageless Tibetan plateaus, 15,000 to 16,000 feet in height on the average, which adjoin and extend for many marches to the south (Pl. 8). Bare of grazing, fuel, and in many places even of drinkable water, these desolate high plateaus effectively close access to the Tarim basin even where the configuration of the range allows difficult tracks to pass through, as above the hamlet of Polur.

Very different in character and yet almost as forbidding and barren is the aspect which the outer slopes of the Kunlun present above the Khotan section of the basin. Here by the side of wide loess-covered peneplains we find areas where a perfect maze of steeply serrated ridges and deep-cut gorges has been produced by erosion (Pl. 4). It can only be due to prolonged water action. Yet only on rare occasions do these barren slopes, unprotected by vegetation, receive any heavy rain or snow fall. But when it does come the great aridity of the climate helps to make its erosive force all the more effective.

To the east of the glacier-girt high ground where the sources of the Yurung Qash river rise, the chain overlooking the Tarim basin takes for over 400 miles a trend to the north-east. Its character does not essentially change here ; but its width and height are somewhat reduced, and the elevated Tibetan plateaus approach it closer from the south. Throughout the whole length of the chain the foot of its northern slopes is formed by a glacis of piedmont gravel, attaining in parts a width of 40 miles and more and everywhere utterly barren. Of the rivers which descend from the chain east of Khotan those of Keriya and Charchan alone carry their water at all seasons across this bare thirsty belt of gravel.

This north-eastern bearing of the outermost Kunlun range ends approximately to the south of the point where the terminal course of the Tarim turns and dies away in the marshes of Lop Nor. From here onwards the mountain rampart hedging in the great basin resumes an easterly bearing and sinks lower. This and the approach from the south-east of the high grazing grounds of the Chimen Tagh and of Tsaidam receiving more moisture from across Tibet account for some routes debouching here towards Lop Nor and the terminal Tarim. Though Lhasa is over

700 miles away from the little oasis of Charkhliq, corresponding to the ancient *Shanshan* of the Chinese and now practically the only permanent settlement in this part of the Tarim basin, there is reason to believe that those routes had at times served for Tibetan invasions from the south and for nomadic inroads also. Whatever life-giving moisture the high valleys and plateaus towards Tibet and Tsaidam may receive, whether from monsoon currents passing across India or from the side of the Pacific Ocean, it certainly does not penetrate to the extremity of the Tarim basin north of this part of the encircling range. A wide and utterly barren glacis, of bare gravel in parts, elsewhere overlain by big ridges of drift sand, stretches down here to that huge waste of hard salt crust which marks the dried-up bed of the ancient Lop sea. To this we shall have occasion to return later.

At its extreme eastern end this dried-up sea-bed is closely approached by the depression which contains the terminal course of the Sulo Ho river and the marshes fed by it. My explorations, I believe, have shown that this drainageless basin of the Sulo Ho at a geologically recent period communicated with that of the Tarim. Along its southern rim there extends the Altin Tagh, as the outermost Kunlun overlooking the Lop tract is known to the people of Charkhliq, until it imperceptibly merges in the Nan Shan, the " southern mountains " of the Chinese. What exactly the morphological relation between the Nan Shan and the Kunlun system is need not concern us here. It is sufficient for us to realize that the part played by the Nan Shan with regard to the drainageless basins which continue the line of the Tarim basin eastwards is just the same as that of the Kunlun where it flanks the latter. In the western portion where the Nan Shan overlooks the Sulo Ho trough for over 200 miles from the river's terminal marshes to its great southward bend near the oasis of Yümensien, its northern slopes with their aridity and far advanced erosion closely reproduce physical features already familiar to us from the Kunlun. But there is a marked division into successive parallel ranges, each growing higher as we move south, and though the southernmost of those surveyed by us rises to peaks about 20,000 feet in height, access through them to the open uplands beyond is easier than in the Kunlun.

On passing east of the Sulo Ho trough into the central portion of the Nan Shan evidence of a climate far moister manifests itself in an increasingly striking manner. It indicates approach to the vicinity of the Pacific drainage area which along the Hwang Ho or Yellow River extends to the adjoining parts of the Kansu province and to the north-eastern uplands of Tibet. Favoured by the moisture which air currents from the Pacific Ocean carry up at different seasons of the year, abundant vegetation clothes the valleys from the westernmost limits of the Suchow river's drainage (Pl. 12, 15). To eyes accustomed to the barrenness of the Kunlun it is an impressive experience to see the excellent summer

grazing offered by the open Pamir-like valleys at the headwaters of that and the Kanchow river, notwithstanding the great elevation, in parts well over 11,000 feet (Pl. 3). Still further to the south-east increasing snow and rainfall permits of plentiful forest growth in the valleys drained by the Kanchow river in the northernmost range of the Nan Shan (Pl. 11).

Here we have arrived close to the watershed of the region which the Hwang Ho drains into the Pacific Ocean, and thus to the eastward border of that wide belt of innermost Asia with which we are dealing. This is strikingly brought home to us by the fact that from the edge of the Kanchow oasis eastwards climatic conditions along the fertile foot of the Nan Shan permit of cultivation being carried on without irrigation and dependent on rain and snowfall only. But none of this moisture reaches the ocean; for the Etsin Gol, which unites all the drainage from the northern slopes of the Central Nan Shan, finds its end in marshy lake-beds surrounded by the "Gobi" of Southern Mongolia and closely corresponding in character to the terminal basins of the Tarim and Sulo Ho.

From here we must turn back in order to complete our circuit of the mountains westwards. At first we may safely do it at a somewhat accelerated rate, for the uniformity of the desert hills which extend along the northern rim of the two easterly drainageless areas just referred to, and conveniently designated as the Etsin Gol and Sulo Ho basins, is quite as marked as their insignificance when compared with the imposing snowy rampart of the Nan Shan. There is little to say of the low and utterly barren hill chains which stretch north of the terrace-like belt occupied by the oases at the foot of the Central Nan Shan. They probably attach themselves to the system of the Ala Shan, which further east abuts on the Hwang Ho. Even where they are highest, near Kanchow, they rise only some 5000 feet or so above the level of the oasis. They could never in historical times have formed a serious barrier against nomadic inroads from Mongolia except by their aridity. Even in this respect their value is bound to have been much impaired by the convenient high-road which the terminal course of the Etsin Gol with its riverine belt of grazing-grounds has at all periods offered for invasion.

It is different with the great desert area extending westwards from the Etsin Gol and comprising the barren ranges and plateaus of the Pei Shan (the "Northern Mountains"). With its southern edge it stretches along the whole length of the Sulo Ho basin to about 93° E. long. There it merges in the equally arid hill chains known by the Turki name of Quruq Tagh, the "Dry Mountains." These continue the great belt of ground incapable of settled life or even nomadic occupation for another 400 miles or so westwards, all along the dried-up Lop sea-bed and right away to the Konche Darya below Qara Shahr. Pei Shan and Quruq Tagh in conjunction form a barrier nowhere from north to south less than

200 miles wide between the nearest places where cultivation is possible nowadays. Considerable portions of this vast stony "Gobi" still remain unexplored.

In the eastern and western portions of this "Gobi" brackish wells or springs can be found at rare intervals in the depressions between the greatly decayed ranges, and thus render a crossing there practicable for small parties at one time. This is the case along the *soi-disant* "road" by which the Chinese maintain communication between Ansi on the Sulo Ho and the Hami oasis at the foot of the easternmost Tien Shan. A very limited amount of grazing on reeds or scrub is ordinarily to be found at such points. But even here neither nomadic occupation nor large migrations were ever possible during historical times. Still less was this the case in the central portion of this lifeless desert. Between the 90th and 93rd degrees of longitude it has been proved by Dr. Sven Hedin's and my own explorations to be completely waterless. Violent winds, mainly from the north-east and icy even late in the spring, blow across this whole region at frequent intervals and cause its crossing to be dreaded by wayfarers.

It is to the east of the Hami oasis that there starts the great mountain chain of the Tien Shan which extends unbroken westwards far beyond the Tarim basin and throughout forms its northern rampart. It varies considerably in its height and width, but everywhere constitutes a strongly marked dividing line in climate and all that depends upon it between that great basin and the regions adjoining northward. These comprise the wide plateaus of Dzungaria, stretching to the north as far as the Altai mountains and southernmost Siberia, as well as great fertile valleys like those of the Ili and Narin, capable everywhere of cultivation or else affording rich grazing like those of the famous Yulduz and Tekkes. However much these tracts may differ among themselves, a distinctly moister climate prevails throughout along the northern slopes of the main Tien Shan. Grazing is to be found there both in plains and valleys, and this has at all times attracted waves of nomadic nations, from the Huns to the Turks and Mongols.

We are not for the present concerned with these migrations and the important bearing they had upon the history of the settled population occupying the oases in the basins to the south. Nor need I attempt here to sketch the orography, even in outlines, of the "Celestial Mountains," distinctly more varied and complicated than that of the northernmost Kunlun; for apart from the fact that my personal acquaintance with them is limited to certain portions chiefly in the east, it will be easier to appreciate the way in which their physical configuration has affected the historical past of the Tarim basin and its adjuncts, after we have passed in rapid review the chief phases in the history of the latter. Certain essential points, however, should be noticed here.

One of these is connected with the fact that the average elevation of the

Tien Shan along its crest line, except around the culminating massif of Khan Tengri (23,600 feet above sea-level), is distinctly lower than that of the Kunlun to the south of the Tarim basin. It consequently does not favour to the same extent the accumulation of reserves of moisture in the shape of glaciers and perpetual snow-beds. At first sight this might lead us to conclude that the amount of the water-supply which the range could assure to the arid tracts in the basin to the south would be reduced in consequence. This, however, is not the case except for short distances to the east and west of the Turfan depression, where at the saddles of Tashihto (*circa* 5300 feet) and Tapancheng (*circa* 3500 feet) the Tien Shan range sinks to its lowest points; for the effect of lesser altitude is balanced by the higher latitude. Of even greater importance is the fact that the atmospheric moisture coming from the side of Siberia is not liable to be intercepted here as in the case of the Kunlun by huge Himalayan ranges and high Tibetan plateaus. This all-important advantage of adequate rain and snowfall is strikingly demonstrated by the fine growth of conifer forest to be found all along the northern slopes of the main Tien Shan up to elevations between 7000 and 8000 feet (Pl. 13), and even in some high valleys to the south of it. It also accounts for the very considerable volume of water which the rivers of Qara Shahr, Kucha, and Aq Su carry down into the Tarim basin at all seasons.

Another point to be noted here has a direct bearing upon the historical past of the Tarim basin and of the old road which, stretching along the southern foot of the Tien Shan, connects it with the westernmost marches of China. I mean the opportunities which the Tien Shan range, notwithstanding the continuity of its rampart, offers to nomadic neighbours on the north for plundering inroads upon the oases and trade routes in the south. These opportunities are due to the mountain rampart being pierced at intervals by passes practicable during a considerable portion of the year for mounted men and transport. Starting from the east we find that the high Qarliq Tagh, the "Snowy Mountains" at the extremity of the chain, is adjoined westwards by the pass known as Barköl Daban of only a little over 9000 feet elevation. It is practicable for horses and camels for at least seven months in the year, and its use must have been particularly convenient for raids upon the Hami oasis (Pl. 14), the keystone, as it were, of the old trade route just referred to. We know from the Chinese Annals that the great Barköl valley to the north was during centuries a favourite haunt for Hun tribes and their nomadic successors. Beyond on both flanks of the great snowy massif of Bogdo Ula the range is crossed with ease over the two previously named low saddles of Tashihto and Tapancheng, which give access to that remarkable depression of Turfan with its fertile oases, situated below the level of the sea.

Passing on to the south-west of Turfan through an arid outlier of

the Tien Shan, the same main trade route brings us to the debouchure of the wide Qara Shahr valley. This descends straight from the high grazing plateaus of Yulduz, and has thus at all times served as an open gate for nomadic inroads into the north-eastern corner of the Tarim basin. Further to the west, too, the important oasis of Kucha lies exposed to attacks across the Tien Shan from the grazing-grounds of Yulduz and Tekkes. Similarly the cultivated tracts around Aqsu and up the open valley of the Taushqan Darya can be reached without serious difficulties over the Bedel and other passes leading down from rich Alpine grazing-grounds above the Issiq Köl lake. Finally we note corresponding conditions of liability to attack across the Tien Shan in the case of Kashgar, both the Terek and Turug Art passes offering access to that great oasis almost right through the year.

Here we have completed the circuit of the mountain barriers which enclose the Tarim basin. We may now turn to a summary survey of the basin itself. Of its vast dimension an adequate idea may be gained from the fact that from the plain around Kashgar to the easternmost inlet of the dried-up ancient Lop sea it stretches over a direct distance of some 900 miles. Its greatest width from the alluvial fan of Kucha to the foot of the gravel glacis of the Kunlun south of Niya is fully 330 miles. Vast as these dimensions are, the uniformity of the prevailing conditions makes it easy to take a bird's-eye view of the several zones represented in this basin and to describe them briefly. By far the greatest among them comprises the huge central desert of bare sand-dunes which is popularly known as the *Taklamakan*, a modern Turki designation convenient if vague in its application.

Its borders to the west, north, and east are marked by the belts of vegetation accompanying the Tiznaf, the Yarkand, and the Tarim rivers. To the south the border of the Taklamakan lies along the northern end of the oases, mostly small, found at intervals along the foot of the gravel glacis of the Kunlun from Qarghaliq to Niya. Further east their line is continued by patches of sandy jungle intermittently watered by streams of small size or subsisting on scanty subsoil drainage. These patches of quasi-tame desert extend below the gravel glacis as far as the debouchure of the Charchan river. Thence the narrow belt of vegetation accompanying this river forms the border of the Taklamakan right down to its junction near Lop Nor with the dying Tarim. There are considerable outliers of the dune-covered area to be found in several places beyond these riverine borders. Of these it will suffice to mention the moving sands of Ordam Padshah, beyond the left bank of the Yarkand river, and the big triangular area filled by high sand-ridges between the terminal Tarim course and the western shores of the dried-up Lop sea-bed.

Not one of the numerous rivers descending from the snowy Kunlun succeeds in making its way through the Taklamakan, except the Khotan river, and that too only during a few summer months. All the rest are

5. VIEW DOWN HEAD GORGE OF YURUNG QASH RIVER, FROM BELOW KANGRE CHIMLIK (CIRC. 15,000 FEET)

6. VIEW DOWN GORGE OF YURUNG QASH RIVER, FROM NEAR QOSHLASH LANGAR

7. QARA TASH RIVER GORGE, WITH BRIDGE BELOW PITLIK AGHZI

8. GLACIERS OVERLOOKING THE BASIN OF THE KERIYA RIVER SOURCES. KUNLUN

9. VIEW FROM QARA KIR SPUR ACROSS YURUNG QASH RIVER GORGE TOWARDS KUNLUN WATERSHED
Below,a short bend of river is just visible

10. VIEW DOWN TANGITAR GORGE FROM TAR BASHI ON ROUTE FROM SARIQOL TO YARKAND

lost in this " sea of sand " (Pl. 18) at a greater or lesser distance from the line occupied by the oases or the areas of desert vegetation which they adjoin. But within historical times a number of these terminal river-courses carried a greater volume of water, and hence permitted ground to be cultivated lying considerably further north than the corresponding " terminal oases " of the present day. This is conclusively proved by the ancient sites which I explored in the Taklamakan to the north-east of Khotan.

These explorations have familiarized me with the uniformity prevailing in the character of this huge desert, probably the most formidable of all the dune-covered wastes of this globe. Whether the traveller enters it from the edge of cultivated ground in the oases or from the jungle belts previously referred to, he first passes through a zone with desert vegetation, mostly in the shape of tamarisks, wild poplars or reeds, surviving amidst low drift sand. A very peculiar and interesting feature of this zone consists of " tamarisk-cones," hillocks of conical form and often closely packed together (Pl. 32). The slow but constant accumulation of drift-sand around tamarisk growth, at first quite low, has in the course of centuries built them up to heights reaching fifty feet or more. Further out in the Taklamakan there emerge from the dunes only shrivelled and bleached trunks of trees, dead for ages (Pl. 17), or sand-cones with tamarisk growth from which life has departed even at their top. These too finally disappear among utterly bare accumulations of sand, in places heaped up into ridges rising 300 feet or more above the bottom of the valley-like depressions between them.

While the shape of individual dunes and especially of those on the crest conforms to the prevailing wind direction, the big hill-like ridges or " Davans " (Pl. 19) to be met with at intervals seem generally to stretch parallel to those river-beds which lie nearest, whether still receiving water or dry for long ages. Another observation of interest, and one which has a direct bearing upon human activity along the edges of this great desert area, calls for passing record here. It refers to the character of the drifting soil which the winds carry across the Taklamakan and to which, from the want of a more specific term, we apply the designation of " sand." In using this we ought carefully to remove from our mind any notion of inherent sterility. This so-called " sand " of the Taklamakan is in reality a gathering of fine disintegrated particles of soil, which microscopical analysis shows to partake of the character of alluvial loess, *i.e.* of mainly sub-aerial deposit on what was once moist ground. This sand is perfectly fertile in itself, and wherever adequately irrigated is capable of producing crops or other vegetation adapted to local climatic conditions. The close approach of such dunes to the fields causes no apprehension to the cultivator as long as his canals carry sufficient water to produce a belt of vegetation which binds together this fertile soil and thereby stops the further advance of dunes.

It is erosion by the winds which produces the material composing these dunes, and the Taklamakan allows us to study the process of this production with remarkable clearness. The winds which during a considerable portion of the year blow with great force across the desert basin, especially from the north-east, constantly abrade the surface of the soft clayey soil, wherever there is a bare surface of ground not actually covered by dunes or protected by desert vegetation. The abrasive force which the winds exercise on such soil is considerably aided by the corrosive action of the disintegrated particles which they drive over its surface in the form of rudimentary dunes. The effects of the resulting erosion are nowhere more strikingly displayed than in the endless succession of parallel furrows and ridges, conveniently designated by the Turki term of *yardang*, which cover a great portion of the dismal belt representing a dead delta by the western shores of the dried-up Lop sea. In places this was once occupied by small settlements of the ancient territory of Loulan. Their remains, of which the first were discovered by Dr. Hedin in 1900, and which I was able to explore during my winter campaigns of 1906 and 1914, afford us an excellent gauge for the rate at which wind-erosion here carries on its work of excavation.

But already, on my first expedition, I had ample occasion to observe how, at the ancient site in the desert beyond the terminal course of the Niya river, all ruins of dwellings or even the remains of ancient orchards and arbours invariably occupy island-like terraces rising high above the wind-eroded bare ground close by. The *débris* of walls or the fallen trunks of trees had here protected the soil from erosion and thus preserved the original level, while the ground around was being scooped out around them lower and lower. Thus these archæological remains of ancient occupation have become " witnesses " for a physical process of distinct geological interest. The period of final abandonment both here and at the Loulan ruins is safely fixed by exactly dated Chinese documents discovered among the ruins, and thus we are supplied with a reliable chronological gauge for the progress of wind-erosion. I have been able to show that the rate at which the open ground in this area is lowered by wind-erosion is a little more than a foot per century.

Upon the questions which the abandonment of these and other ruined sites on the edges of the Taklamakan raises I shall have occasion to touch later. Before, however, we turn from the dead ground of the Taklamakan to the present zone of human occupation around it, we may well ask what becomes of all the soil which the winds are constantly excavating? It is clear that most of it lies heaped up in those huge ridges or " Davans," or is being constantly shifted about in the appalling expanse of minor dunes. But a considerable portion of this so-called " sand," in reality more like dust, is carried up into the air. There its presence accounts for the almost constant dust haze which hangs like a

pall over the whole of the Tarim basin and very rarely allows the traveller to catch a glimpse of the great mountain ranges enclosing it. When atmospheric conditions cause this fine dust to settle down it is caught and retained wherever the ground is covered with vegetation or is moist. It thus materially helps to supplement the process to which is due the fertile alluvial loess of the oases in the basin.

But when the winds are strong, as most of those are which blow into the basin from the north-east, they carry this dust high up into the mountains. There on the slopes of the Kunlun I have observed such yellowish-grey dust clouds covering up and effacing all features in the landscape below altitudes of 12,000–13,000 feet. Up to this height and even higher deposits of true aerial loess several hundred feet in thickness can at numerous points be seen overlying the rocky slopes of the Kunlun south of Khotan (Pl. 9). Much of this loess deposit is in turn washed down into the streams by drainage from occasional rain or melting snow. Then the rivers which gather this drainage in dark brown or chocolate-coloured floods carry the loess dust out again into the Taklamakan. There by the side of their banks and in their terminal deltas they leave it to rejoin the ground where it came from. Thus erosion alternately by wind and by water makes the soil of the Tarim basin rotate in an endless succession of cycles.

The possibility of permanent human occupation within the Tarim basin is confined to the areas left between the Taklamakan and the encircling mountain ranges to the north, west, and south. Compared with the great central desert this zone is of small extent, and the use of its natural resources for the most part limited to that elaborate form of cultivation which wholly depends on canal irrigation. This is fully accounted for by the extreme aridity of the climate, itself a result of the geographical position of the basin, which makes the local rain or snow fall a perfectly negligible factor as regards agriculture. This aridity is sufficiently indicated by the fact that the precipitation as recorded for Kashgar amounts to about two inches per annum. Further to the east and south it is probably even less.

The same deficiency of atmospheric moisture restricts grazing to the narrow belts of riverine jungle. These could never within historical times have afforded possibilities of nomadic existence to any but quite insignificant communities such as the present Dolans on the Yarkand river or the scattered families of Lopliks on the lowermost Tarim. This point is of distinct historical importance; for it explains why the great migrating tribes of Wusun, Sakas, Yüehchih, Huns, Turks, Mongols, and the rest whom, as we know from Chinese historical records, the last two thousand years saw in successive possession of the northern slopes of the Tien Shan, were always ready to raid or to make tributary the oases of the Tarim basin, but never crossed the range permanently to occupy it. To them the laborious and narrowly circumscribed life of the cultivator in these

irrigated oases could hold out little attraction as long as there were big open grazing-grounds to hold or to conquer.

The cultivable ground within the Tarim basin could never have borne more than an extremely slight proportion to the extent of absolute desert it comprises. As the map shows, the green oases of the basin appear like mere specks and splashes on a big canvas of yellow and light brown. The aridity of the climate, coupled with the fact that the difference in altitude between Kashgar in the extreme west and the Lop tract in the east is only about 2000 feet, accounts for the striking uniformity in physical conditions which prevails throughout these oases. Whatever their position or size, the traveller sees everywhere the same fields of wheat, maize, or cotton slightly terraced for irrigation; the same winding lanes lined with white poplars and willows; the same little arbours or orchards inviting with their shade and their plentiful produce of European fruits (Pl. 16). My explorations at widely distant sites of antiquity abandoned to the desert have proved that the same similarity of conditions has prevailed here all through historical times. Yet as the area over which the oases are scattered is so vast we may in our rapid survey conveniently distinguish two belts among them.

