THE GEOGRAPHICAL JOURNAL

PUBLISHED UNDER THE AUTHORITY OF THE COUNCIL
EDITED BY THE SECRETARY

VOL. LI.—JANUARY TO JUNE 1918

LONDON
THE ROYAL GEOGRAPHICAL SOCIETY
KENSINGTON GORE S.W. 7
EDWARD STANFORD, LTD. 12 LONG ACRE W.C. 2
1918

PRINTED BY
WILLIAM CLOWES AND SONS, LIMITED.
LONDON AND BECCLES, ENGLAND

CONTENTS

Authors are alone responsible for their respective statements.

No. 1. January 1918.

No. 2. February 1918.

No. 5. May 1918.

Map.

No. 6. June 1918.

Map.

Feb. 4. Wireless message sent to Navy Office, Melbourne.

Feb. 6—8 : South-west gale for forty-eight hours. *Aurora* averaged 9 knots under steam and sail.

Feb. 9. *Aurora* arrived in Wellington all well at 7 p.m. this evening.

GLACIERS AND PASSES OF THE KARAKORAM

Two Summers in the Ice Wilds of Eastern Karakoram.— Fanny Bullock Workman and **William Hunter Workman.** 8vo. *Maps and Illustrations.* Pp. 296. London : T. Fisher Unwin. 1917. 25*s. net.*

IN June 1909 Dr. T. G. Longstaff, Dr. Arthur Neve, and Lieut. Morris Slingsby set out from Goma at the head of the Saltoro valley in Baltistan to search for the reputed pass across the frontier of Kashmir and Turkestan, somewhere between the now well-known Karakoram Pass that Thomson was the first European to reach in 1848, and the Muztagh Passes that Sir Francis Younghusband forced in 1888. Here only eight years ago there was a whole square degree of country that had never been entered, full of high peaks and glaciers, presumably quite uninhabited, and of which the natives of the surrounding valleys had very little even of legend to tell. Ten years before Sir Francis Younghusband had made a spirited attempt to get through from the north, up the Urdok glacier at the head of the Oprang River, and had come within sight of a col which, though perhaps passable by strong mountaineers, could not be reckoned a practicable route such as he sought. This col he called the Saltoro Pass, because, as he has explained, he thought it led into the Saltoro Basin, and he did not know what else to call it. When Dr. Longstaff and his party started from Goma up the Ghyari nala they expected to reach this pass. The Rajah Shere Ali Khan of Khapalu had told them that beyond the pass at the head of the Bilafond glacier there were two routes, to Nubra and to Yarkand, which had been abandoned not so long before, when the easier passage by the Karakoram Pass became safe under the British raj. So when they had crossed their "Saltoro Pass" and saw before them a great glacier running south-east and north-west, they took it for the Urdok glacier, until on closer acquaintance it proved to be flowing from and not to the north-west. The point where they struck it was so admirably adapted to a rapid reconnaissance that by strenuous work with plane-tabling from a roughly measured base Dr. Longstaff was able to produce the map of the upper Siachen glacier that was published in the *Journal* for June 1910. But when small supplies compelled a retreat by the way they had come, they had not recognized it for the Siachen at all, believing that they were across the watershed, and that their glacier must somehow turn north into the basin of the Yarkand River. It was not until three months later, on the ascent of the Siachen glacier from its tongue in the Nubra valley, that Dr. Longstaff found himself approaching the point he had been at before, and proved that the Siachen is the longest glacier in Asia. This result, curiously enough, he had reached through a desire to avoid the Siachen altogether in the early part of that season, because Dr. Neve and Captain Oliver had proposed to ascend it from its tongue in the autumn of that year, and he wanted to avoid trespassing.

From the point which he had reached in June, a saddle was seen at the head of the glacier to the north-west; and when it became clear that his

Saltoro Pass was not the same as Sir Francis Younghusband's, it was natural to suppose that the latter was represented by the saddle. Consequently, upon his map the pass at the head of the Bilafond glacier is called the Saltoro Pass, and the saddle is called Younghusband's saddle.