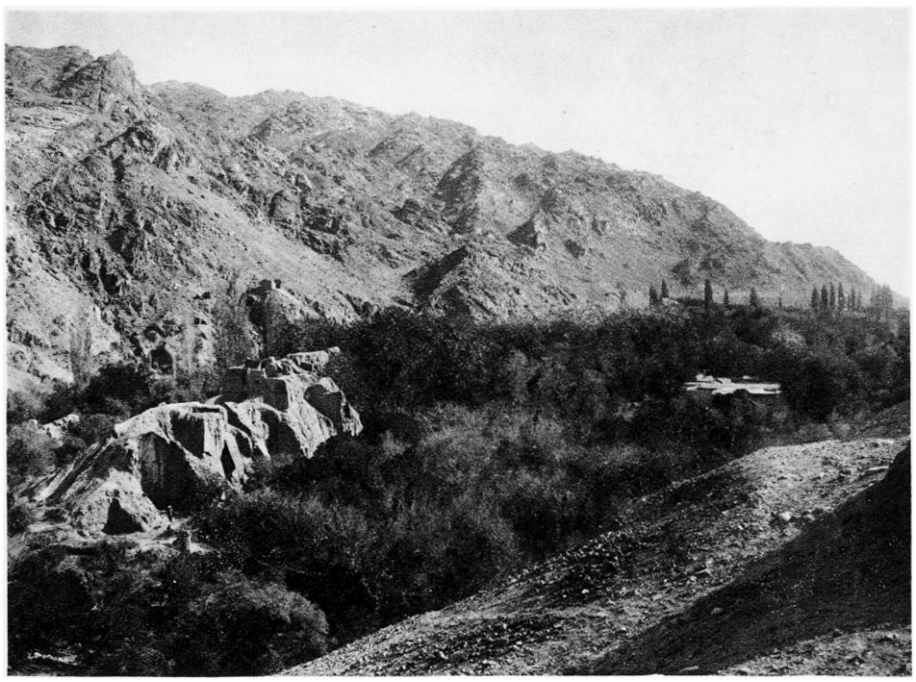
One of them extends in a big arc to the west and the north of the Taklamakan from Yarkand to Kurla. It contains the far larger number of important oases such as Yarkand, Kashgar, Aqsu, Kucha. Owing to these and to the convenient stages at which smaller ones are strung out between them, the route passing along this belt has from the earliest historical times to the present day been the chief line of communication and trade within the Tarim basin. These advantages result mainly from the fact that irrigation is here greatly facilitated by the volume and number of the rivers descending from the mountains as well as by certain features in the configuration of the ground which favour full use of their irrigation resources.

The southern marginal belt of the basin stretches along the foot of the Kunlun from Qarghaliq to the Lop tract. Here only one oasis of real importance is found, that of Khotan. The rest in most cases are separated from each other by considerable stretches of true desert. Thus, on the journey of some 350 miles from the village of Niya to Vash Shahri, the westernmost hamlet of Lop, there is no cultivated ground now to be found except at the small oasis of Charchan, and historical records show even this to have been again and again abandoned during intervals of centuries. The thinness or complete absence of cultivated areas along this belt is duly accounted for by geographical conditions. In the case of Khotan the big volume of water brought down by its twin rivers, the Yurung Qash and Qara Qash, has caused large and very fertile beds of alluvial loess to be formed right up to their debouchure from the mountains. The combined presence of abundant water and of an adequate area of fertile soil, conveniently near to the debouchure for

11. KHAZAN GOL VALLEY, CENTRAL NAN SHAN,
SEEN FROM FOREST-CLAD RIDGE TO NORTH

12. HEAD OF ALPINE VALLEY, N.E. OF SHENLINGTZE PASS, CENTRAL NAN SHAN

13. MOUTH OF VALLEY LEADING TO PANOPA PASS, TIEN SHAN, FROM SIDE OF KUCHENGTZE, DZUNGARIA



14. ORCHARD WITH RUINED BUDDHIST SHRINES AT ARATAM, QOMUL (HAMI), AT S. FOOT OF QARLIQ TAGH

its full use by irrigation, explains the existence here of a large oasis important throughout historical times.

Elsewhere along the foot of the Kunlun much of the water brought down by the rivers is lost through evaporation or absorption on its way across the huge glacis of gravel. The extent of this barren glacis has much to do with the fact that with the exception of Khotan and Qarghaliq all cultivated areas of the southern belt are " terminal oases," *i.e.* they occupy the furthermost ground to which water from the rivers of the Kunlun can be brought for irrigation. Such terminal oases are particularly liable to changes in position and extent owing to a variety of physical causes. Of these I need mention here only the difficulty of maintaining canal heads where the shifting river-courses pass over their fans of gravel deposit or approach their deltaic end in the desert.

Very interesting archæological evidence of such changes is furnished by the numerous ruined sites, marking ancient settlements abandoned to the desert, which I was able to trace and explore in this region. At the same time the fact of the most important among them being found far to the north of the present line of " terminal oases " furnishes definite proof of the water-supply brought down by those Kunlun rivers having undergone reduction within historical times. To the question as to the cause of this reduction and the relation between it and the abandonment of those ancient settlements we shall have occasion to recur later.

Within the Tarim basin there still remains for us to visit the terminal depression of Lop. It is the smallest and certainly the most desolate among the natural divisions of the basin, but offers special interest both to the geographer and the historical student. It may be described as comprising the terminal course of the Tarim ; the marshes in which its waters are finally lost and to which the locally unknown but convenient Mongol term of Lop Nor is usually applied ; and the great salt-encrusted bed of the dried-up Lop sea beyond them, together with the wastes of gravel, drift-sand, and wind-eroded clay which surround it. The whole of this region of *Lop*, as a term of very ancient origin designates it, is now uninhabited, except for three little oases at the foot of the Kunlun glacis where cultivation has been resumed in quite recent times near sites abandoned for centuries. Apart from their four hundred odd households, there are no people, except the scanty remnant of semi-nomadic Lopliks (" Lop people ") fishing and hunting along the terminal Tarim.

The central and geographically most striking feature of this region is the great salt-encrusted bed which our surveys have proved to extend for fully 160 miles from south-west to north-east with a maximum width of some 90 miles. It marks the position of a prehistoric salt sea which was fed by the drainage of the Tarim basin when the climate of Central Asia was moister. It already showed the same forbidding aspects as at present when the Chinese first became acquainted with it more than two thousand years ago. But it is different with the now equally

lifeless ground which adjoins this dried-up sea on the north-west. There, in an area of bare clay overrun by light drift-sand and now undergoing excessive wind erosion, can still be traced a series of well-marked dry river-beds. Our surveys have proved that they belong to an ancient delta formed by the dried-up "Quruq Darya." This during the first centuries before and after Christ carried the waters of the Konche river draining the Qara Shahr valley (together, perhaps, with some addition from the northern tributaries of the Tarim) to the then partially occupied territory of Loulan.

Abundant archæological evidence brought to light at various ruined sites of Loulan since Dr. Hedin first discovered one of them, makes it certain that the waters carried by the Quruq Darya reached here an ancient terminal oasis and the now utterly dead delta around it up to the beginning of the fourth century A.D. Through this once habitable ground and across the difficult salt-encrusted expanse of the dried-up sea beyond it, there had passed the earliest Chinese route leading from the Sulo Ho trough into the Tarim basin. Great historical interest attaches to this route, as it was the line by which China and its silk trade first maintained contact with Central Asia and the West. When later I come to discuss the establishment of this contact and its results, I shall have occasion to describe the truly forbidding aspect of this now utterly lifeless ground, and shall give some account of the difficult explorations by which I was able to track the vestiges of the ancient route through its wastes.

This ancient Chinese route crossed the salt-encrusted sea-bed east of Loulan and then turned round the low southernmost spur of the Quruq Tagh encircling it. Here we find a long bay of that dried-up sea extending to the north-east. In this bay and through a valley-like depression which continues it in the same direction, the ancient Lop sea-bed appears at an earlier but geologically not very distant period to have received also the drainage from the terminal basin of the Sulo Ho adjoining eastward. Along the clearly marked shore-line of the ancient sea and beyond along the southern side of this valley passes the difficult desert track which Marco Polo had followed from Lop to Shachow or Tunhwang, and which rare caravans still use during the few winter months when it is practicable.

This takes us across a dry lake-bed surrounded by a maze of fantastically eroded clay terraces (Pl. 28) directly into the lowest portion of the basin of the Sulo Ho, containing this river's delta and its present terminal marshes. Here we have reached the first of a series of drainageless areas which, if not comparable in size with the Tarim basin, yet resemble it closely in physical features and are linked up with it also in history. This close historical connection is brought home to us at once in a striking manner by the remains of the ancient Chinese *Limes*, or border wall, and its watch posts. I first came upon them in the gravel desert close to the terminal marshes of the Sulo Ho. I subsequently traced and explored

them along the river's course to the eastern end of the basin and thence right away to the Etsin Gol. The many ancient Chinese records brought to light by my excavations have clearly proved that it was constructed at the close of the second century B.C. as a true *Limes* for the protection of that earliest high-road for Chinese expansion into Central Asia to which I have already referred.

The Sulo Ho basin need not detain us long, for notwithstanding its extent of some 220 miles from east to west, its natural features are remarkably uniform, just like its *rôle* throughout history. The Sulo Ho river, fed by the glaciers and eternal snows of the Central Nan Shan, descends into the basin at its eastern end. On its whole course through the basin it receives only a single affluent, the Tang Ho. This, rising on high plateaus towards Tsaidam, provides irrigation for the oasis of Tunhwang or Shachow. Except for this, the only settlement of considerable size in the basin, and for a few minor ones, watered by the Sulo Ho itself, the trough consists mainly of slopes of absolutely bare gravel descending from the western Nan Shan in the south and the utterly barren Pei Shan in the north. The extreme aridity of this desert ground explains the abundance and remarkable preservation of the ancient remains recovered along the whole line of the ruined *Limes*. The importance of the Sulo Ho basin is solely derived from the fact that, flanked by high mountains in the south and desert wastes in the north, it forms a natural and easily defended " corridor " leading from north-western China into Central Asia. In ancient times, when this corridor saw much traffic passing into the Tarim basin, the local resources of the Tunhwang oasis were of special value, as they facilitated the use of the difficult route through the desert beyond.

Where the Sulo Ho trough ends near the oasis of Yümensien, the line of the ancient border wall continuing eastwards takes us over an almost imperceptible watershed into a much smaller drainageless area. Its terminal depression, situated north of the small oasis of Hwahaitze or Yingpan, receives what scanty water is brought down by the streams draining that portion of the Nan Shan which divides the valley of the Sulo Ho from that of the river of Suchow. The aridity of this portion of the range and of the rugged outer hills immediately overlooking the Hwahaitze depression is so great that water for irrigation in the latter is obtainable only from subsoil drainage. To the north-east ground covered with high dunes adjoins for a considerable distance. But even this did not prevent the ancient Chinese *Limes* being carried through it to the left bank of the lower course of the Suchow river.

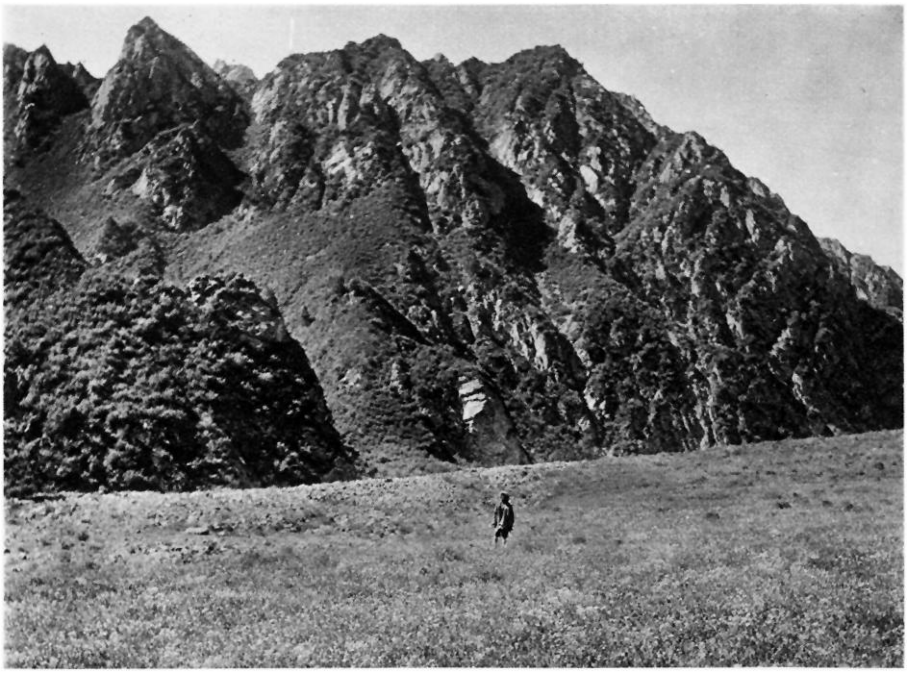
Whether we follow the line of this old border wall of Han times or move by the easier high-road across the plateaus above the Hwahaitze depression to the famous Kiayükwan gate of the mediæval " Great Wall " of China, we now reach the easternmost of the drainageless areas with which we are concerned. It extends from the headwaters of the

Kanchow river and the Pacific watershed in the south-east to the marshy lake-beds in which terminates the Etsin Gol carrying the united waters of the rivers of Suchow and Kanchow. It divides itself into three well-defined zones, all characterized by features which mark transition to adjoining regions of very different climatic conditions. To the southernmost of these, comprising the big snowy ranges of the Central Nan Shan and the wide valleys between them, we have already paid a cursory visit.

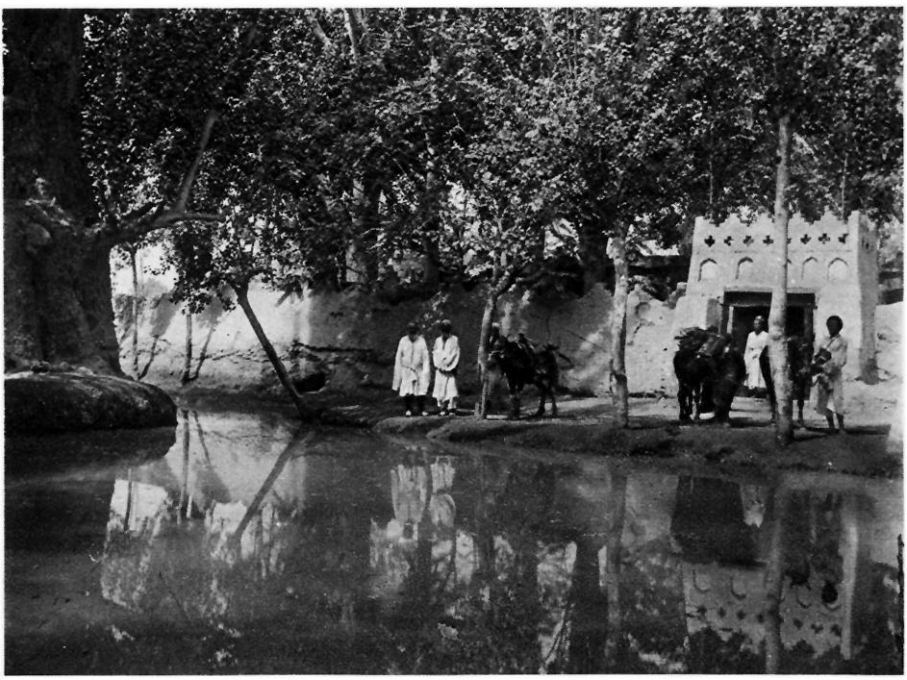
As we descend through the northernmost range in valleys which moisture derived from the Pacific has clothed with plentiful forest (Pl. 11), we come to a broad belt of fertile alluvial fans stretching along the foot of the range at an elevation of from 5000 to 6500 feet. The northern limit of this belt is formed by the barren hill-chain which overlooks the middle course of the rivers of Suchow and Kanchow and divides it from the "Gobi" of the southernmost Mongolia. Over great parts of this submontane belt cultivation is assured not only by abundant irrigation on the alluvial fans of those rivers, but also by favourable climatic conditions. East of the longitude of Kanchow these permit an almost continuous chain of smaller village tracts along the foot of the mountains to be cultivated with the help of rain and snow-fall only.

Owing to the favourable physical features just briefly indicated, this belt was destined in history to become a very important "land of passage" between China and Central Asia. Efforts continued for centuries to protect the empire from those ever-threatening neighbours, the Huns, led under the great Han Emperor Wuti (140–87 B.C.) to the Chinese conquest of the northern slopes of the Nan Shan. The almost inevitable sequel of this again was that policy of Central-Asian expansion which more than two thousand years ago first opened the route along the Sulo Ho to Loulan and thus into the Tarim basin. But before the advent of the Chinese and whenever internal weakening of the empire or other causes led to their losing control, the abundant winter grazing which parts of this territory afford, made it also for centuries an attractive goal of conquest to a succession of nomadic nations, from the Yüehchih or Indo-Scythians down to the Mongols and Dzungars.

For such nomadic invasions from the side of the Altai and the Mongolian steppes, nature has provided a convenient highway in the valley of the Etsin Gol. From its terminal lake-basin far away in the north right up to where the rivers of Suchow and Kanchow break through the barren hill range north of the Suchow and Kanchow tracts, there stretch on either side deserts almost wholly waterless, where even camel-grazing is scanty and confined to rare patches of ground. Cultivation along the Etsin Gol is now confined to two narrow strips, the oases of Chinta and Maomei. But far more important is the fact that grazing is to be found all along the Etsin Gol and its feeders right up to the defiles just referred to. This line of easy access, over 200 miles in length, must at all times have facilitated nomadic invasion to the south-east.



15. VALLEY NORTH OF PASS LEADING TO OPO ACROSS OUTERMOST RANGE, CENTRAL NAN SHAN



16. CANAL-FED TANK AT SHRINE. YOTKAN. KHOTAN OASIS

17. DUNES AND DEAD VEGETATION IN DRIED-UP DELTA,
BEYOND TERMINAL COURSE OF KERIYA RIVER

18. OLD RIVER BED BETWEEN CHARCHAK AND INCHIKE RIVERS,
IN DESERT S.W. OF QARA SHAHR

19. RIDGE OF DUNES IN LOP DESERT, BETWEEN LOULAN SITE AND TARIM RIVER

It is attested by Chingiz Khan's first great inroad of A.D. 1227 into China, which we know to have followed this line. The evidence of the ruined site of Khara Khoto shows that the Etsin Gol delta right down to mediæval times must have received more water than it now does, and this together with certain other features helps curiously to illustrate its affinity in more than one respect with the territory of ancient Loulan and its now completely dried-up delta.

We have now completed our survey of the vast region which for close on a thousand years had served as the principal scene for that important historical process, the early interpenetration of Far Eastern, Indian, and Western civilizations. The dominant geographical features of that scene have exercised a great and constant influence upon this prolonged process. In order to appreciate it fully, we must pass in review, however rapidly, the chief phases in the political history of the whole region. Fortunately we can gather our knowledge of these phases from a very reliable and precise source, the Chinese dynastic Annals, and for the earliest events from the contemporary record of Ssŭma Ch'ien, the Herodotus, as he has justly been called, of Chinese historical literature.*

The story may be said to start with the adventurous Central-Asian mission of Chang Ch'ien. The great Emperor Wuti (140–87 B.C.) of the Former Han dynasty, about 138 B.C. dispatched that young officer to the tribe of the Great Yüehchih who later became the Indo-Scythian rulers of north-western India. The object was to gain their aid against those hereditary foes of China, the Hsiungnu, destined to appear later as the Huns in European history. These powerful nomad tribes, united in a great confederacy, had for centuries from the side of Mongolia harried the northern marches of the empire. The Yüehchih, whom they had ousted some twenty years earlier from their old seats along the northern foot of the Nan Shan, had migrated far away to the west and established a new kingdom on the Oxus in what is, or until quite recently was, Bukharan territory. When Chang Ch'ien, after many trials and difficulties, including a ten-years' captivity among the Huns, at last reached the Yüehchih, these refused to turn back and seek revenge on the Huns. So the mission entrusted to Chang Ch'ien failed in its direct aim. All the same it was destined to open a new epoch in the economical and political relations of China with the world outside its own civilization.

* The following are some of the principal publications which have made Chinese historical records bearing on innermost Asia accessible to Western students in critical translations: Wylie, 'Notes on the Western Regions,' translated from the Former Han Annals (*Journal of the Anthropological Institute*, 1880, 1881); Chavannes, 'Documents sur les Turcs occidentaux' (St. Petersbourg, Acad. Imp. des Sciences, 1903); Chavannes, 'Les pays d'occident d'après le Wei lio' (T'oung-pao, 1905); Chavannes, 'Les pays d'Occident d'après le Heou Han Chou' (T'oung-pao, 1907); Chavannes, 'Les documents chinois découverts par Aurel Stein' (Oxford, 1913); Bretschneider, 'Mediæval Researches from Eastern Asiatic Sources,' 1888; Hirth, "The Story of Chang K'ién" (*Journal of American Oriental Society*, 1917).

Chiang Ch'ien, after a total absence of thirteen years, succeeded in regaining China by way of the Tarim basin, with only one companion surviving out of the hundred with whom he had started. He brought back definite information about the Central-Asian countries he had passed through, including in the west the rich territories corresponding to the present Ferghana, Samarqand, Bukhara, and Balkh, as well as about the still more distant regions of Persia and India. It was he who first revealed to the Chinese the existence of great civilized populations beyond the ring of barbarous tribes by whom all their land frontiers were hemmed in. The great importance of securing access to the former for the sake of the advantages to be derived both from trade and military aid was quickly realized by the Emperor Wuti, and the state of internal consolidation which the reign of this capable and energetic monarch assured, singularly favoured expansion.

The avowed aim of this policy at the outset was to open the road to the large territories in the Oxus region, especially Bactria, " full of rare things, with a population living in fixed abodes . . . but with weak armies and placing great value on the rich produce of China." That a first attempt towards this goal was made from the south-west, on the borders of Szechwan, is significant of the ignorance then prevailing in China as to the true relative position of India through which Tahsia or Bactria, it was supposed, might be gained. It also reflects the time-honoured caution of Chinese policy, ever anxious to avoid if possible the risk of military complications with powerful neighbours. But when this misdirected initial attempt had been frustrated by the resistance of the barbarous hill tribes on the Tibetan border, and, no doubt, also by the difficulties of the ground, the Chinese effort was promptly turned against the Huns. Their hold on the northern slopes of the Nan Shan blocked nature's true highway towards the Tarim basin and the Oxus region. And here the fortune of war soon rewarded the Emperor Wuti's persistent endeavours. After a series of successful campaigns the territories corresponding to the present Liangchow and Kanchow were in 121 B.C. freed from Hun domination. Minor raids into them by Hun bands still continued for a couple of years. Then the Huns were finally forced to retreat to the north of the desert, and by 115 B.C. control of the newly secured border was united in the command of Chiuchwan or Suchow.

This military advance along the great highway towards Central Asia was accompanied by a rapid organization of Chinese political missions to the different states both within the Tarim basin and beyond, even as far as Bactria and Persia. From the account given of the mission which Chang Ch'ien led in person to the king of the Wusun, the powerful nomad race established in the fertile valleys of Ili and Yulduz north of the central Tien Shan, we see how much trouble was taken to impress these and other nations with the power of China and its industrial wealth.

There can be no doubt that among the Chinese industrial products carried by this and the subsidiary missions of Chang Ch'ien, there prominently figured those fine silk stuffs which then began to reach the Mediterranean through Parthia and Syria. They soon carried the fame of the "silk-weaving Seres" to the great centres of Greek and Roman civilization. When Chang Ch'ien returned from this mission he was accompanied, so Ssŭma Ch'ien tells us, "by several dozens of natives," and "thereby afforded them the opportunity to see China with their own eyes and thus to realize her extent and greatness."

The pioneer of China's expansion westwards, fittingly honoured by the emperor with high rank as "the Great Traveller," died about a year after his return from this mission in 115 B.C. But the intercourse of which he had been the pioneer rapidly developed and increased, until embassies attended by several hundred men, we are told, "followed upon one another's heels all along the route." From the account we receive of certain abuses which before long came to attend these missions to distant foreign lands, we may conclude that in many cases they were largely prompted or exploited by private commercial enterprise. We may, in fact, surmise that these "embassies" were often but an early counterpart of those trading caravans from the West which the Chinese court during the middle ages and later prided itself upon receiving under the guise of tribute-carrying missions. And the same probably holds good also of that "coming and going of ambassadors of the foreign countries of the north-west," which after the first opening of intercourse by Chang Ch'ien is said to have become more and more frequent.

There is ample evidence in the records which the Chinese historical texts have preserved of this interesting period to show that the great westward move initiated by the Emperor Wuti was directed quite as much by political aims as by economic considerations connected with trade. No doubt the development of China's internal resources which the Han dynasty had from its foundation taken care to foster, made it very important that the route which Chang Ch'ien's pluck and persistence had opened should be used to secure direct access to fresh markets for China's industrial products, and in particular the most valuable among them, its silk textiles.

Yet even if the wish to obtain allies against the dreaded Huns in warlike tribes like the Yüehchih and Wusun had been absent, troubles attending the newly established intercourse with the West would soon have forced upon the Chinese government political and military expansion in the same direction. It did not take many years before Chinese missions on their way through the Tarim basin experienced serious trouble from the chiefs and inhabitants of petty territories which cut off their food supplies, obviously with a view to blackmail, or directly attacked them. Worse still, the power of the Huns to the north of the Tien Shan remained unbroken, and small parties of these formidable

horsemen would at times "intercept west-bound envoys," where they passed through Loulan or Lop.

Already in 108 B.C. we read of a Chinese military expedition being sent to coerce the chief of Loulan and to overawe the territory of Chü-shih or Turfan, through which Hun raiders could readily gain access to the route where it skirted the foot of the Quruq Tagh. Thus the need for military protection beyond the newly conquered territory along the northern foot of the Nan Shan very soon asserted itself. Nor did it find the Chinese unprepared. Immediately after the first conquest of that great natural "corridor" they had started the establishment of military colonies along it and the construction of a wall extending to the west. This was obviously connected with the defensive border-line of the "Great Wall" which Shih Huangti, the great predecessor of the Han dynasty, in the last quarter of the third century B.C. had created for protection against Hun inroads. By 108 B.C. the wall with its "continuous line of posts and small forts" had been prolonged from Suchow to the "Jade Gate" (Yümen), then established in the vicinity of the Tunhwang oasis.

There can be no doubt that this western extension of the "Great Wall" was primarily intended to protect the newly opened highway into Central Asia. It is equally clear that it was also meant to assure more safety from Hun raiders to the military colonies which were planted in the submontane tracts traversed by the great route. Their agricultural produce was essential for making this long line of communication practicable whether for trade caravans or troop movement. While the earlier "Great Wall" of Shih Huangti appears to have borne that purely defensive character which we are accustomed to associate with the familiar "Chinese Wall" of late mediæval construction, the Emperor Wuti's wall was distinctly intended to serve as the instrument of a "forward policy" conceived on a big scale. The analogy it thus offers to the earlier *Limes* systems of the Roman Empire is most striking; for modern antiquarian researches have proved that the lines of the Roman *Limes* were originally integral portions of the great strategic road system of the Empire.

It has been my good fortune on my second and third expeditions to trace and explore the remains of this ancient Chinese *Limes* from its westernmost end in the terminal basin of the Sulo Ho right through to the Etsin Gol, over a total distance of not far from 400 miles. In my 'Desert Cathay,' and more fully in 'Serindia,' I have been able to give an account of the many fascinating observations and "finds" which rewarded my surveys and excavations along this far-flung *Limes* of Han times. The physical conditions of the ground its line follows and the remarkable state of preservation in which its ruins have survived, especially west of Tunhwang, offer distinct geographical interest. But before I refer to the light they help to throw on questions we have to consider here, it will be convenient to complete our brief synopsis of the historical

developments which followed the first contact of Chinese trade and civilization with innermost Asia.

Events moved rapidly enough. As so often in history, the aims of peaceful penetration in the interest of trade and civilized intercourse called before long for support by political influence and military action. It was the not unusual case of the flag having to protect the trade. From the outset the Chinese policy of Central-Asian expansion appears to have fixed its hopes for profitable trade far more upon Tayüan or Ferghana and other large and fertile territories in Western Turkistan than upon the scattered oases of the Tarim basin. There were obvious geographical reasons; for neither in respect of extent of cultivable ground, population, and other resources, nor as regards vicinity to the great trade centres of the West, could the latter compare with the former. But the distances separating those western territories of Central Asia from China were great. Relying upon the protection thus afforded the people of Ferghana after a time treated the Chinese missions with scant regard; in the end they robbed and killed some imperial envoys who had been sent to secure a far-famed local breed of horses for their master.

Chinese prestige required prompt punishment of such an offence. So a punitive expedition was dispatched in 104 B.C. against Ferghana. It ended in complete failure. The large force sent became exhausted by the difficulties of the route followed across the "Salt Marsh," *i.e.* the dried-up salt sea-bed of Lop, and by the want of supplies beyond, long before its remnant reached Ferghana. There it was utterly routed while besieging a town, and when in its retreat it regained Tunhwang "only one or two out of every ten soldiers were left." To repair so signal a defeat all the resources of the empire were strained. By 102 B.C. the Chinese General Li Kuangli was enabled to set out once more from Tunhwang with a fresh army of sixty thousand men. A huge train and commissariat was provided for the formidable task of maintaining this force on the march towards its far-off goal.

This time Chinese power of intelligent organization triumphed over all the difficulties of nature, almost insuperable for an army as they must appear from our present knowledge of the forbidding desert which it had to cross between Tunhwang and Loulan. The force of thirty thousand men with which the Chinese general reached the capital of Ferghana sufficed to secure victory and the submission of its people. The prestige of China was so strengthened by this great feat that all the small states of the Tarim basin accepted imperial sovereignty. It was, no doubt, in order to make its control effective that measures were taken to safeguard henceforth the road westwards from Tunhwang, which was the natural gate and base for Chinese expansion into the Tarim basin. Thus we read of a military governorship established at Tunhwang and that "westward from here to the Salt Marsh, *i.e.* Lop Nor, the road at many points was protected by military stations." Further west along

the main trade route of the Tarim basin Chinese soldiers were settled as agricultural colonists to assure supplies for missions, etc.

Henceforth Chinese control of the great natural highways, provided by the strings of oases in the Tarim basin, remained practically unbroken for more than a century, until internal disorder in China brought about the downfall of the Former Han dynasty soon after the commencement of our era. The records furnished by the Han Annals about the "Western regions" allow us to see that this prolonged maintenance of Chinese control was due far more to the successful diplomacy of the empire's political representatives in these territories and to prestige based on China's superior civilization than to the force of arms. The mutual jealousies of the many petty states among which the oases of the Tarim basin were divided and a temporary weakening of those dangerous northern neighbours, the Huns, also helped during this period to keep the passage open for China's direct intercourse with the civilized populations of Western Asia. From the references of classical authors to the famous "Seric fabrics," *i.e.* silks, we know that these products of Chinese industrial skill then travelled westwards in an unbroken flow. In return China must then have received, particularly from Eastern Iran, many of the articles of foreign origin, both natural and manufactured, the introduction of which from the West is distinctly traceable in Chinese literary records.

It is to the same period of the "open road" through Central Asia that we may safely attribute the initial stages of that close mingling of cultural influences from China, Iran and India which archæological explorations at ancient sites of the Tarim basin have so clearly revealed as the characteristic feature of the civilization prevailing throughout that region during the pre-Muhammadan epoch. It is true that the earliest relics of that civilization as yet brought to light there by excavation—apart from prehistoric remains of the Stone Age—do not reach back so far. But there is every reason to believe that the people cultivating the oases of the Tarim basin for centuries before were of the same race and speech as those whose documents and literary remains, written mainly in a variety of Indo-European languages, we have recovered from sites abandoned to the desert between the third and eighth centuries A.D. In that exceptionally arid region climatic conditions would allow of the existence of comparatively large communities only on the basis of a highly organized system of irrigation. Thus nature itself had provided there a human medium far more suited for the absorption and transmission of cultural influences, whether coming from the Far East or the West, than nomadic populations could possibly be.

Geography in other respects, too, seems to have singularly prepared the Tarim basin for its chief historical *rôle*. It was to serve as the channel through which the ancient civilizations of China on the one side and of Persia and India on the other, both the latter already stimulated by

Hellenistic influences, were first brought into prolonged contact. We have seen how nature, by denying grazing-grounds to the vast basin between Kunlun and Tien Shan, had protected it against ever becoming the scene of great migratory movements and of such upheavals as are bound to accompany them.

The Huns in the north still remained dangerous neighbours, blocking the route along the northern foot of the Tien Shan range and making their power felt by tribes like the Wusun who held the fertile valleys on that side. But by lending organized support to the small kingdoms along the southern slopes of the Tien Shan between the Qara Shahr valley and Kucha it was not difficult for the Chinese to keep the Huns off from ground where they might have indeed interfered with traffic and exacted tribute from the oases, but never could have remained in permanent occupation. By 60 B.C. the Chinese, through the enterprise of an energetic "Protector-General of the Western regions," put themselves in possession also of the outlying small basin of Turfan, containing a well-cultivated tract south of the eastern Tien Shan, and thereby secured an important flank protection for the great northern trade route. The alternative line of communication along the southern rim of the basin, past Charchan and Khotan, was effectively protected from the danger of nomadic aggression by the mighty barrier of the Kunlun and still more, perhaps, by the utter barrenness of the high Tibetan plateaus adjoining. Not until some eight centuries later, when Tibet had risen from a congeries of barbarous tribes into a centralized state of military power, did Eastern Turkistan experience invasion from that side.

(*To be concluded in the June Journal.*)

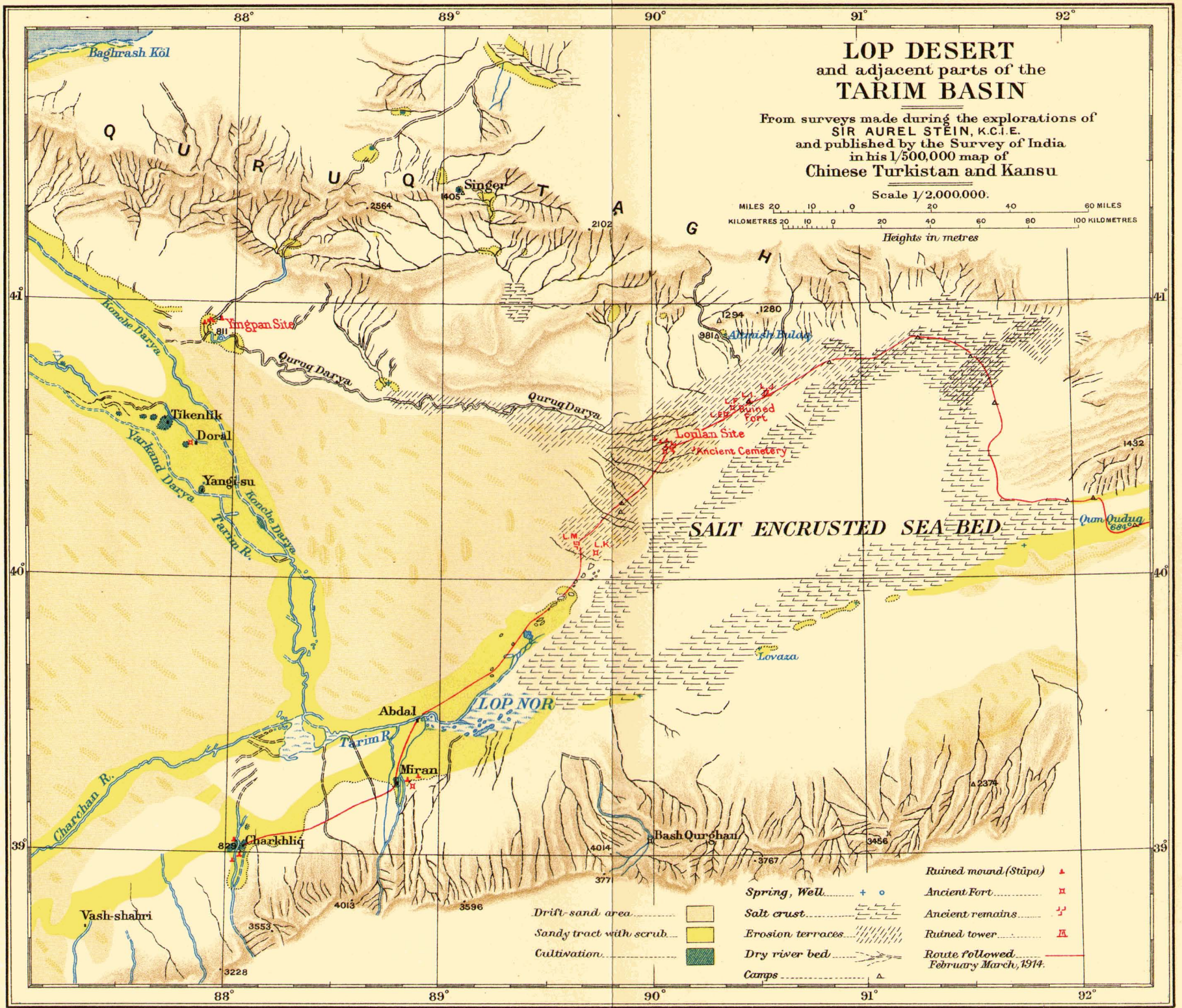
THE PORTOLAN MAPS OF THE RHÔNE DELTA

A Contribution to the History of the Sea Charts of the Middle Ages

R. D. Oldham, F.R.S.

Read at the Afternoon Meeting of the Society, 16 *March* 1925.

THE delta of the Rhône presents probably more varied and more numerous historical problems than any other region of equal size. The Camargue, the name by which that part of the delta enclosed by the two branches of the river is known, is at present a sparsely populated region, where mankind is repelled by a spread of malaria-breeding salt marshes, where the impression produced on the wanderers is that of a solitude more impressive than of the ocean, and where droves of cattle, goats, and horses wander as wild and as free as on the plains of Texas. Yet this same region was described as the granary of the Roman



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Mr. R. D. OLDHAM: It was more in order to find out how those who had studied these maps, as maps, regarded some of the points that come out in my work, than as attaching importance to my own opinions, that I have put them forward, and my paper seems already to have produced fruit, in the very interesting remarks that Prof. Callender has made. The suggestion that St. Gilles and Aigues Mortes are the same was surprising to me, but it is certainly a possibility, yet as regards the incident in the warfare between Genoa and Pisa I think there can be no doubt that the St. Gilles mentioned is the place which we now call by that name. It was then on the river, it was the place which the Rabbi Benjamin of Tudela mentioned as St. Gilles, and of it there seems to be no trace on the Portolan maps. And yet it must have been a fairly important port, and, from the historical records, apparently a true seaport.

As regards Mr. Heawood's remark in connection with Ausonius' mention of Arles, I presume that he refers to the often-repeated quotation from Ausonius containing the words "Arelate duplex." The adjective as used by Ausonius had reference, I think, to the two halves into which the city was divided by the river, for we know that in Roman times Trinquetaille was large and populous, although the eastern side was more important. Some modern writers claim that *duplex* had reference to two ports, the river port, and the sea port which lay to the eastwards and formed the head of the Marian Canal, but I can find no first-hand evidence for that opinion.

As for the hope that the study of the maps might have a bearing on history and geology, it was very largely with that view that I communicated the paper, for if I am right in concluding that the Portolan maps of the Rhône Delta did represent with marked accuracy the sea-face as it was in the fourteenth century, then we may extend this conclusion along the coast to the westwards, where the Portolan maps seem to help in clearing up some difficulties in reconciling ancient history with modern geography.

The CHAIRMAN: The lecture to which we have listened and the remarks of those who have given us their views prove that there has been an enormous amount of research expended on the subject. I must congratulate Mr. Oldham on the immense amount of trouble he has taken in digging out all the very interesting facts he has put before us. These show more than ever how important it is to study both the history and geology of all parts of a country relative to its geography, so that by correlation we may get to know more about all three. As the hour is late, I will now ask you to join with me in a most hearty vote of thanks to Mr. Oldham for his lecture.

LORD CURZON OF KEDLESTON

THE Honourable George Nathaniel Curzon, Fellow of All Souls, and Member of Parliament for the Southport division of Lancashire, became a Fellow of our Society in 1888, and in the same year made the journey along the newly opened Trans-Caspian Railway which was the subject of his first book: 'Russia in Central Asia,' published in 1889. In its preface we read a statement of the author's method: "References, figures, and statistics, I have subjected to verification; while such sources of contemporary history as relate to my subject I have diligently explored"; and again, referring to other writers

EARL CURZON OF KEDLESTON, G.C.S.I., G.C.I.E., F.R.S.

PRESIDENT R.G.S. 1911-14

Painted for the Society in 1914 *by Mr J. S. Sargent*

on the same subject, "I did not start upon my journey without having made myself thoroughly acquainted with their opinions and researches: nor have these pages been written without subsequent study of every available authority." Those who worked with or for Lord Curzon at any time during his strenuous life will admit that these were no vain boasts. His untiring industry and amazing powers of work were the admiration and despair of those who served him.

His travels were inspired by the highest ideals of Imperial politics and public service. To study the authorities, investigate on the spot with full knowledge, and while training himself for his country's service to inform public opinion: these were the aims which inspired his prodigious activity in the eleven years between his journey to Central Asia in 1888 and his appointment to the Vice-Royalty of India in 1899. He was already Under-Secretary of State for India when he became a member of our Council in 1891. His great and famous work on 'Persia and the Persian Question' was the result of journeys during Parliamentary vacations, and published in 1892. When the Conservative Government went out of office in that year, Mr. Curzon went to the Far East, and in the year 1894, when his book on its Problems was finished, he started at once for the Pamirs and the Oxus, and on his return journey stayed with the Amir of Afghanistan.

So in 1895 the Hon. George N. Curzon was awarded the Patron's Medal of our Society for "his work on the History, Geography, Archæology, and Politics of Persia; for subsequent journeys in French Indo-China, and for an expedition to the Hindu Kush, the Pamirs, and the Oxus"; and in his last book, 'Tales of Travel,' written in 1922 while he was Secretary of State for Foreign Affairs, he confesses that this award gave him greater pleasure than it did to become a Minister of the Crown. "Every moment that I could snatch from politics—before they finally captured and tied me down—I devoted to the pursuit of my old love."

During these years of active travel in the intervals of hard political work Mr. Curzon took a vigorous share in the affairs of our Council. Being already strongly convinced of the Society's need for a more spacious home, he spent many mornings house-hunting with Mr. Freshfield, then one of the Honorary Secretaries: but they could find no house suitable for the Society's needs and within its means in the neighbourhood of Savile Row or Saint James' Square. On another matter, the admission of women to the Fellowship, he was prominent among the opponents to that measure. In July 1892 twelve ladies—including the well-known traveller and writer, Mrs. Bishop—had been elected by the Council; but during the following winter strong objections were raised by a number of Fellows, who challenged the power of the Council to include ladies among the "loving subjects" of whom, by the Charter, the Society was to be composed. The controversy became warm: and those Fellows who

are interested in the history of their Society may be amused to turn back to the files of the *Times* for 1893, when they will find a lively exchange of letters between Mr. Freshfield and Mr. Curzon, for and against the admission of women. An informal plebiscite of the Fellows in Great Britain, taken by post, showed a large majority in favour: but that did not prevent a Special General Meeting taking the opposite view, by a small majority, and the result was generally attributed to Mr. Curzon's vigorous conduct of the campaign.

He had indeed a remarkable gift of trenchant language which is not so conspicuous either in his books or in the published reports of his speeches when later he filled the office of President with so great distinction, but which was all-powerful in discussion at Council and Committee; and those who knew him only in the Presidential chair can readily believe that twenty years before he was a formidable opponent in debate. But his strong opinions were not held obstinately, and he was ready to modify them in changed circumstances. Hence it came about that twenty years later it fell to him as President to propose and carry without serious opposition the reform which now seems to us to have been so long overdue.

In 1899 Lord Curzon of Kedleston was appointed, when not yet forty, to be Viceroy of India, and in this high position found time to keep in sight and opportunity to foster the progress of exploration. He had little sympathy with the school of statesmen who desired to discourage or even prohibit all travel beyond our frontiers. It was largely due to his support that Dr. Aurel Stein was able to prosecute his researches and discoveries in the Chinese borderland. He gave his countenance to the Duke of the Abruzzi's exploration of the Karakoram glaciers, and to Mr. Freshfield's high-level tour of Kangchenjunga. Moreover, he recognized from the first the explorers' and climbers' keen desire for a nearer approach to the highest mountain in the world. For this it was essential to obtain the consent of either Nepal or Tibet. To the latter country he had been compelled to send a political mission with a large military escort, and the moment was unpropitious. Lord Curzon believed, however, that there was a good prospect of overcoming the objections of Nepal, and early in 1905 he wrote to Mr. Freshfield asking him to interest our Society and the Alpine Club in preparing a Mount Everest Expedition. But the Durbar of Nepal finally refused to allow passage through their country, and the project was abandoned for a time. Yet it was Lord Curzon's firm treatment of the Tibetan difficulty in 1903–04, when he sent Colonel Younghusband (as he then was) on the famous mission to Lhasa, which paved the way for our present friendship with Tibet, and made the recent expeditions possible.

On his return from India in 1905 Lord Curzon became once more a member of our Council, and in 1911 succeeded Major Leonard Darwin as President. He turned at once to the problem of a new house for the

Society, and set himself to collect the large sum of about £40,000 required to supplement the amount available in invested funds plus the value of the freehold premises in Savile Row and Vigo Street. He wrote with his own hand scores of letters to his friends calling upon them to contribute, and he prided himself upon having varied each letter according to the character of the person addressed. Renewed search for a house or a site in the old neighbourhood proved unavailing, when on the death of Mr. William Lowther his house, Lowther Lodge, with more than two acres of land, came into the market. It was offered him, Lord Curzon used to say, by the then Speaker, now Viscount Ullswater, at the Eton and Harrow match. Lord Curzon resolved immediately that this was the house for the Society, with room to build a lecture theatre, and surplus land for sale to provide the cost; and he quickly overcame the doubts of some members of the Council, whether the position was not too far west. Into the problem of altering the house and furnishing it Lord Curzon threw himself with all that passion for detail which so greatly distinguished him. He chose the wall-papers, carpets, furniture, and ornaments; he hung the pictures, made good many gaps in the portraits of medallists, and collected many of the relics that are now in the Museum. And he had nearly completed the negotiations for sale of the surplus land when a building strike brought the business to a stand, and there it stayed until the outbreak of war. When, in 1919, negotiations for the purchase were opened by the Imperial College of Science and Technology, Lord Curzon was no longer President, but the Council asked him to be one of the three representatives of the Society to conduct the business, and the meeting with the delegates of the Imperial College was held in his house. Those who were present will always remember how he brought the discussion to a head, and obtained the price he had set, by asking what would be his position if he had to face an infuriated meeting of Fellows, demanding why he had given away the Society's property at the blandishments of Lord Crewe. It was a bitter disappointment to him that the bargain then made, and solemnly confirmed by both sides, was afterwards repudiated by the Imperial College, and that during the rest of his life our surplus land remained unsold and the scheme on which he had set his heart was but half completed.