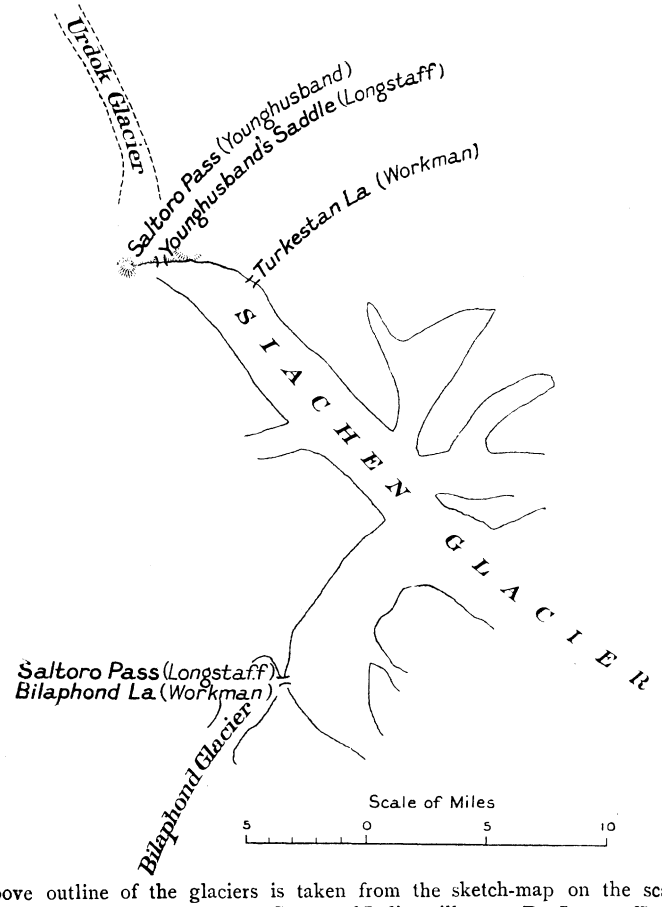
This long preamble is necessary to make clear some points that we shall have to consider in the book under review. It is an account of explorations in the Eastern Karakoram in 1911 and 1912, the authors' seventh and eighth seasons in the Himalaya. Leaving Srinagar in May 1911 they marched by Sonamarg over the Zoji La, the "pons asinorum to many tourists in Kashmir," and proceeded *vid* Kapalu to the Sher-pi-gang and Dong-dong glaciers of the Kondus valley, lying in its eastern or Korkondus branch, while their surveyor, Dr. Calciati, explored the Kaberi glacier for some 10 miles. Returning by Karmading to Hulde they ascended the Hushe valley with its remarkable fans and stratified beds of clay, and pushed up the Masherbrum nala, whence they climbed over the Masherbrum glacier to a peak of nearly 17,000 feet. From this peak, which they have named Quartzite Peak, they were able to convince themselves that the pass reported by the late Mr. Sillem from the Hushe valley to the Baltoro cannot exist. But they were unable to see, as they had hoped to do, the upper reaches of the Crescent glacier, which they had found in a previous season flowing south of Mango Gusor and turning north along its western flank. From a camp on the side of Quartzite Peak Dr. Workman made the curious observation of a very black shoulder, whose débris formed a large moraine and covered the ice to leeward with a black dust that strongly suggested coal.

Returning from the Masherbrum glacier, they proceeded to explore the other glacier feeders of the Hushe River—the Khondokor, the Chogolisa, and the Aling—finding them alike in the inaccessibility of their surrounding cliffs, in the absence of any pass at the head, and in the full vigour of their flow, with no sign of retreat at the tongue, and generally no open passage left along the sides. Dr. Workman, who is responsible for the first part of the book, gives a careful account of what he was able to gather of the structure of the surrounding peaks, and remarks on the curious growth of cedars high up in niches on the rock faces while none are found on the nala floor at the same height. The more serious results of his glacier studies are published in the *Zeitschrift für Gletscherkunde*, 8, 1914; but there is much of general interest in his account of these great glacier systems of what he calls the Karakoram type; and his photographs are magnificent.

Towards the end of the season of 1911 the expedition turned east, following Dr. Longstaff's route over the Bilafond glacier and his Saltoro Pass above it (which they call the Bilaphond La), to the Siachen glacier, which Mrs. Workman often prefers to call the Rose glacier, since Siachen means rose-bush. Resolved to make a thorough examination of this region, they devoted to it the whole season of 1912, engaging the services of Captain Grant Peterkin as surveyor; and they have produced a study of the glacier which is in many ways remarkable. It was published pretty fully in the two papers which the explorers read to the Society in November 1913 (*Geog. Jour.*, 43, 117, with map and 273), so it is enough to mention here some points of topography on which they lay much emphasis—the involved questions of the Saltoro Pass and Younghusband's saddle.

First there is the question whether the pass by which one reaches the Siachen from the Saltoro valley shall be called the Saltoro Pass, or the Bilafond La, or the Bilaphond La. The Survey of India have decided against

the first, and prefer the third. The only remaining question is of spelling. Dr. Longstaff writes the name of the glacier Bilafond. When the Survey adopt the form Bilaphond, following Mrs. Workman, do they intend that it shall be pronounced Bilap-hond, or are they breaking the rules and writing *ph* for *f*? Apart from this doubt, the decision of the Survey is clearly sound, for the name Saltoro was given by Sir Francis Younghusband to a pass which



The above outline of the glaciers is taken from the sketch-map on the scale of 4 inches to 1 inch, prepared by the Survey of India to illustrate Dr. Longstaff's journey. It will serve as a diagram to explain the points discussed in this review. Mrs. Workman's Indira col is something more than a mile north of "Younghusband's Saddle." The position of her "Turkestan La" is shown approximately in its relation to the saddle; it is not so close to the main Siachen glacier as the diagram shows. Detailed maps of the region were given in the *Journal* following the papers by Dr. Longstaff and Mrs. Bullock Workman (*G. J.* 35, 622 and 43, 232).

certainly does not lead to the Saltoro basin; while Dr. Longstaff adopted it for a pass which does lead from the Saltoro basin, but is certainly not the pass which Sir Francis named.

The next question concerns the gap which Dr. Longstaff saw far away at the head of the Siachen glacier, and named Younghusband's Saddle. Mrs

Workman describes it as a "snow-gap with a bergschrund at its base. . . . The supposed saddle is a narrow connecting link between two elevations of the intricate Siachen reservoir, merely an idiosyncrasy of Nature thrown in to mislead any one casually looking up from the middle Rose." Beyond this false saddle lies a deep snow-basin, the natural watershed being further back. "Some distance to the north"—a distance more than a mile, but not otherwise defined—they came to a cornice above a perpendicular snow-wall falling 5000 or 6000 feet to a basin, and below it the head of a glacier flowing north-north-east, which seemed to be the Gasherbrum glacier. This identification is based on her own observations, and "after consultation with Colonel Sir Francis Younghusband," though the evidence seems to us far from conclusive. The cornice they have named the Indira col, and the name Younghusband's Saddle is omitted from their map.

Some 4 miles south-east along the watershed from the Indira col they found a snow col at a height of 19,210 feet—which they named the Turkestan-La—with a drop of 2000 feet on to a short crevassed glacier, which as an affluent joins a wide trunk glacier flowing north-west. After consultation with Sir Francis Younghusband "there appears to be but one conclusion possible, that this is the glacier he ascended in 1899 when in search of the Saltoro pass, and named the Urdok. . . . If this be the case, it is the col at the head of the Urdok glacier which should bear the name of Younghusband's Saddle, and not the meaningless false col lying some miles west. . . ." There seems to be no evidence that there is a col at the head of this glacier which could have looked promising enough to Sir Francis Younghusband to warrant his taking it for the pass he sought; and even if Sir Francis was willing to accept Mrs. Workman's identification as a probable solution, we believe that his route traverse, with an astronomical latitude, but doubtful in longitude, is not really sufficient to decide the question, whether when he turned back from the impracticable head of the Urdok glacier he was below the Indira col or some miles further west. The Survey of India, in the sketch-map which they made to show Dr. Longstaff's route, took the former view; and we know of no substantial reason to alter it. The argument derives its importance from the point which we have now to make.