From time to time after he had vacated the Chair, Lord Curzon would come to Lowther Lodge, and remark every detail that had been changed since he had placed it. He took the keenest interest in expending as opportunity arose the gift of £500 for the adornment of the house which he had obtained from the late Lord Glenconner: some of our best pictures and the clock in the entrance hall were bought by him at Christy's from this fund. He used to say that attending these auctions was his only recreation in London. Throughout the recent years when he was Secretary of State for Foreign Affairs he found time

to complete the very interesting and characteristic Tales of Travel from which we have already quoted: and in the press of the most critical public affairs he would telephone to the Librarian requiring minute details of the great waterfalls of the world, or write letters of many pages to the Secretary on the problem of the Singing Sands. It will ever be a mystery how he contrived, without any of the usual aids of private secretaries and typewriters, to carry on his multifarious activities, in spite of always delicate health, and frequent severe pain.

Our Society was supremely fortunate in claiming so large a share of his great and varied talents, and when he gave up the Presidency nearly twelve years ago the Council resolved upon offering him the honour unique in the Society's history of asking him to sit for his portrait, to be hung over the mantelpiece in the Council Room. The fine painting which Mr. Sargent then made in the summer of 1914 shows him in the dark blue robes of the Order of the Indian Empire. It is here reproduced to support this inadequate tribute to the remarkable talents of the great man who served the Society as he served the State with the whole force of his strength.

THE LAND OF ELAM

Lieut.-Colonel F. R. Maunsell, C.M.G., C.B.E.

MUCH has been heard lately of great archæological discoveries in Mesopotamia at Ur of the Chaldees and at Kish; the dwellers in Mesopotamia have come more in evidence; even the people of the mountains of the Medes, the Kurds, have now their place in modern history, yet those of the great land of Elam still remain shrouded in obscurity.

Elam in modern times is represented by a province of South-West Persia, most of which is comprised in the district of the Pusht-i-Kuh and part of the province of Kermanshah. It also includes most of Khuzistan or Persian 'Arabistan stretching down to the shores of the Persian Gulf. This latter portion, with the deltas of the Karun and the Karkheh, is sufficiently well known, and the ruins of Shush, the ancient Susa the capital of former empires, have been thoroughly explored by French archæologists.

It is the mountainous part of Elam along the middle course of the Karkheh, with the northern districts crossed by the Zagros ranges, that still remains in archæological and largely in geographical darkness.

The Pusht-i-Kuh is firmly ruled by the celebrated Vali of the Pusht-i-Kuh, Hassan Ghuli Khan, who holds a position virtually independent of Tehran, largely owing to the security from attack afforded by the mountains by which he is sheltered. His people are the Faili branch of the Lurs, a section of the family as great but lesser known than the

were able to navigate the river down to Matopo, a distance of 90 miles; beyond which navigation was rendered impossible by the Murchison cataracts. From 1905 onwards the fall in the level of the lake made navigation more and more difficult, and by 1910 the river had become impassable even for small craft. Since then the Upper Shire has been useless as a waterway although the level of the lake is now above the maximum of 1898, when river transport was at its height. Dr. Dixey ascribes the condition of the Upper Shire to the clearing of vegetation from the valley of the river, with a consequent increase of erosion by rain.

As to the future, it is probable that the level of the lake will go on rising until the next sunspot maximum, which should occur about 1928, or until the lake attains such a height that the river gains sufficient strength to begin clearing away the obstruction from its bed. When this occurs the river will assist in lowering the level of the lake. This process would place the river in danger of becoming silted up once more. D. B.

THE POPULATION OF INDIA

Census of India, 1921. Volume I. India. **Part I.** Report.— **J. T. Marten, M.A., I.C.S.** Calcutta: 1924. 13 × 8¼, pp. xii. + 293 + xxvi.

THE Report of the Census of India which was taken in March 1921 marks a new departure. Previous reports have been a mine of first-hand information on the geography of India, and on the ethnology, social structure, religions, languages and dialects of its peoples. Under orders from the Government of India, with which the author of the present report is in agreement, this valuable and interesting feature of former census reports has been discontinued, and the object of the present report is merely to provide such information as bears directly upon the census statistics. Considerable curtailment in the length of the report has thus been found possible. It consists of 331 pages as against the 479 pages of the report of 1911. Notwithstanding the restrictions imposed the report is one of great interest to geographers. The essential bearing of geography upon many of the questions dealt with in a census report is emphasized when geographical considerations are only brought in because they must be.

Like so much of the work of our administrators in India, the Census is taken as a matter of course. It is not realized what an achievement it is to effect the enumeration of 319 millions of mankind, most of whom have not reached a European standard of civilization, and also to collect a great variety of information about them with remarkable accuracy, and at small cost compared with the cost of the census in England and Wales. It is not so easy as it is in England to take the census on the exact decennial anniversary of its predecessor. It must be taken when there is ample moonlight, when the season is not too hot or too cold or too rainy, and when there is least disturbance of the population owing to great fairs or pilgrimages. Even so the census could not be synchronous in some of the wilder tracts. On the other hand, the remarkable immobility of the Indian population as a whole is in favour of accuracy. Ninety per cent. were enumerated in their native districts, and special inquiries made in a number of villages showed that very few had ever visited the chief town of the province, and that in one of the more sequestered areas, Chota Nagpur, only one in thirty-one had ever travelled by train. Fortunately also in 1921 there were no disturbing factors

due to plague or other epidemics. The only difficulties, and those not general, arose from the non-co-operation movement, which had the effect of making some of the lower literate classes unwilling on this occasion to do work for the census without remuneration.

The usual comparisons are made of the population of India with the populations of other great areas in the present and the past. India with an area half that of the United States of America has a population nearly three times as great. The Roman Empire at its greatest extent was greater than India by about three-quarters of a million square miles, and the population of this area is now about 210 millions. But in Roman times it probably did not exceed 100 millions. A comparison of more practical interest is one between India to-day and India at the death of Akbar. The population then was, according to Mr. Moreland, about 100 millions. At that time the common people of northern India were undoubtedly almost naked. Blankets were unknown, and shoes seldom worn. The common people have long been more or less substantially clothed and shod, and the small comforts and conveniences now in frequent use, such as tea, cigarettes, matches, buttons, pocket knives, and looking-glasses, show that the standard of living is gradually rising.

The average decennial increase of the population since regular censuses were begun in 1872 has been 4 per cent. But in every decade, except 1881–1891, the natural rate of increase has been reduced by some special disaster —famine, or pestilence, or both. The casualties of Indians in the War were insignificant compared with the casualties that are caused in India by the slightest of epidemics. The increase of the population when unchecked by wide-spread calamities is estimated at from 7 to 8 per cent. The close of the decade under report was marked by an epidemic of such disastrous virulence—the influenza epidemic of 1918—that the census figures of 1921 are specially abnormal, and in some of the provinces obscure the general character of the decade. The total mortality was estimated at from 12 to 13 millions—more than that from plague in twenty years, and more than double the whole famine mortality from 1897 to 1921. Four provinces—Bombay, Central India, the United Provinces, and Bihar and Orissa—returned a population smaller than in 1911 ; indeed, had the census of this last province been taken in March 1918 the population would have been 1½ millions greater. Rural areas, largely no doubt for lack of medical aid, were most severely affected, and whole villages were left desolate. The mortality was very high among the younger adults, especially women. The disease seems to have been more virulent in the drier, colder parts of the country than in the hotter, damper regions. The map of influenza mortality shows that Bengal and Burma escaped most easily, and next to these the districts of the east and west coasts of the peninsula. Past experience shows that, given a few favourable years, even this appalling wastage of life will soon be made up. The birth-rate for India is from 35 to 40 per thousand (in England and Wales last year it was 18·8), and although the death-rate is high, it is being continually attacked by science, while the birth-rate seems likely to remain at its present figure.

The density of the population in India is 177 per square mile. This figure is obtained by dividing a total which is heterogeneous, comprising persons young and old, and of all sorts and conditions in life, by a number, also heterogeneous, comprising all kinds of land—mountain and plain, desert and marsh, fertile and barren. The meaning that can be attached to the quotient

diminishes as the area concerned increases and its homogeneity is less, and for large areas is of little use except for very general comparisons. France among European countries has most nearly the same population density as India, but obviously a comparison of France with India in this respect is less illuminating than a comparison with Germany, which has 332 inhabitants to the square mile.

When the people of a country depend predominantly upon agriculture it is the level tracts that, other things being equal, carry the largest population. In India half the population lives on one-sixth of the area—on the well-watered plains of the north and on the coastal plains of the peninsula. In mountainous regions also the seat of the population is the valley bottoms and the easier slopes where agriculture is possible. To say that the population density of Kashmir is 39 means little until we know the nature of the country and the proportion of cultivable land, and the density on the cultivable land of Kashmir actually exceeds 1000 per square mile. In fact, the figures expressing density of population become truly significant in proportion as the areas dealt with are physically homogeneous; and such figures are therefore most useful when they are obtained for the natural regions of a country. An important step towards this was made in the 1911 census, in which the census statistics of density, density on area cultivated, the proportion of cultivable land and the net area cultivated, rainfall, and the principal crops, were given, together with a map, for sixteen natural divisions made on a basis of rainfall. Although these natural divisions were large, and therefore not thoroughly homogeneous as regards surface relief, or even in respect of climate, the result was a more scientific picture of the correlation of population and natural conditions than had previously been presented. In that scheme the administrative province of Bengal was the only province taken without change as a natural division, as being both geographically and ethnologically the most homogeneous of all the great provinces of India. And yet its population density at the recent census varied from 34 per square mile in the Chittagong Hill Tracts to 1148 in the Dacca district. The mean density of the province was 578, but the exclusion of the hill districts of Darjeeling, the Chittagong Hill Tracts, and the Tripura State gave an area still more homogeneous which had a density of 640 per square mile. The valuable map showing density by districts given in the 1911 Report affords material for carrying further the division of India into homogeneous areas, and a similar map in the 1921 Report would have been welcome. But Mr. Marten has not continued the presentation of the census statistics in accordance with the large natural divisions of 1911. He remarks that the movement of the population during the decade is largely the result of an influence (influenza) not closely related to the principles on which the natural divisions were based. He has preferred to follow the natural divisions adopted for the individual provinces whenever it is necessary to represent the statistics for India as a whole, and has therefore provided a map of India giving the density of population by natural divisions of provinces and states. In this, of course, the natural divisions of 1911 are divided up among the administrative divisions. Nevertheless the map is one of great interest. The shading brings out clearly the concentration of the population on the level areas with adequate rainfall, and shows that the largest continuous areas with a population density of 600 and upwards are the north-east of the United Provinces with North Bihar, and Eastern Bengal. The eastern portion of the Ganges plain in the United Provinces has the highest density, 711 per square mile, of any of the provincial natural divisions in India.

Is India yet anywhere overpopulated? This question is distinct from the question of overcrowding, which over large parts of India is as great in the villages as in the towns. The statistics show a close correlation between density of population and development of resources, but none between density of population and undue pressure of population. Economic pressure may exist at any degree of density, and the chief stimulus to progress is the overtaking of the existing material resources by the expansion of population when there is land still awaiting cultivation, or when more crops, or more profitable crops, can be grown on land already under cultivation, or when circumstances favour industrial development. In parts of Eastern Bengal, which is freely drained and healthy, the density exceeds 1000 per square mile, and goes on increasing, and the standard of living is higher than in parts of West Bengal, where the density is below 500 and is stationary or declining owing to the prevalence of malaria. In parts of Cochin and Travancore a population of 1200 per square mile is maintained in comfort owing to the substitution of coco-nut, rubber, and tea for rice. On the other hand, the maximum density has probably been reached in most parts of North Bihar, where it would appear that the agriculturist is, on the present system, getting all he can out of the land. But taking India as a whole, and apart from possible industrial development, there cannot be serious overpopulation in these days of easier communications, so long as there are still large areas of cultivable land, estimated in 1911 at a quarter of the whole, not yet under cultivation.

The population of India is essentially rural, and seems likely to remain so. To the majority town life is unpopular and artificial. One of the most interesting and important features of the last decade was the gradual decline of the medium-sized country town. It is true that the larger industrial cities are growing, but the unnatural character of city life is shown by the dangerously low proportion of women in the city populations—in Calcutta only 470 women to each 1000 men.

Turning to other matters dealt with in the Report, we find that the returns of age are admittedly inaccurate, as they always have been. Few Indians know their age; if they did it would be most unlucky to state it; but ordinarily they have no interest in their own age or in that of others. This inaccuracy makes it impossible to follow in the census reports each batch of the population from infancy to age, and watch the influence upon it of mortality or migration. But it is certain that Indians grow old sooner than Europeans, and are relatively shortlived, especially the tribal aborigines, and that the mortality among children under a year old is excessive. Infant mortality accounts for a fifth of the total death-rate, and a great contributory cause of this is undoubtedly the custom of early marriage, and as its consequence, immature mothers.

Females are the majority of the population in the countries of Western Europe, and the fact that they are a minority of the population of India has provoked much comment and inquiry. It has been suggested that the difference is due to concealment of women, to female infanticide, and to racial factors, causes which are now proved inadequate or inoperative. The increased accuracy of the census has not increased the proportion of women; female infanticide, though formerly common in the north and north-west, has greatly declined. The most probable explanation of the deficiency of women is that female children are unwelcome, and are therefore less cared for; that the risks to the mothers from childbirth, owing to the customs of the country,

are excessive ; and that the hard lot of young and especially childless widows is not conducive to longevity. But, after all, it is the countries of Western Europe that are exceptional in this matter, and the Indian provinces, Madras, and Bihar and Orissa, that have a preponderance of women, are provinces from which there is much migration, mostly of males, and are also the provinces in which there is the largest proportion of female births, though here, as all the world over, male births are in excess.

The elaborate discussions of caste in the census reports of 1901 and 1911 are not continued in the present report, but what is said is much to the point. No part of the census work interests the Indian people so much, and the excitement caused by the attempt in the census of 1901 to determine the order of social precedence among the castes is still alive. Caste is still the foundation of the Indian social fabric, and its record is the best guide to the changes in the various social strata. Every Hindu is born into a caste, and his caste determines his religious, social, economic, and domestic life. The inquiry "Who are you?" is equivalent to "What is your caste?" and has to be made whenever clear identification is required, whether in courts of law or in everyday life. The question is always understood, and the answer immediately gives the place occupied in the social structure. No doubt there is some weakening of caste among the more advanced and educated classes. But among the people generally there is no sign of the disappearance of caste feeling. On the contrary, there is a growing caste consciousness which shows itself, among other ways, in the persistent claims of the less-considered castes to a higher status, and, in connection with this, by the tendency to observe with exaggerated strictness the traditional customs of the higher castes as to widow remarriage, and endogamy—a tendency which acts against the efforts of Hindu social reformers.

The enormous complexity of the caste system renders impracticable a division of the population for census purposes on the basis of caste, especially as the members of a caste no longer necessarily follow its traditional occupation. But it is possible to divide the Hindu population into three large classes the clear distinction of which would not be disputed. These are the Brahmans (14 millions); the "depressed" classes (60 millions), comprising the "impure" castes of the Hindu social system and the tribal aborigines recently absorbed into Hinduism; and, intermediate between these two social extremes, the non-Brahman castes (143 millions), which include most of the cultivating, professional, and higher artisan groups, and a certain proportion of the lower artisans and labourers. The total, 217 millions, is the Hindu community of India, which has declined slightly in numbers during the decade. Christians are now more than double their number in 1881. This rapid growth is due to the large-scale Christianization of aboriginal tribes, and to conversions from the "depressed" classes who have nothing to hope from their own community, and, as Christians, improve their status and manner of life. Christianity makes little appeal to the caste-Hindu or the Muhammadan.

The spread of literacy will ultimately do much to raise the status of the masses in India. How much remains to be done is apparent from the fact that only 139 in every thousand men and 21 in every thousand women are literate in an Indian vernacular; while only 18 men in a thousand, and less than two women in a thousand, are literate in English. On the north-west frontier literacy is still under the suspicion of being unmanly. The spirit both of Brahmanism and Islam is opposed to the education of women,

but the influence of foreign standards and ideals is causing a steady advance. The possibility of a standard Indian language is important in connection with the general development of India. There are now 222 vernaculars spoken, but the scientific distinctions between many of these languages are unknown to the people. To the ordinary person the real languages of northern India are Hindi, Urdu, and Panjabi, and the distinction between Eastern and Western Hindi, and between true Panjabi and Lahnda, a word meaning "western" invented by scholars, is not popularly recognized. The Census Reporter for the United Provinces claims that the languages of this province recognized as distinct by the Linguistic Survey are not different languages, but dialects of the same language. There is a common element in the main languages of northern and central India, which renders their speakers, without any great conscious change in their speech, mutually intelligible, and this common basis already forms an approach to a *lingua franca* over a large part of India.

The Government of India directed that special attention should be given in the Census of 1921 to the collection of statistical and general information bearing on the industrial and economic side of the life of the people. The Report admits that in point of interest and importance the statistics of occupations are perhaps the most valuable of all those obtained at a periodical census, but, it is added, they are the most difficult to collect with accuracy and to combine with precision. Mr. Marten remarks that there was much difference of provincial treatment in this part of the census work, and it seems clear that a consistent method in dealing with it is yet to seek. What was aimed at was an industrial classification of occupations, and to carry further the attempt of 1911 towards a complete industrial census.

Agriculture is the primary occupation of 71 per cent. of the population, and agriculturists have increased a little faster than the whole population. The number engaged in industries has actually decreased. The very small holdings which are a feature of the country leave the cultivator for a large part of the year with little or nothing to do. He cultivates his land on an "extensive" system suited to large areas, and neither the energy of the worker nor the productivity of the land is used to the full. This is the root cause of the ryot's poverty, for the average agriculturist is deeply prejudiced against other forms of employment. One of the economic problems of the future is how profitably to employ the considerable leisure enjoyed by the ordinary cultivator.

Only 1 per cent. of the population are engaged in organized industries, such as tea, cotton, jute, and coal, and there is much difficulty in maintaining an adequate labour force, for the labourer is often also an agriculturist. Moreover, his standard of living is low, and if he can make as much as he needs in three days he does not see why he should work for the whole week. Unorganized industries occupy 10 per cent. of the population, and it is significant that nearly two million handlooms are still in use.

Trade is the occupation of only 6 per cent. of the population. Perhaps to a foreigner in India one of the most striking things about an ordinary village is the absence of shops. The ordinary local retail trade is done at weekly or half-weekly markets, held at some convenient place, and the exchange of commodities produced on the land is kept very much in the hands of the cultivators themselves. Attendance at these markets is one of the ryot's greatest pleasures.

The position of women as workers is of special interest. The proportion

of female to male workers in the whole population is given as 455 women to every thousand men, but it is admitted that, owing to the confusion caused by the distinction of worker and dependant, the figures give no accurate impression of any social or economic truth. Women of the lower classes actively help in agricultural operations, but a large number are registered as unemployed because they are also engaged in domestic duties, often strenuous enough: cooking, taking food to their families in the field, grinding grain, pounding rice, carrying water, in addition to the care of children. In organized industries just over a quarter of the workers (including children) are females, by far the majority of the women workers being employed on the tea and other plantations. The only occupations common to both sexes in which the women are in a majority are the spinning of cotton, wool, silk, and other fibres, the preparation of foods, and trading in fodder, grass, and fuel. The seclusion of women among Muhammadans and in the higher castes of Hindus leads to a vast waste of female labour. There are no women clerks, or post and telegraph operators, and very few women shopkeepers. The loss from such waste has done much to hinder material progress. No European country could maintain its present standard of living without the assistance derived from female labour.

The points that have been touched upon in this review may serve to indicate the wealth of important and interesting matter that has been presented by Mr. Marten in his valuable report. W. H. A. W.

REVIEWS

EUROPE

The Ancient Entrenchments and Camps of Gloucestershire.— Edward J. Burrow. Cheltenham and London: Ed. J. Burrow & Co. 1924. 11½ × 9, pp. 165. *Plans and Illustrations.* *7s. 6d. net.*

THIS is an abridged edition of a larger work issued some four years ago, with some new illustrations of camps, very small plans of four typical earthworks, and a useful index of all Gloucestershire earthworks. Its chief feature is the long series of attractive illustrations (reproduced from the author's drawings), clear and helpful, especially in showing the general setting of most of the camps. The text, as far as it goes, is sound. An introduction on ancient earthworks puts lucidly, patiently, and accurately before the reader most of what is known about the conditions of life among the men who made, or lived in, or were buried in, these camps and barrows of various degrees of antiquity, whether of Goidel, Celt, British, Roman, Saxon or Danish stock. Having already described the earthworks of Somerset, Mr. Burrow has made it the hobby of three years to do the same for Gloucestershire, to read up the authorities (including Allcroft's 'British Earthwork,' *Archæologia*, and the best local publications), to go thus armed to the places themselves, to see and appreciate with his own eyes, and finally to describe with pen and brush. Part II. consists of such descriptions arranged in alphabetical order—picture and short text and references in each case. There are well over a hundred such earthworks in Gloucestershire, and some twenty known Roman villas. What a country for enthusiastic excavator or antiquarian with a car! On such a quest the amateur should not leave behind this pleasing record. The Chedworth Villa is skilfully reconstructed (p. 31). On p. 14 "Dr. Thurman" should probably read "Dr. Thurnam." In the pictures cloud and distance effects are skilful.

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INNERMOST ASIA: ITS GEOGRAPHY AS A FACTOR IN HISTORY

Sir Aurel Stein, K.C.I.E., F.B.A.

The First "Asia Lecture."

Continued from page 403. *General Map following page* 556.

IT is necessary to keep well in view the exceptional importance and advantages which the Tarim basin possessed for the Chinese as a safe line of passage for trade intercourse and political expansion westwards, if we are to understand the reasons which induced them to face and overcome the forbidding natural difficulties besetting access to it. The explorations carried on during my winter campaigns of 1907 and 1914 enabled me to trace the route used for Wuti's enterprises over the formidable wastes of sand, bare gravel, and salt which it crossed. For all detailed evidence regarding its line and the physical conditions prevailing along it in ancient times I must refer to 'Serindia' and to the final report on my third Central-Asian expedition now ready for the press. But the observations made in the course of those explorations are of sufficient geographical interest to warrant our retracing the line, be it only in a rapid sketch.