Throughout the book which Dr. and Mrs. Workman have written there is a constant disparagement of Dr. Longstaff, which adds a disagreeable flavour to what should have been a wholly fascinating tale. First we have two pages of comment on the case of the "two sahibs carrying their own luggage" [Longstaff and Slingsby: see *Geog. Jour.*, **35**, 624]—one of them a "traveller on his first visit to Baltistan" [Longstaff]—of whom it was told in coolie gossip repeated by Dr. Workman, "that they were not *bara* (or important) sahibs with a numerous following." The disparaged travellers "descended into the Siachen basin, remaining one day;" theirs was a "short visit," a "short stay," a "cursory visit," a "limited visit;" and not further to abuse the richness of the English language, again "only one day," and a "short visit." Dr. Longstaff only "decided that the glacier extended further north than had been supposed," while the map of the Workman expedition is the "first detailed and fairly accurate map," though it is in its main features entirely corroborative of Dr. Longstaff's.

The first impression given by this book will be that it is an uncalled-for and ungenerous attack on Dr. Longstaff, and this, we feel assured, will be the final verdict of geographers; but Dr. Longstaff, however, does not suffer alone. The authors twice speak slightingly of Colonel Godwin Austen. Because Dr. Neve is well known for surgical skill and care for sufferers in

lonely places, Dr. Workman must "mention the presentation of deformed and incurably diseased persons to the notice of the traveller as an unnecessary annoyance. . . . Incidents of this kind described in Holy Writ as occurring in Palestine two thousand years ago are almost exactly reproduced here to-day, so many thousand miles away." The parallel is startling but not complete, and it were better avoided. Our travellers have no love for the people of the country. The headman, who had served Dr. Longstaff well, this "native paragon" is charged with theft and swindling, though he "was certainly the best of the Kapalu Court retainers with whom we had to do, the others being most egregious rascals." A "Srinagar babu . . . proved to be the second human black sheep in our caravan;" and in fact "perhaps some in our employ become possessed of the evil eye, for on different occasions men we have employed, praised for character by other persons, have proved harmful and even dangerous to the furtherance of our interests." Only one found favour in his master's sight, a Pathan entrusted with the duty of clearing the road. "This task suited his talents exactly, which could not be said of some of his other duties, and he performed it admirably, not only by vigorous use of voice and stick forcing the pony-wallahs and shepherds to drive their animals forthwith from the path, sometimes on to declivities of dangerous gradient and character, but also with an air of great authority compelling native travellers mounted or on foot, of any rank lower than a Raja or Tehsildar to step aside till we had passed. His zeal in the performance of this office proved a great convenience and also a source of considerable amusement to us." A passage such as this will be read with profound regret by all Himalayan travellers and Anglo-Indians. The authors would seem to have forgotten that they were guests in a foreign land, and responsible for their servants' behaviour as much as for their own.

To another aspect of this expedition we feel impelled to accord the prominence desired by the, shall we call it, self-consciousness of the "lauriate (*sic*) used in the Continental sense," who appears in a pair of striking pictures facing p. 128. A note concluding the account of the work on the Siachen proclaims that "a woman was the initiator and special leader of this expedition . . ., and at present it behoves women, for the benefit of their sex, to put what they do, at least, on record. In stating this I do not wish to ignore or underrate the valuable co-operation on this expedition of my husband."

Personalities apart, the book is written with skill, and the topographical descriptions of intricate country are generally full and easy to follow with the maps. Some ugly words are introduced, as séracked, schrund-gashed, monsoonish, snow-*tourmentes*, and pocket-penitente; while the phrase "a great blow-out reigned all night at this camp" is open to misunderstanding. But the strong element of antagonism to those who had preceded them must be held to deprive the authors' work of judicial value in the determination of disputed points. It is a thousand pities that this should be so. Dr. and Mrs. Workman have many of the aptitudes required for scientific exploration of the highest class—courage and skill, strength and endurance, geographical insight and facility in description.

If they fail to reap their natural reward in the cordial appreciation of their readers it will be because of the lamentable temper they show in regard both to the explorers who went before them and to the people of the country in which they were allowed to travel.

Mgeta Pass to Mahenge through the extremely rugged bracken-clad range of the Utshungwe Mountains. The bracken here is very thick; rain falls almost throughout the year; and the luxuriance of the vegetation in the mountain glades is amazing. From the eastern rim of the Utshungwe there is a magnificent view over the Ulanga flats and the valley of the Kilombero or Ulanga River, which further east becomes the Rufiji.

This vast and wonderfully fertile colony has now passed into our hands with its agricultural and pastoral wealth, its potential mineral value, and its population of close on eight million natives—a fruitful field for the study of British geographers. One of our first duties should be to restore the original native names of Neu Langenburg, Bismarckburg, Wiedhafen, Sphinxhaven, and other places. Bismarckburg has already been re-christened Kasanga by the Northern Rhodesia Administration; Neu Langenburg should again become Ntukuyu and Wiedhafen Ilela. There remains the problem of a new name for the colony as a whole.

Civil administrations are now beginning to cope with the various problems in the conquered territory which press for solution. The unrest resulting from over three years of war in which native soldiers, officered by whites, have been taught how to kill white men with modern weapons, is likely to be not the least of the difficulties that the administration will have to face. Questions of religion also loom large. Many natives have deserted the Cross for the Crescent during the war, and the whole subject of Mission influence and organization will have to be re-considered. It is of much interest to learn that through the agency of the British Mission to the Vatican, it has just been arranged that all the missions of the Roman Catholic faith in German East Africa shall be taken over by missionaries of the same religion, but of British origin.

The campaign has brought about an immense development of communications in German East Africa, particularly in the southern territory. Good roads now exist from the north end of Lake Nyasa to the Central Railway line and these will prove a great factor in the development of trade. A railway linking up Nyasa with Tanganyika, if not with the Dar-es-Salaam–Ujiji, line would exploit an exceedingly rich country. The Germans neglected its development in the past, but there is ample justification for the new administration embarking on an active policy when Southern "German" East Africa is handed over by the military authorities to civil rule.

ROUTES FROM THE PANJAB TO TURKESTAN AND CHINA RECORDED BY WILLIAM FINCH (1611): DISCUSSED BY SIR AUREL STEIN

THE following notes are abridged from a paper contributed last year by Sir Aurel Stein to the *Journal of the Panjab Historical Society*. As this publication is not very accessible in this country, and as Finch's

is probably the earliest English account of Kashmir and the old trade-routes which connected the Panjab with Eastern Turkestan and western-most China, we avail ourselves of the editor's permission to reproduce the substance of the article in the *Geographical Journal.*

Finch's travel-notes have been preserved for us in Purchas's 'Pilgrimes,' and Sir Aurel Stein's attention was specially directed to them by Mr. William Foster, who is re-editing them (with other early Indian travels) for the Oxford University Press. The text, so far as it bears on the present subject, runs as follows ('Pilgrimes,' 1, Bk. 4, Ch. 4):—

"From Cabull to Cascar, with the caravan, is some two or three moneths journey. It is a great kingdome, and under the Tartar. A chiefe city of trade in his territorie is Yar Chaun, whence comes much silke, purslane, muske, and rheubarb, with other merchandize: all which come from China, the gate or entrance whereof is some two or three moneths journey from hence. When they come to this entrance, they are forced to remaine under their tents, and by license send some ten or fifteene merchants at once to doe their businesse; which being returned, they may send as many more; but by no meanes can the whole caravan enter at once.