Let us start from the side of China and its north-western marches in the great province of Kansu. We have already seen in our description of the drainageless basins of the Etsin Gol and Sulo Ho that the submontane belt on the northern slopes of the Nan Shan provided a great natural corridor westwards, easy both to follow and to protect. Abundantly watered from perpetual snow-beds of the Nan Shan, it could as far as Suchow furnish produce amply sufficient for the needs of any number of men and animals that trade or military movements might bring along it. From Suchow onwards the ancient route undoubtedly led, just like the present high-road into Chinese Turkistan, through the succession of small oases which extend along the left bank of the Sulo Ho as far as Tunhwang. To the north of the river there stretch the gravel and stone wastes of the Pei Shan Gobi right away to the foot of the easternmost Tien Shan (Pl. 25). In spite of their barrenness they were in ancient times as little as now impassable for small parties. Hence

there was need for the protection which the *Limes* line of the Emperor Wuti here provided against Hun raids. I could trace it first along the northern bank of the Sulo Ho to the river's last defile at the Wanshantze ridge and thence south of the river towards Tunhwang.

This oasis, in spite of many vicissitudes, including utter devastation during the last great Tungan rebellion, is still a place of some modest resources. It was destined by nature to serve as the base for the early Chinese advance into the Tarim basin. It was then, as now, the last locality capable of cultivation. Beyond it the route had to cross some 300 miles of true desert before striking the once habitable area in the now dried-up delta of the ancient Quruq Darya. West of Tunhwang down to the terminal marshes of the Sulo Ho there extends a bare gravel desert. Narrow strips of reed beds and other desert vegetation are found only along the deep-cut bed of the Sulo Ho and along the succession of small lakes which the dying river feeds at the time of its summer floods.

Desolate as this ground is, it is here that my explorations have revealed the most striking evidence of the thoroughness with which Chinese power of systematic organization had prepared for the safe use of the difficult route into the Tarim basin ever since it was first opened. We know from Chinese historical records, as already mentioned, that immediately after the success achieved by the second expedition against Ferghana (102–101 B.C.) the road from Tunhwang westwards to the "Salt Marsh" was protected by military posts. The westernmost extension of the Emperor Wuti's *Limes* is meant here, and of this my explorations have enabled me to recover the remains in an unbroken line and in a remarkable state of preservation.

The exceptional aridity of the climate prevailing here ever since the *Limes* was constructed made it possible to discover many very interesting relics of the life led during the first two centuries before and after Christ along this most desolate of borders. Among the hundreds of Chinese documents on wood excavated by me at the ruined watch-stations and deciphered by that lamented great scholar and incomparable collaborator M. Chavannes, there are a number of which the exact dates take us back to the very beginning of the first century B.C. The latest do not come down beyond the middle of the second century A.D., when altered political conditions caused the guarding of the *Limes* to be abandoned. Most of these records, written not only on wood but also on silk and in a few instances on the oldest known paper, were found in shallow refuse heaps on to which they had been thrown from time to time out of the military clerks' offices. Their survival here, protected often only by a few inches of gravel, bears conclusive testimony to the atmospheric conditions on this desert ground having been more than two thousand years ago quite as dry as they are now.

Equally interesting from the geographer's point of view is the evidence afforded by the wall or *agger* along which the ruined posts of the *Limes*

with their watch-towers were placed at distances varying from about one to two miles according to the character of the ground. It was throughout constructed of carefully secured layers of fascines alternating with layers of stamped clay or gravel. This method was specially suited to withstand the most destructive of nature's forces in this desert region, slow grinding but almost incessant wind-erosion. It was, besides, the only one practically adapted to rapid construction on ground bare of all resources and over great distances even devoid of water. Along those sections where the *Limes* line lay parallel to the prevailing direction of the winds, blowing mostly from the east and north-east and often with great violence and persistence, the wall still rises in remarkable preservation, in places to a height of 10 feet or more (Pl. 29). Its survival in spite of the apparently perishable nature of the materials used conclusively proves that the climate on this ground has been arid in the extreme ever since the wall was first constructed more than two thousand years ago.

Incidentally I may also mention here the curious collateral evidence furnished by the materials used for the fascines which served to assure cohesion of the wall. Generally these were made of reeds, the material readily obtainable from the reed beds still found in the riverine depressions along the Sulo Ho. But in certain sections of the wall the reed bundles are replaced by fascines made of tamarisk brushwood or branches of the wild poplar, and it is significant that this growth of desert vegetation is just the one now found on the ground through, or near, which those sections of the *Limes* pass. Economy of effort has at all times been a characteristic feature of Chinese methods of work, and here we have a proof of it in the intelligent adaptation to the local resources.

Nor should I here omit an observation which has a direct bearing on that much-discussed question of climatic change usually spoken of in connection with Central Asia as "desiccation." In keeping with its character as a portion of the "Great Wall," the *Limes* west of Tunhwang shows a continuous line of wall except in places where the general direction permitted its designers to substitute for it impassable marshes or lakes, and thus to economize in constructive effort. Exactly the same method is found in certain *Limes* lines of the Romans where a "wet border" had been inserted into a chain of frontier posts. Now where the line of the Tunhwang *Limes* thus abutted on small lakes or marshes, remains of the wall were ordinarily traceable to a level within a few feet of that still reached by the water. This suggests that the volume of water received by these depressions could not have greatly varied since Wuti's *Limes* was constructed.

This is not the place to indicate the many interesting glimpses which the mass of ancient record recovered gives us of the organization of the troops (largely recruited from convicts) guarding the *Limes* line; of

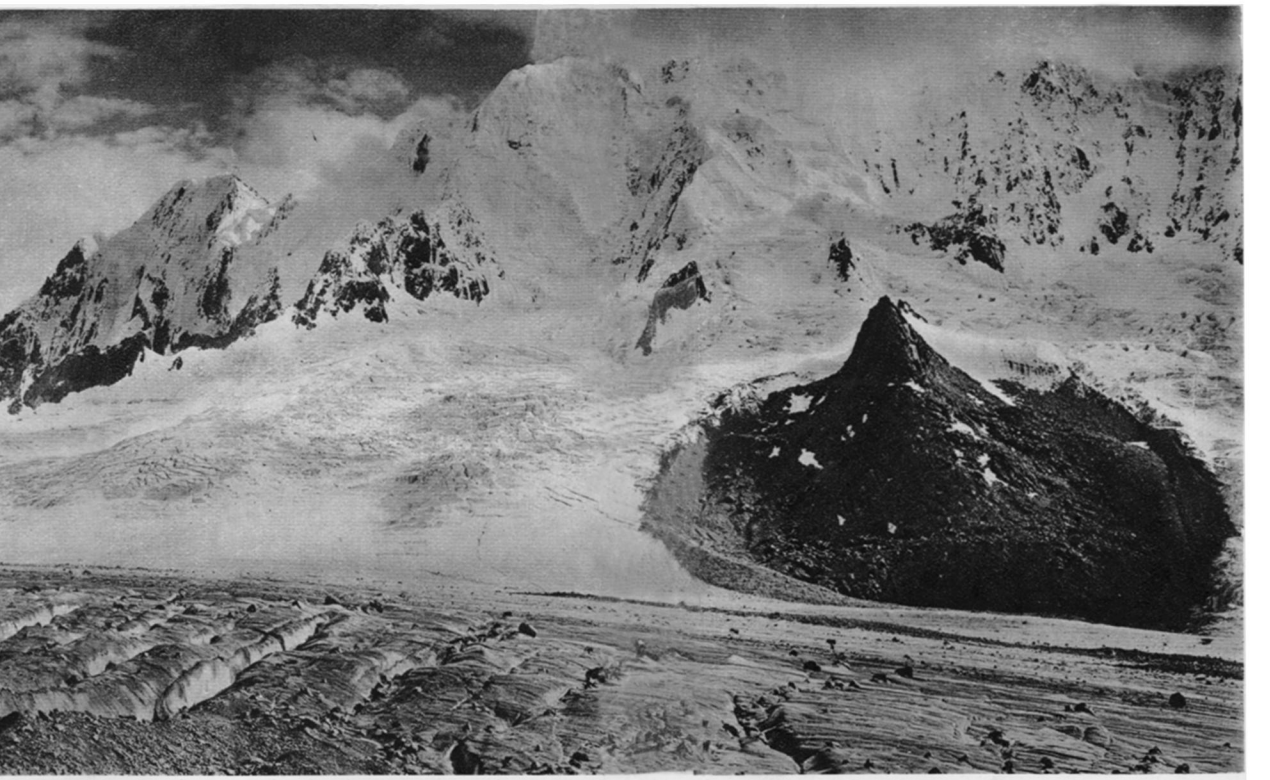
the elaborate system of supplies and transport provided for them; of the service of fire signals maintained along the line, etc. It must suffice to call attention to the evidence which the great size and solidity of the ruined magazine still rising close to the actual caravan route behind the *Limes* affords of the traffic once passing along it (Pl. 24). Throughout the disposition of the watch-posts, sectional headquarters, etc., bears testimony to that remarkable eye for topography which has always distinguished the Chinese. The use of this particular quality for strategic purposes is well illustrated by the way in which those old military engineers of the Emperor Wuti secured a natural flanking defence for their *Limes* line by letting it end close to the terminal marsh basin of the Sulo Ho (Pl. 30).

Beyond this the direction of the ancient route is indicated only by a couple of advanced signal towers along the present caravan track leading towards Lop and by the configuration of the ground. This marks out the desert valley of Besh Toghraq as the only practicable line for further progress between the utterly waterless wastes of the Quruq Ṭagh in the north and the high dunes of the Qum Tagh, or "Sand mountains," in the south. Here obviously there was no need for assuring safety by a *Limes;* for nature itself had provided for the defence of the route line against raids by impassable deserts on either side. And here the question obviously obtrudes itself as to why the Chinese, in spite of very serious difficulties and their traditional aim at economy of effort, had found it at all necessary to carry their protective line of wall and towers so far beyond the oasis of Tunhwang.

The answer to this question is, I think, clear, but obliges us for a moment to turn our attention away to the north. There at a distance of only some 200 miles in a straight line from Tunhwang lies the oasis of Hami at the foot of the Qarliq Tagh (Pl. 14), the easternmost snowy outlier of the Tien Shan. This important area of cultivation provides the natural bridge-head for the easiest route connecting Eastern Turkistan with the Kansu marches. Through it now passes practically the whole of the traffic between the two regions. But at the time of the first expansion of Chinese power into Central Asia and for fully two centuries later Hami was in the power of the Huns who in the great Barkul valley just across the Tien Shan and elsewhere on the northern slopes of the Qarliq Tagh held congenial grazing-grounds amply provided with water. As long as the Hun nation remained a formidable neighbour on the north-western borders no permanent advance to the Tien Shan across the "Gobi" of the Pei Shan could safely be undertaken by the Chinese. Yet without securing a hold upon Hami it was impossible for them to prevent Hun raiding parties crossing the Pei Shan towards Tunhwang and the terminal course of the Sulo Ho beyond it; for in this central portion of the Pei Shan well water for small parties of horsemen can even now be found at certain points, and along the marsh-lined bed of the Sulo Ho such bands could

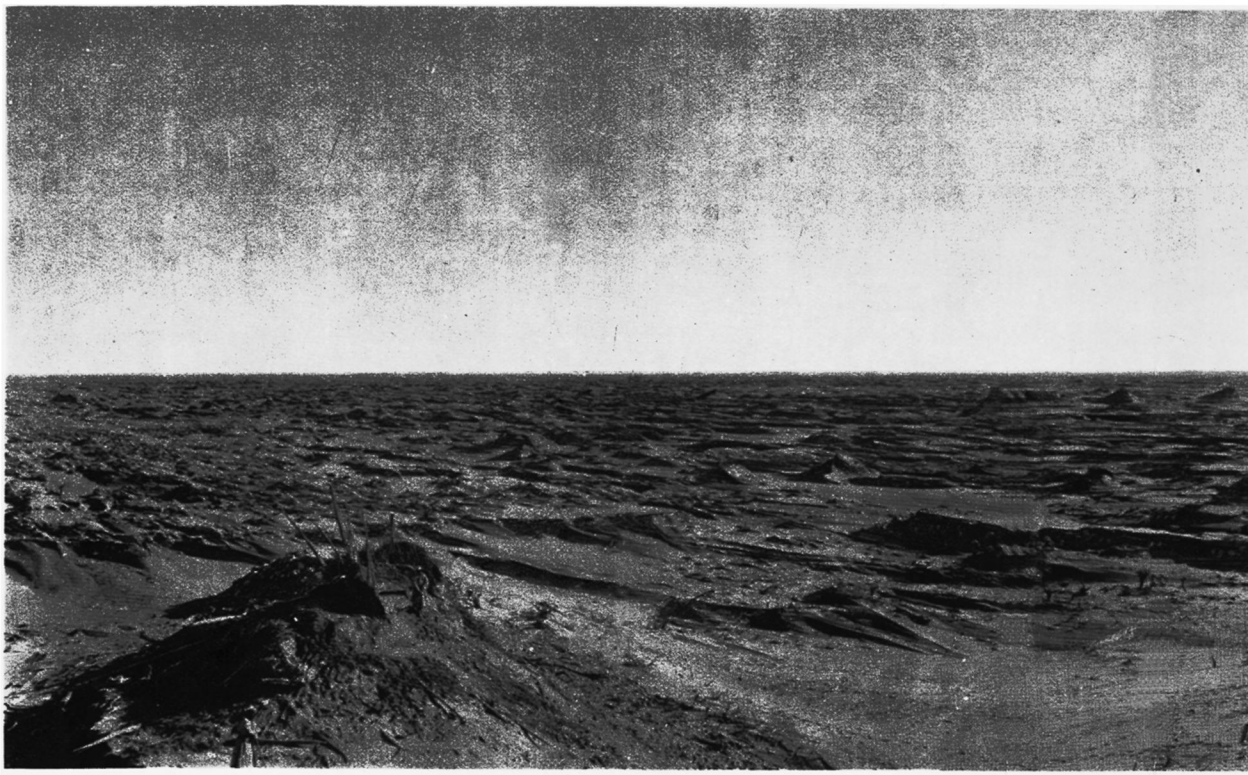
20. DARKOT AND CHATIBOI GLACIERS. SEEN FROM THE FOOT OF THE
On left the Darkot Glacier, over which the ascent to the Darkot Pass (15,600 feet) leads. On right the C

21. ASCENT TO DARKOT PASS FROM NORTH, WITH CREVASSED GLAC



OI GLACIERS. SEEN FROM THE FOOT OF THE RUKANG SPUR, MASTUJ
t to the Darkot Pass (15,600 feet) leads. On right the Chatiboi Glacier, below Koyozum Peak (22,603 feet)

T PASS FROM NORTH, WITH CREVASSED GLACIER IN FOREGROUND



22. VIEW TO SOUTH-EAST AND SOUTH, FROM RUINED STUPA OF LOULAN SITE, A
In foreground remains of ruined dwellings, showing original surface level. At *A* traces of eastern face

23. BODY OF NATIVE OF ANCIENT LOULAN, IN GRAVE OF CEMETERY EXPLORED ON MESA L.F.

24. RUINS OF ANCIEN

OUTH, FROM RUINED STUPA OF LOULAN SITE, ACROSS WIND-ERODED GROUND
owing original surface level. At *A* traces of eastern face of ancient circumvallation carried off by wind

24. RUINS OF ANCIENT CHINESE MAGAZINE ON *LIMES* OF TUNHWANG

always collect with ease and prepare for attacks. Hence arose the need for the executors of Wuti's Central-Asian policy to extend their *Limes* right away to the river's termination.

The difficulties of nature which beyond this had to be faced by the Chinese on their earliest route into the Tarim basin were great indeed. They might well have appeared altogether prohibitive from the point where it reached the bed of the dried-up salt sea which had to be crossed to Loulan, in the ancient delta of the Quruq Darya. But the Chinese at all times have been far more willing to face and overcome the difficulties and dangers of nature, however formidable, than to struggle with barbarian foes—ready to expose their lives and to endanger those of others. Thus alone can we account for the line followed by that ancient highway, for the most part over truly forbidding ground.

In tracing its line we are aided to some extent by the data which brief references in the Han Annals and a couple of Chinese historical texts composed somewhat later furnish as to successive stages of the route. But it is only since the surveys and archæological discoveries made on my third expedition that we can arrive at definite conclusions regarding it. I have had occasion to indicate the main outlines of these conclusions in 'Serindia,' and to discuss the evidence for them fully in 'Innermost Asia,' my forthcoming detailed report. The topographical facts are recorded in the Lop desert sheets (Nos. 29, 30, 32, 35) of the recently published atlas, 1:500,000, of my Central-Asian surveys. To these publications I may refer for all details.

Over a distance of close on 140 miles the general direction of the ancient route is adequately determined by the configuration of the ground. Starting from the extreme western point of the *Limes* the route was bound to lie along the desert depression which separates the southernmost chain of the utterly barren Quruq Tagh from the high sand-ridges of the Qum Tagh. This depression, as already noted before, contains the easternmost bay-like extension of the dried-up Lop sea. It may be called the Besh Toghraq valley from the name of the halting-place at its head. Past this leads the caravan track which was once followed by Marco Polo and after the abandonment of centuries was brought into rare use again in recent years. Further on it skirts the southern shore of the great salt-encrusted sea-bed (Pl. 27).

In order to reach this point the route in ancient as in modern times had to cross an earlier terminal basin of the Sulo Ho filled with a maze of fantastically eroded clay terraces or *Mesas* (Pl. 28). A series of high ridges of drift sand projects into this basin and accounts for the name of *Sanlung-hsia*, the "Three Sand-ridges," which an early Chinese itinerary, in the *Wei lio*, mentions near the first stage on the route to Loulan. At Besh Toghraq, which boasts of two wells less brackish than the rest in this valley, the line of the ancient route separates from the track still followed by occasional caravans towards Lop and continues along the

northern edge of the gradually widening bay. Strips of ground covered with light drift-sand and scanty desert vegetation intervene here between the well-defined shore-line of the prehistoric sea and the dismal expanse of salt crust, mostly hard but in places still boggy, which marks its former extension into this bay. Thus for a distance of about 80 miles from Besh Toghraq we may suppose that those following the ancient Chinese " route of the centre," as the *Wei lio* calls it, could still count upon finding in places water, not altogether undrinkable, and a minimum of reeds and scrub for their animals.

The difficulties of moving large convoys and big bodies of troops over desert ground so far from the nearest supply base at Tunhwang must have been serious enough. But they were as nothing compared with the formidable obstacles to be faced on the onward journey to Loulan. About 16 miles beyond the point where nowadays the last trace of vegetation is found, though no drinkable water, a final offshoot of the hill chain so far followed juts out into a vast expanse of hard salt crust (Pl. 34). This stretches here away, absolutely level and unbroken like the open sea, over some 180° of the compass. Here the salt-encrusted great bay which the route has skirted merges in the eastern extremity of the dried-up Lop sea-bed. To trace from this point onwards the route by which those old Chinese wayfarers had made their way to Loulan, still close on 100 miles off to the west in a straight line, would have been an impossible problem if attempted from this side. The forbidding salt waste ahead would afford no landmark to the traveller, and similarly the old Chinese accounts fail us as regards direction, stages, or distances. But they show clearly enough the terror with which this portion of the journey was regarded.

It was only from the opposite side, that of Loulan, that any attempt could be made with any chance of success, and, let me add, with due regard for safety. In the preliminary account I gave before you when I returned from my third expedition,* I had already occasion to relate how in the winter of 1914, helped by archæological discoveries and some measure of luck, I succeeded in tracking the ancient route through this waterless wilderness. But the story bears, perhaps, repeating in brief outlines, be it only for the light which some of its incidents throw upon the physical conditions now prevailing on this ground and on the life long ago departed of which it was once the scene.

The explorations which I carried out in 1906 among ruins first discovered by Dr. Hedin in the dried-up delta of the Quruq Darya, had furnished full archæological proof that they marked the site of an ancient station occupied under Chinese control down to the third century A.D. The documents found there made it clear beyond all doubt that it had served as the western bridge-head, as it were, in Loulan territory for the route which crossed the Lop desert towards Tunhwang. Excava-

* See *Geographical Journal*, August–September, 1916.

tions and surveys resumed in February 1914 enabled me to make further interesting discoveries, *inter alia* to trace remains of the square circumvallation which once enclosed the main site (Pl. 22). Excessive wind erosion, proceeding since moisture and vegetation departed, has sculptured this ground into a maze of steep clay terraces and trenches (Pl. 31), and has almost completely carried off the once massive ramparts. But of particular importance for the main task which had drawn me back to this desolate ground, now close on 100 miles away from the nearest drinkable water, were the results of reconnaissances made into the desert north-eastwards. They revealed there a succession of remains which clearly indicated that the ancient route towards China had followed that direction, at least in its initial portion.

The nearest among these was a cemetery situated some 4 miles off on the top of an isolated clay terrace or *Mesa*. Rapid clearing revealed that it contained grave-pits into which miscellaneous relics of earlier burials had been collected by pious hands at some period before Loulan was finally abandoned. The mass of beautiful figured silks, both polychrome and damasks, here recovered have proved quite a revelation as regards the artistic style and technical perfection of those products of Chinese silk-weaving which travelled westwards through Loulan while trade still followed this route.* Collateral evidence proves that the original burials belonged to the early period of Chinese expansion into the Tarim basin, and that they had undergone already prolonged exposure to erosion before the danger of complete destruction caused them to be collected in these pits.

These relics of Chinese textile art from the time of Christ and before, claim special interest because they have been preserved for us on the very route of the earliest silk trade. But equally important is it for the student of those early relations between the Far East and the West to note that among the decorated fabrics there are found fragments of exquisitely worked tapestries in wool which display a style unmistakably Hellenistic. Whether they are of local make or imports from Central-Asian territories further west, we have in them striking illustration of a cultural influence which that ancient desert route also served for centuries, but in the reverse direction.

Continuing to the north-east for another 12 miles, we soon left behind the last dry river-bed once fed by the Quruq Darya (Pl. 26) and still marked by trunks of wild poplars and tamarisks dead for centuries. Then we came upon the ruins of a small walled *castrum*, undoubtedly once serving as an advanced *point d'appui* on the road from Tunhwang. Its walls, built with alternate layers of carefully secured reed fascines and stamped clay, showed such close agreement in all constructive details with

* For a preliminary account of these textile finds, see F. H. Andrews, "Ancient Chinese Figured Silks excavated by Sir Aurel Stein" (*The Burlington Magazine*, 1920).

the wall of the westernmost Chinese *Limes* that there could be no doubt about its dating, just as this does, from the first military advance of the Chinese into the Tarim basin. The destructive forces of two thousand years had not succeeded in seriously breaching these massive walls. Under their shelter dated Chinese records survived, belonging like most of those found at the Loulan station to the period preceding the final abandonment of the route, soon after the end of the third century A.D. But the interior of the fort had suffered terrible havoc through wind-erosion scooping out deep hollows.

All the more gratifying was the remarkable state of preservation which the elevated position on the top of a high *Mesa*, together with the exceptional aridity of the climate since ancient times, had assured to remains of an outlying look-out post traced some 3 miles further to the north-east. Here we found graves holding bodies of the indigenous Loulan people who once tenanted the small stronghold (Pl. 23). Several of the bodies were so wonderfully well conserved, together with their burial deposits, that I felt myself brought here face to face with the race of semi-nomadic herdsmen and hunters whom the Han Annals describe as the native population of Loulan. Their features showed close affinity to that *Homo alpinus* type which, as the anthropometrical materials collected by me have proved, still continues the chief element in the racial constitution of the present population of the Tarim basin. The distant view gained from this elevated point made it certain that we were here near the eastern extremity of the ground once reached by life-giving water from the river. Beyond to the east there lay the boundless expanse of shimmering salt, marking the dried-up sea-bed.

The topographical indications I deduced from the position of the remains successively discovered seemed to point to the ancient route having lain to the north-east. Yet this bearing would lead us at right angles away from the line on which, as our preceding mapping showed, we should have to look for the direct route to the debouchure of the Besh Toghraq valley. It was an observation distinctly discouraging with regard to the search we should have to make for the ancient route. The ground ahead was sure to prove devoid of all resources for human life, including water. Careful preparation was essential for ensuring safety on such a journey through an absolute wilderness. By its estimated length of at least ten days it was bound to put to a severe test the endurance of our brave camels, already hard tried by work of the preceding weeks. So it became necessary at this stage to gain first the distant salt springs of Altmish Bulaq at the foot of the Quruq Tagh to the north, in order that the camels might gather fresh strength by a few days' grazing at reed-beds as well as by the chance of a drink.

After two trying marches from Altmish Bulaq, across a perfect maze of steep clay terraces and hillocks encrusted with hard salt, we regained the vicinity of that outlying little fort. There I was fortunate enough to

discover more remains confirming my conjectural conclusion that the initial bearing of the route lay to the north-east. At the very edge of the area showing some dead vegetation I came upon the remains, almost completely eroded, of an ancient watch-tower of the type familiar from the *Limes*. Beyond this there were no ruins to guide us; for we were now passing into ground which all through historical times must have been as devoid of plant or animal life as it now is.

But as we steered north-eastwards by the compass across absolutely barren wastes of clayey detritus or salt crust, chance came again and again to our help by strange finds. They seemed as if meant to assure us that we were still near the ancient track by which Chinese missions, troops, and traders had toiled for four centuries through this lifeless wilderness; that I was right in my reliance on the Chinese with their topographical sense having for good reasons selected this bearing, puzzling as it seemed at the time.

It must suffice here to mention what perhaps was the most striking and welcome of these finds. The last traces of dead vegetation marking the termination of the ancient delta had long remained behind when we suddenly found the old route line plainly marked by some two hundred Chinese copper coins strewing the dismal ground of salt-encrusted clay for a distance of about 30 yards. They lay in a well-defined line running from north-east to south-west. The coins, square-holed, were all of the Han type and seemed as if fresh from some mint. Clearly they had got loose from the string which tied them, and gradually dropped out through an opening of the bag or case in which they were being carried by some convoy. Some 50 yards away in the same direction there were scattered bronze arrow-heads, all manifestly unused. Their shape and weight exactly agreed with the ammunition of Han times so familiar to me from finds along the *Limes* of Tunhwang. There could be little doubt that coins and arrow-heads had dropped from some convoy of stores proceeding to Loulan in Han times. Their having remained on the ground is easily accounted for if the convoy moved at night-time and a little off the main track but still in the right direction.

That day's long march was taking us past a far-stretching array of big *Mesas* which with their fantastically eroded shapes curiously suggested ruined towers, mansions, or temples. It was easy to recognize in them those wind-eroded mounds which an early Chinese text mentions near the north-western edge of *P'u-ch'ang*, or the ancient Lop sea-bed, and in which Chinese eyes saw the ruins of a mythical "town of the dragon." Finally, after continuing our north-easterly course for another day across bare clay and mica detritus, we arrived at a forbidding belt of salt-coated erosion terraces (Pl. 35). They clearly corresponded to those which Chinese notices of the ancient route to Loulan repeatedly mention as the dreaded "White Dragon Mounds," and graphically describe. Progress between them was very trying for our poor camels' feet, and also for us

men. But still worse it was to face the crossing of the bed of the dead Lop sea with its terrible salt surface which I knew to lie beyond.

A fortunate find of Chinese coins and metal objects marking a halting-place on the ancient route induced me now to head straight eastwards for that bed, and the crossing effected next day proved that I had been rightly guided. The march of 20 miles across this petrified sea-bed, with its hard salt crust crumpled up into big cakes aslant and small pressure ridges between them (Pl. 36), was most fatiguing for men and beasts alike. But subsequent surveys showed that without several days' détour northward the crossing of this forbidding salt surface could not have been shortened, but on the contrary only lengthened.

It was, no doubt, this consideration which had determined the early Chinese pioneers in the choice of this line for their route. Archæological evidence of ancient traffic on it cropped up again soon in the shape of coins and beads, when through the opposite belt of "White Dragon Mounds" we had gained the eastern shores of the ancient salt marsh. Three marches along these over ground easy but still devoid of any trace of vegetation, dead or living, finally brought us to the debouchure of the Besh Toghraq valley. There I found the ancient Chinese road still plainly marked in one place by the straight wide track which the passage for centuries of transport animals, and probably also carts, had worn into the salt-encrusted ground.

How traffic of such magnitude as the Chinese Annals indicate was organized and maintained on a route passing across some 120 miles of utterly barren ground, already in ancient times without water, fuel, or grazing, is a problem we need not discuss here. But it is well to keep in view that great power of organization which was needed to solve it in practice, if we are adequately to realize the remarkable qualities which enabled the Chinese for centuries to control and keep open that far-stretched corridor of the Tarim basin. It was an achievement fraught with momentous results for the interchange of civilizations, and there is deep significance in the fact that it was due far more to prestige, economic resources, and political ability on the side of China than to any military prowess among its people or its rulers. It may well, in fact, be looked upon as a triumph of the mind over matter, whether manifested in space or in brute force.

The intercourse thus established through Central Asia suffered its first interruption about the beginning of our era through the rapid decay of internal order which took place in China during the short-lived reigns of the last two emperors of the Former Han dynasty (6 B.C.–A.D. 5). With the consequent weakening of Chinese control in the Tarim basin "the principalities of the Western countries," we are told in Later Han Annals, "broke up and formed fifty-five territories." When, on the accession of the usurper Wang Mang (A.D. 9), trouble arose with the Shanyü or supreme chief of the Huns, the territories before controlled

by the Protector-General in the Tarim basin and near it " broke off all relations with the Middle Kingdom and all again submitted to the Huns." The exactions of the Huns made those petty chiefships turn, indeed, again to China for protection towards the middle of the first century. But the empire reconstituted under the founder of the Later Han dynasty was not as yet sufficiently consolidated to resume a policy of Central-Asian expansion. The north-western marches of Kansu subsequently became exposed to prolonged raids from the Huns, until at last the need of effective protection for its borders forced the Chinese empire again to start upon a " forward policy " in Central Asia.

It is interesting to note that the first move made in A.D. 73 under the Emperor Ming was aimed directly at the Huns by the taking of Hami. This strategically very important oasis was the key to that " route of the north " which passed along the foot of the eastern Tien Shan and through the Turfan depression. It was destined by nature to serve as the easiest road into the Tarim basin—provided it could be protected against nomadic attacks from across the Tien Shan. Some temporary weakening in the power of the Huns still holding the grazing-grounds to the north appears to have influenced this diversion of the Chinese effort to a new line. But its success was short-lived ; for though the chiefs of the small territories in the Tarim basin had promptly offered allegiance after that first forward move, and again invited a Chinese " Protector-General," the difficulty of maintaining a hold on that exposed northern line forced the Emperor Chang, Ming's successor, by A.D. 77 to evacuate both Hami and Turfan.

It was not until thirteen years later that Hami was re-occupied by the Chinese. But meanwhile the Tarim basin had become the scene of events which in the end placed the empire once again in undisputed possession of that great passage land. Incidentally they also proved the value of the desert route first opened from the side of Tunhwang nearly two centuries earlier. This is not the place to relate the story of the remarkable exploits by which the famous Pan Ch'ao, the greatest of the soldier statesmen who ever served China's Central-Asian policy, re-established effective imperial authority throughout the Tarim basin. It must suffice for us to note that Pan Ch'ao started his series of brilliant successes when deputed in a subordinate capacity to the chief of Shan-shan, as the Lop territory, the ancient Loulan, had been renamed in the first century B.C. By a bold night attack made with a handful of men, he surprised and exterminated a mission sent there by the Huns. Then, having thus safeguarded the line of communication with China, he proceeded to win his way by the " southern route " all along the foot of the Kunlun. Gradually he gained mastery over the chiefs of Khotan, Yarkand, and Kashgar, not by the force of arms but by bold bluff and skilful diplomacy. Pan Ch'ao's maxim, as stated by him in a very interesting memorial to the Emperor which the Annals have preserved, " was to use the barbarians for attacking the barbarians." Thus securing

needful support in the country itself, he succeeded after many set-backs and hard struggles in steadily extending Chinese supremacy over the "Western Countries," until by A.D. 94 the last of the powerful kingdoms along the Tien Shan had been forced into submission.

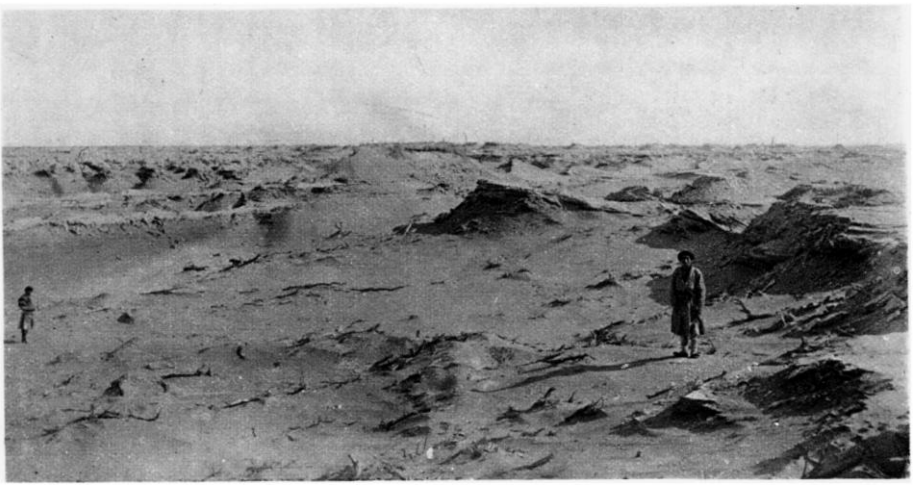
Chinese political influence had, in consequence of Pan Ch'ao's triumphs, been extended westwards even beyond the Tsungling or the Pamirs. Diplomatic relations were established with the Parthians and direct contact sought with distant Ta Ts'in or Syria by means of a mission which A.D. 97 appears to have reached the sea in the Persian Gulf. By A.D. 102, when Pan Ch'ao, grown old and laden with imperial honours, returned to the distant capital soon to end his days there, Chinese prestige and power in Central Asia may be said to have reached its apogee.

It is just about this time that we may assume *Scythia extra Imaon*, or the Tarim basin, to have been traversed by the trade agents of that Macedonian merchant, Maës Titianus, whose reports enabled Marinus of Tyre and through him Ptolemy, the Alexandrian geographer, to furnish us with information on the route followed by the caravans bringing to the West the silk of far-off Serike, the land of the Seres, *i.e.* China. But the same period probably witnessed also the first important developments in the use of that maritime route through the Red Sea and the Indian Ocean which made exchange of merchandise, whether direct or through Indian channels, possible between China and the trade centres of Egypt and Syria.

The opening of this new channel of commercial intercourse between China and the West may not have immediately affected the importance of the Central-Asian trade route. But changes more local took place likely to hamper its use. By A.D. 107 revolts among the "Western Countries" and subsequent inroads of the Huns led to the complete withdrawal of Chinese control from the Tarim basin. From A.D. 123 onwards endeavours were made to recover the ground lost. It is of interest to note that the first efforts, carried out under the leadership of Pan Yung, Pan Ch'ao's son, were based upon the ancient route *viâ* Loulan and first directed towards Turfan. Hami was not re-occupied until A.D. 131, when the Huns had been defeated north of the Tien Shan. But in spite of the partial successes recorded, the Later Han Annals clearly tell us that imperial prestige gradually decayed in the Western Regions during the century of increasing internal weakness which preceded the final downfall of the dynasty, A.D. 220.

The epoch of the "Three Kingdoms" which followed this event saw China divided between rival dynasties. Effective Chinese control over the whole of the Tarim basin was not likely to be maintained in these troubled times. Hence references to the Western Regions are scanty enough in the historical texts dealing with this period (A.D. 220–265) and that of the Chin dynasty (A.D. 265–419) which succeeded. Yet there is evidence that those territories still continued to be open to trade

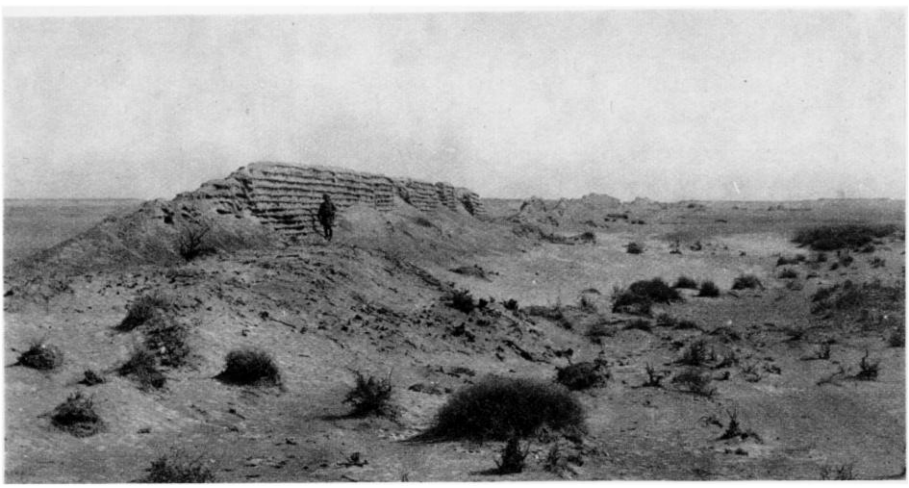
25. CAMP TO N.W. OF MINGSHUI WELLS, PEI SHAN



26. DRY BED IN DEAD DELTA OF QURUQ DARYA, N.E. OF LOULAN SITE

27. SALT SPRING OF LOVAZA, WITH ICE SHEET BELOW OLD SHORE-LINE, AND VIEW ACROSS SALT-ENCRUSTED LOP SEA BED

28. WIND-ERODED TERRACES (MESAS), 100-120 FEET HIGH, IN ANCIENT TERMINAL BASIN SULO HO



29 ANCIENT CHINESE BORDER WALL BUILT WITH LAYERS OF REED FASCINES, EAST OF WATCH-STATION T.XIII., ON *LIMES* OF TUNHWANG

30. RUIN OF ANCIENT WATCH-TOWER, T.IV.C. ON WESTERN FLANK OF TUNHWANG *LIMES*, WITH VIEW ACROSS ERODED BASIN TO NORTH

and cultural influences both from the East and the West, even though political power from the side of China could assert itself only intermittently and in the parts nearest to the Kansu marches.

The evidence I allude to is fortunately supplied not merely by such brief notices as M. Chavannes' learning has rendered accessible from the *Wei lio* and the Chin Annals, but by the abundant remains of two very interesting ruined sites I have been able to explore. I mean the ancient settlement brought to light in the desert sands beyond the termination of the Niya river, and the ruins at and around the ancient Chinese station of Loulan, which I have already had occasion to mention as the western bridge-head of the earliest Chinese route into the Tarim basin.

In ' Desert Cathay ' and ' Serindia,' as well as in the publications on my first expedition which led to the discovery of the Niya site, I have found occasion to deal at length with the manifold interesting aspects of the conditions of life and administration revealed by the remains both there and in the Lop area. Here only the most characteristic among them may be noted before we turn to those questions of direct geographical import which are raised by the abandonment of both sites to the desert and the state of utter desolation now prevailing there. Both at the Niya site and in Loulan we have the evidence of dated documents proving that occupation had continued until about the close of the third century of our era.

This approximately contemporary occupation accounts for the close similarity observed in most features of the ruins and of the finds their exploration has yielded, though the two sites are separated by a direct distance of close on 500 miles. At the Niya Site, the *Chingchüeh* of the Han itineraries, it is easier for us to reconstruct the conditions of life once led there; for its ruined dwellings, scattered along the ancient termination of the Niya river over an area measuring about 15 miles from north to south, with a maximum width of about 4, are far more numerous. They have also suffered less by destructive wind-erosion, while abundant drift-sand has helped to protect whatever the last occupants had left behind.

The careful construction of the houses once tenanted by local officials or landlords (Pl. 33); remains of well-made household furniture and implements; objects of decorative art in the shape of fine wood-carvings, etc., all attest a highly developed state of civilization. The products of local industrial arts and crafts clearly show the prevalence of a strong Hellenistic influence as transmitted from Eastern Iran and the north-western borders of India. Yet the use of articles of Chinese workmanship, such as silk fabrics and fine lacquered ware, is also well attested. Finds of objects of Buddhist worship in the shape of shrines and relic towers or Stupas make it quite certain that Buddhism, India's greatest contribution to the spiritual development of civilized mankind, had by

that time already acquired that predominant position in the religious and intellectual life of the indigenous population of the Tarim basin which it was destined to preserve for nearly a thousand years.

This strong influence of Indian culture is very strikingly reflected also in the mass of written records recovered in the ruined dwellings and the refuse heaps adjoining. At the Niya site I found by the hundred wooden documents comprising correspondence, mainly official, contracts, accounts, miscellaneous memoranda, and the like, all written in that Sanskritic language and Kharoshthi script which during the first centuries before and after Christ were used on the Indian north-west frontier and in the adjacent portions of Afghanistan. But the ingenious methods of wooden stationery used for all these writings is undoubtedly of Chinese origin. Chinese records, also on wood, found at the Niya Site prove that some measure of Chinese control still extended so far west. But the local administration was carried on under the authority of native chiefs whom the Kharoshthi documents name under the title of "Maharaja." At the Loulan station the vast majority of the written remains found are in Chinese, and comparatively few in Kharoshthi and Early Sogdian, the language of the Oxus region; for there, so much further to the east, on the ancient main line of communication between China and the Tarim basin, Chinese authority, while it lasted, was bound to assert itself far more directly.

We are able with almost as much clearness to reconstruct the physical aspects of the life once witnessed by these sites. At the ancient settlement beyond the present end of the Niya river I could clearly make out the position and arrangement of the orchards and arbours, as marked by the trunks of their fruit trees and poplars, dead for over sixteen hundred years, but often still upright. Fences and hedges could be traced marking the enclosures of residences or fields (Pl. 32), and in places also the lines of the canals which had once carried life-giving water to the cultivated area. The terminal course of the Niya river, as it then ran, was definitely indicated by the footbridge at one place lying across a dry bed which elsewhere is completely overrun by tamarisk-cones or smothered under sand-dunes.

At the Loulan site the surface of the ground had been abraded far more through wind-erosion (Pl. 22), and hence could not retain the traces of ancient cultivation so clearly. But there, too, everything in the way of dead vegetation, materials used in buildings, etc., distinctly point to conditions of cultivation and climate having been essentially the same as those now observed in oases of the Tarim basin similarly situated and still occupied. For detailed observations supporting this conclusion I must refer to my previously mentioned publications.

Just as in the present terminal oases of the Tarim basin, so cultivation at those sites must have been entirely dependent on irrigation, moisture in the local atmosphere being a factor wholly negligible for agriculture.

Had not such conditions of extreme aridity already prevailed in ancient times, it would be impossible to account for the survival in almost perfect preservation of a multitude of objects, very perishable by nature, in places so exposed as refuse heaps outside houses. Yet there is abundant antiquarian evidence to prove that the accumulation of such refuse, including the " waste papers " of more than one local reign, must have proceeded over a considerable number of years.

Exactly corresponding observations are furnished by what archæological explorations at other ancient sites of the Tarim basin have taught us. Whether their remains are found in the desert sands beyond the present limits of Khotan and other southern oases, as *e.g.* at the sites of Dandan Öilik, Khadaliq, and Endere, or in now deserted localities of Kucha territory to the south of the Tien Shan, or eastwards in the depression of Turfan, the archæological evidence uniformly points to the same conclusion. The climatic conditions of the periods immediately preceding abandonment—periods varying here at different sites from about the fifth to the thirteenth or fourteenth centuries—must have been practically as arid as they were since and are now.

This uniform and important fact invests the question as to the cause or causes which led to the abandonment of all these old sites, with special interest both for the geographer and historical student. That question has received much attention in recent years owing to its connection with much-discussed theories of " desiccation " within historical times. If I were to attempt to examine all the facts bearing on this question which archæological and geographical exploration of ancient sites in Chinese Turkestan has yielded, a separate paper would be needed. Instead of this I shall content myself here with emphasizing two observations which ought to be kept prominently in view by those generally interested in the problem.

One concerns the necessity of realizing how varied the initial causes of abandonment may be in the case of individual sites before assuming *à priori*, be it only as a " working theory," that the cause must in each case be connected with some phase of general or regional " desiccation." Where settled occupation on any scale is possible only with the help of so elaborate an organization as artificial irrigation presupposes, its chances of development or shrinkage are affected by the uncertainties of human activity vastly more than on ground where nature itself provides for the fields that indispensable element of agricultural production, adequate moisture. The factors influencing human activity may be manifold and are often very complex, and cultivation wholly dependent on irrigation is particularly liable either to benefit or to suffer by them. To ascertain the factors which had a determining influence upon such cultivation at a given period must be very difficult, where no definite record is preserved ; for human factors quite different in character may produce results which may appear indistinguishable to those who after the lapse of

centuries attempt to trace their causes in the light of purely archæological evidence.

Thus in the Tarim basin quite a variety of causes entirely, or at least partly, of human origin might lead to reduction in the size of oases or even to the complete abandonment of outlying ones. Prolonged periods of war or internal disorder; devastating epidemics; changes in the beds of rivers rendering existing canal heads useless and producing results with which the local population is unable to cope owing to deficient resources of labour; diversion of traffic and trade causing labour to recede from certain oases which are separated from others by long distances of desert and hence difficult to protect or to render profitable:—all these causes and their effect upon the oases of this region can actually be illustrated from experience gained in recent periods. Other causes, too, of a similar character might be suggested on ground where the conditions of cultivation are so complicated and the technical means available for the maintenance of canals comparatively so primitive.

The results of such diverse causes as I have indicated, must in each case be the same, viz., abandonment of once cultivated ground. The same result would obviously be produced if the supply of water needed for irrigation were from some purely natural cause to undergo serious diminution or altogether to fail. On ground thus abandoned to the desert and subsequently left unreclaimed the ancient remains preserved through the aridity of the climate will enable us to fix the time of abandonment with more or less accuracy. But it is clear that the critical student will not be prepared to assign this abandonment to a particular cause, whether originating from nature or some human factor, unless definite evidence in the shape of reliable records or unmistakable archæological indications are forthcoming.

Unfortunately, at none of the old sites explored in this region do we as yet possess such evidence as methods of sound historical research would allow us to accept as conclusive. To make up for the regrettable want of such evidence by means of a "working theory" would be of no real help; for where matters of a historical past, more or less distant, are under consideration it is impossible to apply those experimental tests without which a "working theory," however tempting, must remain intrinsically useless.