"From Lahor to Cassimere the way is as in Cabull way to Guzerat [Gujrat in the Panjab, between the Jehlam and the Chenab]. From thence north (or somewhat easterly withall) 16 c. [*kos*] to Bimbar; to Joagek Hately 14 c.; to Chingesque Hateley 10 c.; to Peckly 10 c.; to Conowa 12 c.; thence 8 c. you ascend a mountaine called Hast Caunk Gate, on the top of which is a goodly plaine, from whence to Cassimer is 12 c. thorew a goodly countrey. The city is strong, seated on the river Bahat. The countrie is a goodly plaine, lying on the mountaines some 150 c. in length, and 50 c. in breadth, abounding with fruits, graine, saffron, faire and white women. Heere are made the rich Pomberies* which serve all the *Indians.* This countrey is cold, subject to frosts and great snowes; neare to Cascar, but seperated with such mountaines that there is no passage for caravans; yet there commeth oft-times musk, with silke and other merchandize, this way by men; and goods are faine to be triced up and let downe often by engines and devices. Upon these mountaines keepes a small king called Tibbot, who of late sent one of his daughters to Sha Selim to make affinitie."

This information is remarkably accurate, and was evidently gathered from traders familiar with the ground. For the journey from Kabul to Kashgar the allowance of two to three months would still hold good, whether by the longer route through Bokhara and Ferghana, or by the shorter but more difficult route up the Oxus and across the Pamirs. Silk, porcelain, musk, rhubarb are still regular articles of export from China through Yarkand ("Yar-Chaun"). The "gate or entrance" of China is the gate in the Great Wall near Su-chou, described in other early

* This term, Mr. Foster informs us, must be the "pomerin" or "pamorine" of the East India Co.'s factors—the Hindi *pámri*, a shawl or mantle. It appears in Peter Mundy's travels (Hakl. Soc. Publ., Ser. ii., vol. 35, p. 218) as "Pummering," and is there explained by the editor (Sir R. Temple) as probably equivalent to what is now known as *pashmina*, a fine cloth of wool or goat's hair.

narratives, and (in modern times) by Sir A. Stein in his 'Ruins of Desert Cathay' (vol. 2, pp. 273 *seq.*). The two or three months' journey from Kashgar to the "gate" of China also agrees well with the actual time taken by Stein in 1907–08 and 1914–15.

The route from Lahore to Kashmir is no doubt identical with the "Imperial road" used by the Mogul Emperors (still marked by their *Sarais*), and described by Bernier in his 'Travels' (Constable's edit., 1891, pp. 390 *seq.*). It is now usually called the Pir Panjal route, which leaves that to Kabul at Gujrat and leads *viâ* the Pir Panjal (Pantsal) Pass to the valley of Kashmir. Finch's distance of 10 kos from "Guzerat" to "Bimbar" agrees well with the 28 miles of the modern guide-books. "Chingesque Hately," as already recognized by Constable, is the present Chingas Sarai, a stage below Rajauri, and 40 miles from Bhimbar. "Joagek Hateley" cannot yet be identified, and the word Hateley itself remains a puzzle, though apparently used generically like Sarai or some similar term. Sir G. Grierson suggests that if the first part of the word was meant to be pronounced as the English *hate*, it probably represents the Hindi *hēṭhlī*, low ground at the foot of a village on a height. In "Hast Caunk Gate" the Pir Panjal Pass seems clearly indicated, overlooked as it is by the conspicuous mountain ridge of *Hastivanj*. "Gate" (Sansk. *Dvara*) has from ancient times been specifically applied in Kashmir to watch-stations guarding all regularly used passes into the valley. The "goodly plaine" at the top is the wide upland descending gently eastward from the actual watershed, which has its counterpart on no other regularly used pass across the range. Of the two halting-places next before the pass, "Conowa" may perhaps be connected with *Kambuva*, recorded as the name of an ancient watch-station on this route; it may be placed at or near Pushiana, the last inhabited spot below the pass. "Peckly" presents a difficulty, but may possibly have had its origin in a misunderstanding. From Rajauri a well-known route diverges north-west through the hill state of Punch to the Haji-pir pass, and is used when the Pir Panjal route is temporarily closed by snow. It joins the main road up the Jehlam to the "gate" of Baramula, which itself is the main line of access to Kashmir from the hill territory known as *Pakhlī* from Mohammedan times to the present day. Finch or his informant may thus have misunderstood a reference to a branch route from "Chingesque Hately."