There is, however, a second observation to be borne in mind in connection with the question of "desiccation" so far as it concerns innermost Asia, and for this can be claimed a more positive character, in view of what the ancient settlements discovered at the Niya Site and in the Lop desert teach us. The former at its northern end is separated by fully 70 miles from the nearest point in the present oasis of Niya where cultivation is now possible. Yet its irrigation comes from the same river which about seventeen hundred years ago still carried its water to the fields of ancient Chingchüeh, the now sand-buried Niya Site. In the case of

the remains of Loulan the change in this respect is even more striking; for the small oasis of Tikenlik, the nearest cultivated area on the Tarim which now receives the water once flowing in the Quruq Darya to Loulan, lies over 120 miles to the west of the extreme point once irrigated from the "Dry River."

The circumstances connected with this wide separation of the two ruined sites from the present end of the rivers to which they once owed their irrigation, are not exactly parallel. At the Niya Site we have a striking and perfectly clear instance of shrinkage in the volume and length of course of the river which until the third century A.D. rendered the existence of a terminal oasis possible so much further away than it does at present. There has been no change in the direction of the river course. This, as our mapping shows, still runs straight towards the site, though what little water it carries below the present Niya oasis dies away in the sand before reaching the ruined area. We observe conditions closely corresponding also at other ancient sites abandoned to the desert at the southern edge of the Taklamakan from Dandan Öilik to Endere.

In the Loulan tract the situation may at first sight seem somewhat different. Here we find that the Konche Darya which carries the drainage of the big Qara Shahr valley and once had its continuation in the Quruq Darya, instead of flowing eastwards to the Loulan sites, now turns to the south-east and joins the network of beds representing the lower course of the Tarim. Yet whatever the relation may have been between this diversion of the Konche Darya and the abandonment of ancient Loulan, there is every reason to believe that here, too, a very great shrinkage has taken place in the available volume of water since the times when the Quruq Darya fed the extensive delta traced to the east and south of the Loulan ruins. There are indications pointing to similar shrinkage also in the case of other rivers which descend from the Tien Shan into the Tarim basin.

If we review the observations just summarized in brief outlines, we are forced to two conclusions by definite archæological evidence. One is that climatic conditions quite as arid as the present ones prevailed within the big trough of the Tarim basin as far back as ancient remains and available records can take us. The other conclusion is that the amount of water carried by its rivers has greatly diminished during the same historical period. It is possible that geological and meteorological research may have more than one conjectural explanation to offer which would account for the apparent contrast between these two conclusions. But the explanation which at present appeals to me most is the one which Colonel Sir Sidney Burrard, late Surveyor-General of India, first verbally suggested to me in 1908 on my return from my second journey; and the same has been recently proposed by a competent observer, Dr. Ficker, with regard to similar conditions in the Oxus basin.

This theory seeks the reason for the diminished volume of the rivers in the shrinkage of the glaciers on the high ranges which are their main feeders. It accounts for the shrinkage itself by assuming that those glaciers comprise great reserves of ice which have been left behind by the last glacial period and have since been undergoing slow but continuous reduction through milder climatic conditions. This continued process would suffice to explain shrinkage in the irrigation resources during historical times without the climate of the basin as a whole having in the course of this period, very short in a geological sense as it seems, undergone any appreciable change.

Two facts might, as Sir Sidney Burrard thought, be adduced in support of this view: in the first place, the large size of the glaciers still in being on the northernmost Kunlun which seems to be disproportionate in comparison with the annual snowfall actually received by that range; and next the enormous masses of detritus which overlie all these Kunlun glaciers. The thickness of this detritus cover was very striking indeed, wherever I had occasion to survey the glaciers of the Khotan river's headwaters. It is bound to offer very effective protection for "dead" or "fossil" ice derived from a preceding glacial period. It finds its own explanation in the rapid decomposition which the rocks all over the Kunlun undergo through the great variation of extremes in diurnal temperatures.

But by whatever explanation we may endeavour to reconcile these two apparently discordant observations on the physical side, we cannot expect it, in the present state of our knowledge, to furnish a safe answer to the question as to the direct cause of their abandonment. The critical student has to keep well in mind the great complexity of the human factor and of all its actions. He cannot accept the cogency of the argument that because both ancient settlements were apparently abandoned to the desert approximately about the same period, therefore the cause of this change must necessarily have been identical. Certainly both these once cultivable areas have since the beginning of the fourth century A.D. become incapable of settled occupation owing to the impossibility of securing water for irrigation there. But it would obviously be a mistake to assume the *post hoc* as implying a *propter hoc* and then on the basis of such an assumption to try and interpret developments in the history of the Tarim basin or of Central Asia in general, mainly by conjecturally determined changes of climate.

Instead of such speculations it will be better to resume, however rapidly, our survey of the part which the Tarim basin by its geographical function as a great corridor played in later phases of Central-Asian history. For more than three centuries our knowledge of this history is very meagre indeed; for with the disappearance of Chinese political control our chief sources of trustworthy historical information about the "Western Regions," as furnished by the imperial Annals, dry up for

the most part. While China itself was divided between rival dynasties, several of them of foreign origin, the Huns in the course of the fourth century had started westwards on the great move which ultimately led them to water their horses on the Danube, Rhine, and Po. After an interval during which the rulers of different great oases appear to have disputed supremacy of the Tarim basin, the whole of this, together with vast territories to the north and west, passed for about a century under the domination of a branch of the Huns, known to the Chinese by the name of Juan-juan and in Western Asia as the Hephthalites, or White Huns.

Neither this domination from outside nor the period of contested sovereignty within, which preceded it, appears to have seriously affected the firm footing which Chinese civilization had acquired in the oases or to have interfered with the steady flow in the opposite direction of Buddhist doctrine and literary as well as art influence from easternmost Iran and India. The growing closeness of religious and intellectual relations thus established is reflected by the journeys of Chinese Buddhist pilgrims, who at this period made their way through the Tarim basin to the sacred places of Buddhism in distant India. Of their narratives those of Fa-hsien (A.D. 400) and Sung Yun (A.D. 519) are the only ones of any length preserved to us. They clearly show how cultural influences from both sides mingled in the territories which the pilgrims visited before descending across the Pamirs and Hindukush to the north-western borders of India.

Sung Yun had found the " Western Regions " he visited, together with the states of the Oxus basin, still subject to the Hephthalites or White Huns and one of their rulers holding sway on the Indus. But some thirty years later a fresh wave in the stream of nomadic migration which was moving westwards along the Tien Shan, slowly at one time, more rapidly at another, had put the great confederation of Turkish tribes, known to the Chinese as the Western T'ouchüeh, *i.e.* Turks, in ascendency over the vast Central-Asian region, previously dominated by the Hephthalites. Like their predecessors they were content to levy tribute from the settled territories to the south of their grazing-grounds. Hence trade and other intercourse between the Tarim basin and the rich territories to the west could continue unbroken. But the Western Turks and their allies, the Northern Turks, were in the east troublesome neighbours to the Chinese empire, which by A.D. 589 had after nearly three centuries of division become once more united.

Hence the gradual consolidation of Chinese power which continued after the accession of the great T'ang dynasty by A.D. 618, was at first accompanied by a policy of rigid seclusion on the north-western marches. We receive very interesting glimpses of the jealous care with which the routes leading towards the Tarim basin were then guarded, in the story of the greatest of Chinese Buddhist pilgrims, Hsüantsang, my Chinese

patron saint, as I used to call him. In a paper contributed some years ago to the *Geographical Journal* * I have traced the details of the adventurous desert crossing on which the young traveller, anxious in spite of imperial prohibition to set out for the holy places of Buddhism, escaped A.D. 630 the vigilance of the posts watching the frontier in the Tunhwang region. The account of the extreme hardships and risks he encountered on his way across the Pei Shan to Hami, strikingly illustrates the " Chinese wall " policy which at that time tried to strangle China's intercourse with the West.

It was soon to give way to a " forward policy " on a grand scale which for over a century made Chinese imperial power under the T'ang dynasty expand over wider regions of Central Asia than it had ever before. When Hsüantsang after seventeen years' wandering returned to China *viâ* Khotan, A.D. 645, the northern line of access to the Tarim basin had already passed into Chinese hands. The ancient route through Loulan had by then been completely abandoned for centuries. The route along the easternmost Tien Shan was the only one practicable for serious military operations. The T'ang Annals fully acquaint us with the movements, significantly enough first directed towards the grazing-grounds on the northern slopes of the range, by which Hami and subsequently Turfan were wrested from Turkish supremacy. The power of the Western Turks was already weakened by tribal dissensions which Chinese diplomacy skilfully fostered. By A.D. 660 it was finally shattered by the Emperor Kaotsung's forces. China thus succeeded to their claim over a vast dominion extending from the Altai Mountains to beyond the Hindu Kush.

For a time the prestige of the imperial power and the diplomatic activity of its representatives sufficed to assert political control not only in the Tarim basin but also, in a more limited sense, over the territories now comprised in Russian Turkistan to the north of the Oxus. The routes of the Tarim basin must have seen then as much trade and traffic of all kinds as in the spacious times of the Han. The interchange of the influences, artistic and other, exercised at this period both from China on the one side and Persia, India, and the Near East on the other, are strikingly illustrated by the many finds which excavations at ruins of Turfan have yielded. Thus in the case of those conducted by myself at the seventh-century cemetery of Astana they included fine figured silks both of Chinese and pure Sassanian style, the latter undoubtedly manufatured in Eastern Iran or even nearer to the Mediterranean.

But this period of renewed Chinese expansion into Central Asia was not destined to be one of continued peaceful intercourse. The fact of China now claiming succession to the wide dominions once held by the Western Turks was bound to prove in time a source of trouble and weakness. The Chinese forces stationed in what were called " the

* See " The Desert Crossing of Hsüan-tsang," *Geo. Journ.*, November 1919.

31. WIND-ERODED GROUND OUTSIDE WESTERN FACE OF RUINED CIRCUMVALLATION, L.K., LOP DESERT

32. TAMARISK-CONES ABOVE WIND-ERODED GROUND AT SOUTHERN END OF ANCIENT SITE BEYOND NIYA RIVER END

33. CENTRAL HALL AND OFFICE ROOM IN RUINED RESIDENCE, N.XXIV., ANCIENT SITE BEYOND NIYA RIVER END, AFTER EXCAVATION

34. CARAVAN CROSSING SALT-ENCRUSTED BED OF ANCIENT LOP SEA

35. SALT-ENCRUSTED HILLOCKS OF "WHITE DRAGON MOUNDS"
NEAR WESTERN SHORE OF DRIED-UP LOP SEA BED

36. CAMELS AMONGST BLOCKS OF HARD SALT, COVERING DRIED-UP BOTTOM
OF ANCIENT LOP SEA

Four Garrisons " had to guard not merely the oases of the Tarim basin but also territories to the north of the Tien Shan. These offered attractive grazing-grounds to nomads, and were hence constantly subject to being disturbed by restless Turkish tribes. More serious still was the danger presented by aggression on the part of the Tibetans, who were then rapidly growing into a new military power. After the close of the seventh century they invaded the Tarim basin and were ever threatening the corridor between Tunhwang and Suchow.

Towards the middle of the eighth century there was added to the pressure from the Tibetans in the south fresh danger in the west from the steady advance of Arab conquest in the Oxus basin. The Tibetans were endeavouring to join hands with the Arabs as common foes of China's Central-Asian supremacy. By pushing down the Indus valley and thence across the Hindu Kush territories corresponding to the present Gilgit and Yasin they actually reached the uppermost Oxus valley. This junction threatened the Chinese position in the Tarim basin with being outflanked simultaneously both in the east and west. An effort had to be made to ward off this serious strategic risk. It led to an enterprise which stands out as perhaps the most memorable among the many proofs of Chinese capacity for overcoming by organization formidable geographical obstacles.*

In A.D. 747 the Deputy Protector-General of the " Four Garrisons," Kao Hsienchih, a general of Korean origin, collected a Chinese force of ten thousand men at Kashgar and led it through the gorges and passes of the Muz Tagh Ata range and across the inhospitable high valleys of the Pamirs to the uppermost Oxus. How such a force could be maintained in that elevated mountain region of the " Roof of the World " devoid of all resources, is a problem which might baffle any modern General Staff. But the detailed account preserved in the T'ang Annals which M. Chavannes' research has made accessible, proves that this most difficult task was faced and successfully overcome. After effecting a successful concentration at Sarhad, the highest habitable point in Wakhan, Kao Hsienchih completely defeated the Tibetan force which was guarding the Baroghil, the only pass across the Hindu Kush practicable for military purposes in this region.

But an achievement still more remarkable was his subsequent crossing of the very difficult glacier pass of the Darkot (Pls. 20, 21), at an elevation of 15,600 feet, with a Chinese force of three thousand men. I had twice occasion to cross the Darkot, and feel sure that those few British officers, first among them General Sir Edmund Barrow and the late General Lockhart, whom the duty of looking after the Hindu Kush defences of India has brought to this scene of Kao Hsienchih's exploit, would have thoroughly appreciated its greatness. If judged by the

* Cf. Stein, " A Chinese Expedition across the Pamirs and Hindukush," *Geo. Journ.*, February 1922.

physical difficulties encountered and vanquished, this crossing of the Darkot and the Pamirs may well be held to surpass the great Alpine feats of commanders famous in European history, from Hannibal to Napoleon and Suvorov.

The prestige accruing to the Chinese arms from Kao Hsienchih's expedition was deservedly great. But it did not save them from being signally worsted two years later. In a battle near Tashkent Kao Hsienchih was completely defeated by the Arabs and the revolted Turkish tribes, their allies. About A.D. 750 the Tibetans from the south secured mastery over Tunhwang and the adjoining tracts at the foot of the Nan Shan, and thus cut off the Tarim basin from all direct communication with the Chinese empire. Yet the Chinese administrators and garrisons within the former, notwithstanding their isolation, succeeded in holding out for another forty years—a heroic but obscure chapter in history.

In this long postponement of the final downfall we may well recognize direct proof, not only of the tenacious strength of Chinese organization, but also of the natural protection provided for the Tarim basin by the great mountain barriers in the north, west, and south and by the desert in the east. It is an interesting and, in more than one way, significant observation that the abandonment of a series of ancient sites in the Khotan region, such as Dandan Öilik, Khadaliq, Mazar Tagh, can be proved to synchronize with the end of Chinese control in T'ang times. It may well illustrate that dependence on ordered and fairly efficient administration which is so important a human factor wherever cultivation is wholly contingent on irrigation.

The period of about four hundred years following the disappearance of T'ang rule is a dark one in the history of the Tarim basin. We know that Tibetan domination in that region did not outlast a century, and also that Islam spread among the Turkish chiefs who acquired control over Kashgar and other oases in the western portion of the Tarim basin. From about the middle of the tenth century onwards it led to the gradual overthrow of Buddhist doctrine and culture by force as well as by propaganda. In the north-eastern portion, however, and in the outlying territory of Turfan, Buddhism continued to flourish much longer, side by side with Manichæism and Nestorian Christianity, under the protection of the Uigurs.

This virile tribe of the Turks, firmly established along the eastern Tien Shan, was the first among their great nation to show capacity for absorbing Western civilization, whether conveyed through Christian or Muhammadan channels. Other Turkish tribes, too, whom bravery and enterprise have carried far away towards Europe, have later on displayed the same capacity, combined with readiness to receive into the national fold and to digest racial elements from conquered populations more advanced in civilization. To these qualities, here only noted in passing

we must attribute the fact that throughout the Tarim basin Turkish is now, and has been for centuries, the only language spoken. Yet the population there, as the anthropometrical materials collected by me and analysed by Mr. T. A. Joyce prove, still retains in the main the fine *Homo alpinus* type, preserved in purity by the Iranian-speaking hillmen of the Pamir region, and shows but slight admixture of true Turkish blood.

It is difficult to believe that from the ninth to the twelfth century the conditions affecting the Tarim basin as a land of passage between Western Asia and China underwent any serious change. It was a time when China, under the weakening rule of the T'angs and then later under the Sung dynasty, was obliged to maintain towards Central Asia a policy of passive defence, if not of rigid seclusion. The north-western border lands passed under the domination, more or less transient, of foreign tribes, whether of northern race such as the Kitan (Khitai) or the Tanguts, who were of Tibetan affinity and established their kingdom along the foot of the Nan Shan. The Khitai who gave their name to *Cathay*, when driven from Eastern Mongolia and the adjoining parts of Northern China moved westwards and by 1126 established their supremacy all along the Tien Shan as far as Samarqand. The Uigurs as well as the smaller states in the oases of the Tarim basin owed them allegiance. Thus the contact with Muhammadan Central Asia which conquests of Uigur and other Turkish chiefs in what is now Russian Turkistan had established long before, was maintained. But in the absence of direct relations with China proper the importance of the ancient trade route leading through the Tarim basin must have greatly diminished.

The phenomenal rise of the Mongols under the great Chingiz Khan, another Napoleon, in the first quarter of the thirteenth century brought about vast changes in political conditions throughout Asia. By the time he died in Kansu, A.D. 1227, his astonishing conquests had brought all countries from the Black Sea to the Yellow River under direct control of the Mongol "Great Khan." The operations continued by his immediate successors ended some thirty years later in uniting the whole of China under the same Mongol dynasty which by its several branches held sway over all Central Asia as far as Persia, and over a great part of Eastern Europe as well. The establishment of one sovereignty across the whole of Asia again cleared the way for direct intercourse and trade between China, the Near East, and Europe. The policy of the Mongol empire distinctly encouraged relations with the Western nations, and thus opened an epoch of free interchange between the Far East and the Far West in commerce, arts, and knowledge such as the world had never known before.

For more than a century the trade routes to the north and south of the Tien Shan saw an undisturbed flow of traffic, and the accounts preserved to us of envoys, traders and travellers then seeking far-off Cathay

from the west tell us a good deal of those routes and of the ground which they crossed. None of those accounts, in accuracy of detail and interest for the geographical student, approach the immortal work of Marco Polo, the greatest of mediæval travellers. The route which he followed in 1273, when on his way from Persia to Kublai's court with his father and uncle, led through the uppermost Oxus valley and across the Pamirs into the Tarim basin. There he travelled by the caravan road between the Taklamakan and the Kunlun to the southern edge of the dried-up Lop sea-bed, and so on to Tunhwang, Suchow, and Kanchow. It has been my good fortune in the course of my journeys to retrace the footsteps of the Venetian along the whole of this route, and to justify by observation on the spot how right Sir Henry Yule, Marco Polo's great modern commentator, was in his implicit reliance on the correctness of Marco's narrative.

The Mongol dominion over China which Marco Polo still saw in its full greatness under the Emperor Kublai came to an end through internal decay within a century of Kublai's accession. The Chinese dynasty of the Ming which replaced it was necessarily bent upon safeguarding the north-western borders against fresh Mongol invasion. They remained exposed to this danger through the continued existence of the Chagatai Khanate along the Tien Shan until the death of Timur, or Tamerlane, and through the subsequent predominance of the Mongol clans of the Oirat in the same region.

Hence a policy of strict seclusion stifling trade once again prevailed on China's marches towards Central Asia. The wall which was erected under Ming rule to serve this close watch of the border still runs, more or less preserved, round the cultivated areas at the northern foot of the Nan Shan. The fortified gate station of Kiayükwan, a day's march to the west of Suchow, marks the place where this wall is crossed by the high-road leading to Tunhwang, Hami, and the Tarim basin.

Of the rigorous watch once kept here over the rare caravans or missions allowed to enter the sacred soil of the " Middle Kingdom," we receive interesting glimpses in the descriptions left us by Shah Rukh's embassy of 1420; by the Turkish Dervish whom Busbeq, the Emperor Charles V.'s ambassador, interrogated at Constantinople between 1555–62, and by Benedict Goës. This devoted Jesuit traveller arrived there in 1606 after a three years' difficult journey across the Pamirs and by the northern road of the Tarim basin. His detention at Suchow for sixteen weary months until death relieved him of all troubles, is proof of the extreme caution with which the admission of foreigners was controlled. That Goës parted only at Suchow " with the last lingering doubt as to the identity in all but name of Cathay and China " is striking evidence how knowledge of the oldest land route to China had faded in the West since Mongol domination had ended.

The rapidly developing use of the sea route to China, following upon

the first Portuguese voyages to India, had long before Goës' time deprived that ancient Central-Asian highway of its former importance for Western trade. Hence the renewed expansion of Chinese power into the Tarim basin which began under the great Manchu Emperor K'anghsi towards the close of the seventeenth century, cannot claim such great interest as that under the Han and T'ang. Yet it deserves here brief mention, be it only as an illustration of the marked influence which unchanging geographical factors must exercise upon historical developments in this region.

This time it was the growing power of the Oirats or Dzungars which forced upon China a fresh advance into innermost Asia. They were Mongolian tribes established north of the Tien Shan in the wide region still known after them by the name of Dzungaria. United under the energetic and ambitious chief Galdan, the Dzungars overawed eastern Mongolia and thus threatened the frontiers of China. The difficult expedition which the Emperor K'anghsi led in person into outer Mongolia ended in 1696 with a signal victory over Galdan. Then Chinese garrisons were first pushed forward to Barkŏl at the eastern extremity of the Tien Shan. Next by the occupation of Hami the direct route was opened across the Pei Shan desert. Thus protection was secured for the Kansu marches, exactly on the same lines as Chinese " forward policy " had been obliged to follow more than a thousand years earlier against the Western Turks.

The danger from the Dzungars still continued. Their force was impressively demonstrated by the adventurous inroad into Tibet which brought them some twenty years later under Galdan's successor right to Lhasa through Lop, the ancient Shanshan. But it was not until 1755 that renewed aggression by the Dzungars led to expeditions organized by the great Manchu Emperor Ch'ienlung which finally brought the whole of the Tarim basin as well as Dzungaria north of it under direct Chinese administration. Once again, as under the Han and T'ang, a policy purely defensive in its origin had resulted in Chinese expansion over vast Central-Asian regions right up to the Pamirs and the Altai Mountains.

That Chinese control of these regions has continued to the present day, in spite of the growing internal weakness of the empire and the great upheaval caused by the Tungan or Chinese Muhammadan rebellion in the third quarter of the last century, is instructive for the student of political geography. The explanation lies in the fact that for the first time in history China's Central-Asian frontiers had become contiguous with those of a great civilized power, such as the Russian Empire was, capable of dominating the border populations and gradually restraining their nomadic migrations. It was Russia's temporary occupation of Kuldja and the fertile Ili valley which facilitated the Chinese reconquest of the " New Dominion " in 1877, after the Muhammadan rebellion had

flung the Tarim basin for a decennium first into anarchy and later on into oppressive misrule under Ya'qub Beg, a usurper from Western Turkistan. But it was their own organizing capacity which enabled the Chinese to overcome the very serious difficulties of supplies and transport. Thus they gradually moved up troops through the utterly devastated tracts along the northern foot of the Nan Shan and subsequently concentrated them upon Hami across the arid wastes of the Pei Shan.

The times of that "self-determined independence" of the Tarim basin are still remembered with sadness by the people in the oases. According to reliable information I received, the population in some among them had during those times sunk to one-half of what it was before, and it is certain that the cultivated area had everywhere shrunk greatly.

The strings of oases between the Tien Shan and the Kunlun no longer serve a great trade route. So the brave patient camels which carry what traffic there is as efficiently as in the times of Chang Ch'ien or Marco Polo, are not likely to be replaced soon by the rushing motor car or the bustling railway. The traditions of China's great past as a Central-Asian power still protect the peace of the region of which we have followed the fortunes through history. Let us hope they will suffice also thereafter to ward off those troubles and sufferings of which its less secluded neighbour, Russian Turkistan, has had abundant experience during the last few years.

Note on General Map of Chinese Turkistan

This map is based upon the surveys of Sir Aurel Stein and the Indian Surveyors attached by the Survey of India to his expeditions in Central Asia, and published by the Survey of India as an atlas on 1/500,000 *to accompany his 'Innermost Asia,' the detailed report on the last of his three expeditions of* 1900–8, 1906–8, 1913–15. *In the compilation of this material account has been taken of the corrections to be applied to the positions of triangulated points, as indicated by Major Kenneth Mason in Appendix A to Sir A. Stein's 'Memoir on Maps of Chinese Turkistan and Kansu' (Dehra Dun,* 1923), *pp.* 112, 141 *sqq. By permission of Colonel Winterbotham, Chief of the Geographical Section, General Staff, the original compilations for the G.S.G.S. map of Asia on the scale of* 1/4 *Million have been used for most parts outside the range of the Stein surveys.*

Before the paper the PRESIDENT (the EARL OF RONALDSHAY) said: Before I introduce the lecturer you will, I know, desire that I should extend a cordial welcome from this Society to Their Royal Highnesses the Crown Prince and Princess of Sweden, who are honouring us with their presence to-night. We welcome them for the keen interest which they display in the science in which we ourselves are mainly interested, and I might perhaps be permitted to add

CHINESE TURKISTAN

and adjacent parts of CENTRAL ASIA AND KANSU

From surveys made in 1900-1, 1906-8, 1913-5 during the explorations of

SIR AUREL STEIN, K.C.I.E.

and published by the Survey of India in his 1/500,000 map of

Chinese Turkistan and Kansu

combined with other material, including the War Office map of Asia on the scale of 1/4,000,000

Scale 1/6,000,000

MILES 100 50 0 100 200 MILES

KILOMETRES 100 50 0 100 200 300 KILOMETRES

Heights in metres

Routes (ancient)
Drift-sand area
Sandy tract with scrub
Cultivation
Dry river bed
Ancient site
Ancient frontier wall

Conical Projection with Errorless Meridians and Standard Parallels 36° and 44°

Published by the Royal Geographical Society

CHINESE TURKISTAN
Stein

Conical Projection with Errorless Meridians and Standard Parallels 36° and 44°

Published by the Royal Geographical Society.

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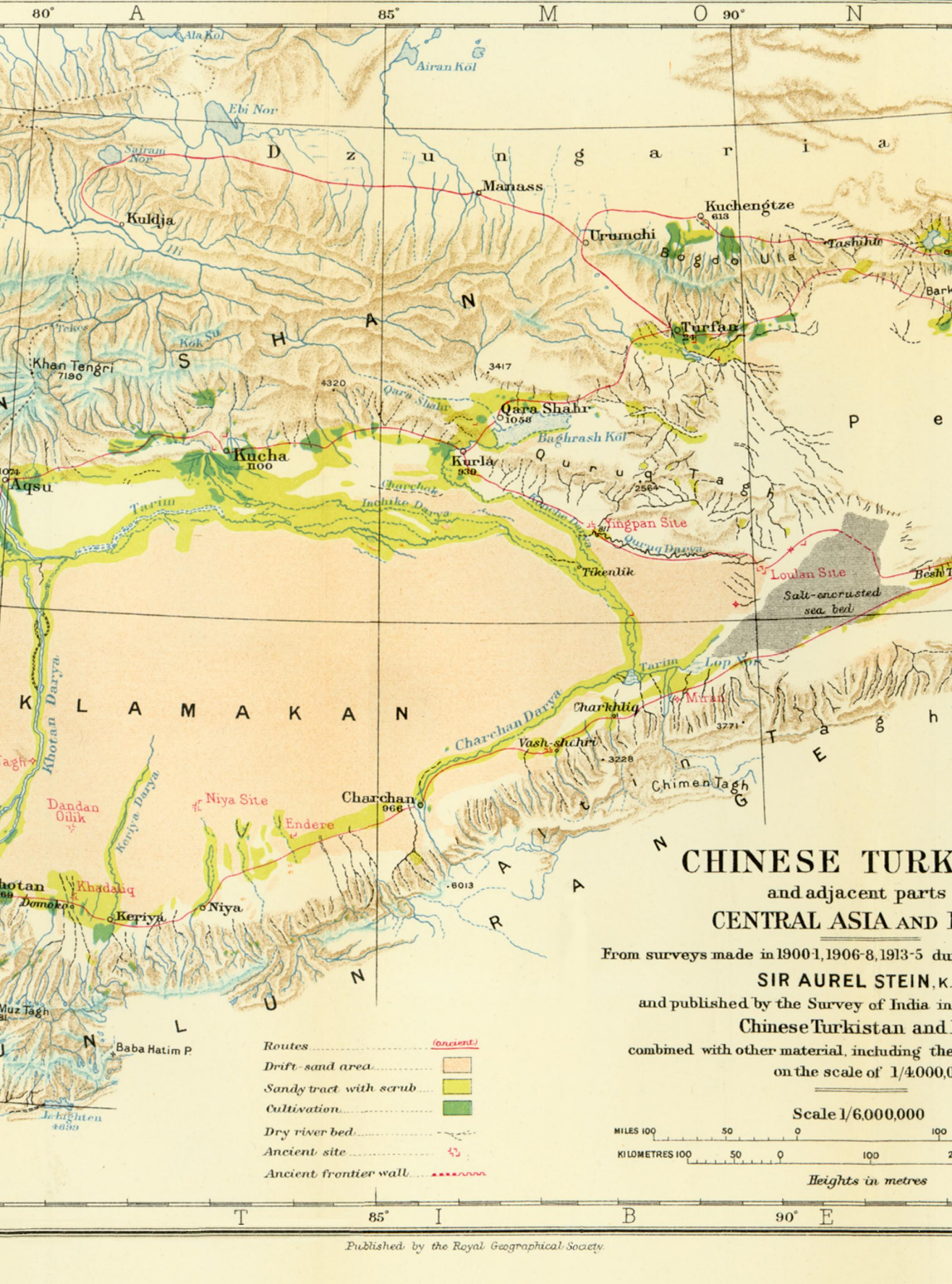
CHINESE TURKISTAN

Conical Projection with Errorless Meridians and Standard Parallels 36° and 44°



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CHINESE TURKISTAN
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that we welcome especially Her Royal Highness amongst us as the daughter of a late member of the Council of our Society.

We are beginning our Session this year with the first biennial lecture upon discovery in Asia, a series which has been established by us, thanks to the generosity of a Fellow of this Society, Mr. P. L. Dickson, and we have been fortunate in securing for the inaugural lecture so distinguished a scholar and explorer as Sir Aurel Stein. Indeed, our lecturer requires no introduction to an audience of this Society, for his geographical work in Central Asia and Western China earned for him the gold Victoria Medal of the Society some fifteen years ago; and the geographical and archæological exploration which he began in Kashmir and the Afghan borderlands more than a quarter of a century ago and which he has carried on at intervals almost ever since in Central Asia and Western China has excited the admiration and the interest of geographers and archæologists the world over. For his lecture this evening Sir Aurel Stein has chosen the subject of the influence of the geography of innermost Asia upon history, and in the course of his remarks he will conduct us to that amazing tract of country which lies south of the Tien Shan Mountains and north of the snowy highlands of Tibet, a vast desert desiccated almost beyond belief and yet the background of rich romance; for it was along this arid and dusty corridor that the civilizations and culture of the West, of India and of the Far East passed and mingled. The long line of communication across hundreds of miles of forbidding desert opened up more than two thousand years ago by the organizing ability of the Chinese has been traced by Sir Aurel Stein in the course of his explorations. He will tell us this evening of many interesting and exciting moments during those days of toil when he was wresting from the sand hummocks of the Tarim basin the secrets of the past. But the height of romance, surely, was reached when the trail of the ancient trade route which he was searching for was dramatically revealed. At one place in a wilderness of salt-encrusted clay he happened upon a scattered line of copper coins of the ancient Han Dynasty of China, covering a stretch of some 30 yards of ground in a well-defined line running from north-east to south-west. How came they there? You can picture for yourselves, I think, the manner of their coming. A caravan of camels travelling silently through the cool of night a little wide of the main track; a hole worn in the sack in which the cumbrous coinage, with which those who have travelled in the interior of China are familiar, was carried; a break in the string on which the coins were strung; the falling to the ground of a few coins with each forward lurch of the camel as it moved on its way: a thing that so easily might happen, resulting in the scattering of a few handfuls of coins, unnoticed, upon the surface of the desert, to lie there until, after the lapse of many centuries, they were to be discovered by our lecturer of this evening. And that is but a single episode in the wonderful story which I will now ask Sir Aurel Stein to unfold to us.

Sir Aurel Stein then read the paper printed above.

The PRESIDENT: Sir Edmund Barrow, whose name has been mentioned by the lecturer, is present this evening, and would like to add a word to the evening's discourse.

General Sir EDMUND G. BARROW: At this late hour I will not detain you for more than a few minutes, but I should like to pay a small tribute to my friend, Sir Aurel Stein. I am brought into contact with this very interesting lecture by the fact that some forty years ago I was a member of a small exploration party under Colonel Lockhart, as he then was, and afterwards

Commander-in-Chief; and part of our duties was to explore all the passes and country in this northerly region of our Empire. May I add, parenthetically, that we were at that time expecting to go to war with Russia, and it was urgently necessary to get information regarding the routes by which India could be approached. The fact of my having been in that part of the world brought me into touch with Sir Aurel Stein twenty years later, or thereabouts, when I happened to be the General commanding on the North-West Frontier at Peshawar. Notices had appeared in the newspapers that a Director of Education for the North-West Frontier Province and Baluchistan had been appointed, and that his name was Mr. Aurel Stein. He was quite unknown to me at that time, but one day I received a card—"Mr. Aurel Stein." He was shown in, and I did not quite know to what I owed the honour of a visit, but in a very few minutes I knew I was in the presence of a most interesting personality who astonished me by his great historical and archæological knowledge of the regions north of the Hindu Kush and the Kunlun. But what surprised me even more was the fact that a Director of Education contemplated making what I knew from my past experiences to be a most arduous and even dangerous journey, and I warned him of the very great difficulties of the routes which lay before him. Being a person of great spirit and enterprise, he was not in the least deterred. For the next two years or so I did not set eyes on Mr. Stein, as he then was. No doubt, the youth of the North-West Frontier Province lost a great deal in the way of education during those two years, but, on the other hand, Mr. Aurel Stein was educating the whole world in very interesting archæological and geographical knowledge—the knowledge of ancient Central Asia.

Sir Aurel Stein was good enough to mention my name in connection with the Darkot Pass and the Baroghil. He mentioned the fact that a certain General Hsien-Chih had actually crossed the Darkot to our side of what is now the Indian border. In his lecture he speaks of this feat as rivalling the exploits of Hannibal and Napoleon. I quite agree with Sir Aurel Stein as to the extraordinary military enterprise that General Hsien-Chih displayed, but I go further and think he *out*-rivalled Bonaparte. I won't trouble you with Hannibal, as it is getting late, and I don't know much about his passage of the Alps. In the first place, you must remember that the passage of the Darkot involved going up to 15,600 feet. The St. Bernard is about 8000 feet, so that the former was double the height of the latter. Moreover, Bonaparte had a made road by which to cross the Alps. In fact, there had been a road there for many years, it having been originally made, I think, about the time of Augustus. There was, in any case, a road with post-houses, and so on, in Roman times. On the Darkot there is not even a path as you approach the top, and certainly from 13,000 feet you are going over soft snow and glacier, and for a good many miles below the snow-line there is the most horrible moraine. How any general could have brought a force of three thousand men over that high and difficult mountain range, I do not know. It was an amazing feat! and the wonder is that he got safely to the southern end, and, more wonderful still, that having got there he was not stopped; because 3 miles up the pass on the Indian side there is a spur which comes out from the main range, and that spur is covered with ancient ruined fortifications. I have often intended to discuss those fortifications with Sir Aurel Stein, because it seems to me that they may be connected with General Hsien-Chih's passage. They are very remarkable, and no one seems to know anything about them. If you ask the inhabitants they say the Kafirs built them, but as they also call us Kafirs, that does not convey much.

I do not think there is anything more I need say. I can only tell you that I have always been filled with the greatest admiration for the exploits of the lecturer, because I know the very great difficulties with which he has had to contend.

The PRESIDENT: The hour is late, and I will therefore not invite others to speak. For the same reason I do not propose to add anything myself. I only desire to assure Sir Aurel Stein that the manner in which he has wrested the secrets of the past from the shifting sands of the Taklamakan Desert and from the salt-encrusted wilderness of the dead Lop Sea has excited out highest admiration. I think I can safely assure him that Mr. Dickson, who is unfortunately prevented from being here to-night, will be deeply gratified when he reads the first of the Asia lectures which he has so generously endowed.

THE DETERMINATION OF GRAVITY AT SEA IN A SUBMARINE

Dr. A. F. Vening Meinesz

Read at the Afternoon Meeting of the Society, 20 April 1925.

IT may be expected that the determination of gravity at sea will give important contributions to many scientific questions concerning the figure of the Earth and the constitution of the Earth's crust, and it therefore has already several times been the subject of experiments. The first valuable observations were made by Hecker, who from 1901–1908 made voyages in the Atlantic, Indian, and Pacific Oceans. He applied the method indicated by Mohn of determining simultaneously the pressure of the air in two different ways, by the ordinary mercury barometer and by the boiling-point of a fluid. The first of these methods gives a result which depends on the intensity of gravity, and the second a result which does not, so the comparison of the two gives the desired intensity of gravity.

Hecker's observations led to the important general conclusion that in the mean gravity at sea does not deviate much from the normal value. It was however not yet possible to attack successfully the majority of the problems under consideration, as for that a greater accuracy of 1/100,000 or 1/200,000 is necessary. This paper is an account of a new endeavour in this direction, made during a voyage from Holland to Java, which has given satisfactory results, as the accuracy seems to comply with this requirement.

After studying the subject it seemed that an improvement of Hecker's method or of another statical method, to give a considerable reduction of the mean error, would present great difficulties. This opinion has since then found support in the recent publication of the experiments of Prof. Duffield, in spite of the admirable skill which he brought to bear on the application of these methods.

On the other side there seemed reason to doubt the general opinion

book may be specially recommended to some of the hustling irrigators in California.)

Part II. deals with the Crop, first generally, and then in details; and the selection and treatment of the essential for the various crops may be fairly called a model of what should be done. Special attention is given to cotton, wheat, rice, and sugar-cane; and in each case there is emphasis on just the three or four factors which are absolutely vital to the particular crop. Thus, in the chapter on cotton—a "dry" crop—the emphasis is laid on the need for a permeable and well-aërated soil; in that on wheat—a "cold season" crop—temperature is stressed, limitation of temperature at both ends of the season practically restricting the varieties and the geographical distribution. So the nitrogen problem is dealt with under "rice," the relation of temperature to moisture under "sugar-cane."

Part III. is devoted to Organization, with special reference to the ideal investigator—such as Mr. Howard is himself.

The book may be most strongly recommended to geographers.

L. W. L.

Peacocks and Pagodas.— Paul Edmonds. London: George Routledge & Sons, Ltd. 1924. 9 × 6, pp. xii. + 282. 45 *Illustrations by the author.* 12*s.* 6*d. net.*

Mr. Paul Edmonds frankly admits that he visited Burma as a "fine-weather tourist"—the half-contemptuous appellation given by British residents to the casual winter visitor—and this book is a light-hearted account of his journey up the Irrawady as far as Bhamo. He did not stray far from the beaten track, but he has a quick eye for the unusual and the picturesque, and presents the fruits of his observations and experiences in a pleasant manner; he is always readable and often humorous, and some of his sketches of this sunny land and its people—perhaps the happiest and most contented in the world—are very effective. He has something to say on such varied subjects as lacquer-work, Burmese superstitions, ruby mines, opium smuggling, snakes, and leper asylums; all this, and much more besides, the general reader will find of interest, but to the student of Burma the most valuable of the author's notes will be those on Burmese music, the foundation of which, he suggests, is that earliest and most primitive of scales, the pentatonic. The chapter on politics gives a concise and lucid account of the situation in Burma to-day. Here Mr. Edmonds shows himself a sensible and well-informed observer, and recognizes that while the extremists of the towns (with the support of the priests) clamour for independence, the happy-go-lucky Burman of the country districts is indifferent to such aspirations and is unlikely to become restive so long as he has a rice-field to plant, a cheroot to smoke, and a quid of betel-nut to chew. Moreover, while he avoids the dangers of hasty generalizations, he maintains (rightly, as all who know Burma must feel) that whatever advantages the Burman may gain from any further political concessions, he will not add thereby one iota to his happiness.

O. R.

Early Travellers in Central Asia, 1603–1721.— C. Wessels, S.J. The Hague: Martinus Nijhoff. 1924. 10 × 7, pp. xvi. + 344. *Frontispiece and Map.* 21*s. net.* 12 *guilders.*

Recent explorers in Central Asia have had to face not only the natural difficulties of travel in that remote region, but also the jealousy and suspicion of the inhabitants. This aversion is of comparatively recent growth, and did not exist until Chinese rule influenced Tibet by "grafting its own love

of seclusion on the inhabitants." Therefore during the seventeenth and eighteenth centuries travellers were not confronted with this additional difficulty, and a considerable number of Europeans, particularly missionaries, were able to visit and partially explore the country. These travels were long neglected in general histories of Asiatic exploration, and though attention has been called to them in recent years the published accounts are often very summary and sometimes quite inaccurate. Father Wessels, who has for some time been known as a keen student of the subject, has produced a work which fills this notable gap in the history of exploration so far as concerns the travels of the Jesuits in Central Asia from 1603 to 1721 (for it must be remembered that something was done also by their successors the Capuchins).

The first two narratives—of the journeys of Bento de Goes and Antonio de Andrade—have the special interest attaching to pioneer work. Goes' achievement has been known to English students through Yule's carefully edited version included in his 'Cathay,' but Father Wessels is able to further elucidate certain points by the help of recent research. He discusses the question of the true name of the traveller, some having held that "Goes" was assumed only on his joining the Jesuits after a somewhat wild youth. But as it has been found that a family of that name was in existence at the traveller's birthplace—Villa Franca in San Miguel (Azores)—the author thinks the theory that the true name was Gonçalves (a family also represented there) must be abandoned. As is known, Goes' journey was undertaken with a view to determining the identity of the Cathay of the mediæval travellers, the result being to prove the correctness of Ricci's guess that it was none other than China. That after setting out from Kabul he crossed the Pamirs—being the first European to do so since Marco Polo—has long been an accepted fact (though doubted by Humboldt and Ritter), but it is impossible to be certain of his exact route, and Father Wessels does not entirely agree with Yule's suggested solution. From Yarkand (after a trip to Khotan, of both which towns, as also of the nephrite mines, there are interesting accounts) he took the route by the northern oases to Hami, and thence across the desert to Suchow, being the first modern European to reach China from the West. But "seeking Cathay he found Heaven," for he died at Suchow in 1607.

The next travellers of the series—Andrade and his immediate successors—have been much less generally known, and the research by which Father Wessels has succeeded in sweeping away prevalent misconceptions about them is perhaps the most valuable part of his labours. But as he had previously published his conclusions on the subject (cf. *Journal*, 40, p. 332), it is unnecessary to say much about them here. With a view to reaching the Christians supposed to be living in Tibet, the traveller went by way of Hardwar and the source of the Ganges (the route followed in 1807 by Webb and Raper) to Tsaparang in the valley of the Upper Sutlej, being the first European to cross the Himalayan range into Tibet. From the careful description of the place published in Calcutta in 1919 by Capt. G. M. Young, the author finds no difficulty in reconstructing the town as it was at the time of Andrade's visit. Francesco de Azevedo continued Andrade's work, and made a journey from Tsaparang to Leh, returning to India by the Baralacha and Rotang passes in 1640. But a more extensive journey was that of Stephen Cacella and John Cabral (1626–30), and the details given about this will be new to most readers. Entering Bhutan by way of Buxa, they made their way by Gyantse to Shigatse, whence Cabral returned to India through Nepal, being probably the first European to traverse that country.

The journey of John Grueber and Albert D'Orville (1660–1662) from Pekin *viâ* the Koko Nor to Lhasa and on through Nepal to India is much better known. By judiciously piecing together the scattered material yielded by sources of unequal value, Father Wessels has given as full a description of the journey as is possible, and in the task he has been aided by documents hitherto unpublished, and not used by Tronnier (cf. *Journal*, 24, p. 663). D'Orville did not give a very detailed description of his remarkable journey or of the town of Lhasa, but Hippolyte Desideri, who in 1714 travelled by Kashmir and Ladakh to Lhasa gives a very full account of Tibetan life and of the capital. The account was only discovered in 1876. Father Wessels' comparison of Desideri's and Younghusband's descriptions of Lhasa will be found particularly interesting.

The author remarks that he did not think it necessary to add a physical description of Central Asia, but he shows himself well acquainted with its geography, and by comparing the Jesuit accounts with those of recent explorers like Sir Aurel Stein and Sven Hedin proves clearly, in many instances, the remarkable accuracy of the former. The book represents a vast amount of research, and the references are very full. The author has spared no pains to clear up obscure points by inquiry in India and elsewhere, whilst also making the best use of the available literature, of which he gives a useful list.

The more important documents are printed in appendices, and an adequate map shows the routes of the travellers. A photograph of the Goes monument at Villa Franca forms the frontispiece. E. W. G.

Western Civilisation and the Far East.— Stephen King-Hall. London: Methuen & Co. 1924. *With three Maps.* 18*s. net.*

The writer of this remarkable book is a young naval officer who comes from a family well known in the annals of the British sea service. An earlier work, 'The diary of a German Submarine commander,' was written with such skill and naturalness that many even in naval circles were misled into thinking it really the work of a German officer. The volume under review deals with problems arising out of contact between the white races on the one hand and China and Japan on the other, and its object is to examine the most important phases of those problems from a distinctly *post-war point of view*—a fact which no doubt accounts for the somewhat pessimistic spirit in which much of it is written. A good general survey is given, in the second chapter, of the early conditions of the impact of the West on the East, but the main part of the book is devoted to the gradual rise of Japanese power in Eastern Asia and the progress of her policy and intervention in Chinese affairs on the mainland. One of the most interesting sections is that dealing with the rise of Socialism and the development of the Labour question in Japan. In this connection a significant and entertaining illustration is given of the control exercised by the police over the organization of Labour demonstrations as shown in the regulations issued for that of May Day 1921.

It is unfortunate that, in his survey of the policy of Western Powers towards China in the nineteenth century, the author fails to realize that, while it is undoubtedly true that the Chinese merchants, as a class, do largely deserve the honourable reputation they have gained, the officials—with whom he brackets them—really stand in a totally different category. Similarly his sympathy with China in her resistance to the intrusion of the Western Powers for the purposes of trade leads him to overlook almost completely the worst features of China's opposition—her bad faith, arrogance, and the frequent