Finch's description of the position of "Cassimer" on the Bahat (Sansk. *Vitasta*, Kashm. *Vyath*—the classical *Hydaspes*) is perfectly accurate, as is also his account of the climate and products of the country. The account of the difficult mountain tracks by which alone Kashgar ("Cascar") could then be gained from Kashmir is of particular interest. It proves that such trade as then passed between Kashmir and Chinese Turkestan had to be carried on through Baltistan and across the main Karakoram range beyond it. That Baltistan or Little Tibet is meant by the territory "with such mountaines that there is no passage for caravans"

becomes certain from the mention of the "small king called Tibbot" whose daughter was married to Shah Selim; for, as Sir E. Maclagan has pointed out, this union of Jahangir with a daughter of Ali Rai, chief of Skardo, is recorded as having taken place in 1590–91 A.D. In the graphic description of the carriage of goods by men across the mountains we can trace first-hand information about the hazardous tracks leading along the precipices of the Braldo valley and the glaciers of the old Mustagh route —so difficult that the route has since been wholly abandoned. Bernier (1665) speaks of the political troubles which caused trade with Kashgar and "Cathay" to be diverted from the Ladakh route to the far more difficult region of "Little Tibet," and Finch's record shows that similar conditions must have already forced the Baltistan route into use at an earlier date. The former use of difficult mountain passes has often been directly due to troubles of human origin besetting the easier routes—a fact which has scarcely as yet received adequate attention in the historical topography of Alpine routes and passes.

THE PROBLEM OF THE HIMALAYA AND THE GANGETIC TROUGH

"**The Attraction of the Himalaya Mountains upon the Plumb-line in India.**"— **Major S. G. Burrard, R.E.** Survey of India: Professional Paper No. 5. (1901.)

"**Pendulum Observations in India, 1903–07.**"— **Major G. P. Lenox-Conyngham, R.E.** Survey of India: Professional Paper No. 10. (1908.)

"**Investigation of the Theory of Isostasy in India.**"— **Major H. L. Crosthwait, R.E.** Survey of India: Professional Paper No. 13. (1912.)

"**On the Origin of the Himalaya Mountains.**"— **Colonel S. G. Burrard, C.S.I., R.E., F.R.S.** Survey of India: Professional Paper No. 12. (1912.)

"**Notes on the Relationship of the Himalayas to the Indo-Gangetic Plain and the Indian Peninsula.**"— **H. H. Hayden, C.I.E., F.G.S.** *Records Geol. Surv. India*, 43, 108–167. (1913.)

"**The Origin of the Himalayan Folding.**"— **Sir Thomas H. Holland, K.C.I.E., A.R.C.S., F.R.S.** *Geol. Mag.*, Dec. 5, 10, 167–170. (1913.)

"**Note in Reply to Mr. Hayden's Paper . . .**"— **Lieut.-Colonel G. P. Lenox-Conyngham, R.E.** *Records Surv. India*, 5, 161–164. (1914.)

Presidential Address to Section C, Brit. Assoc. (Australian Meeting).— **Sir Thomas H. Holland, K.C.I.E., A.R.C.S., D.Sc., F.R.S.** *Geol. Mag.*, Dec. 6, 1, 411–418, 457–464 (1914); and *Rep. Brit. Assoc.*, Australia, 1914; (1915), 344–358.

"**On the Effect of the Gangetic Alluvium on the Plumb-line in Northern India.**"— **R. D. Oldham, F.R.S.** *Proc. Roy. Soc.*, A, 90, 32–41. (1914.)

"**On the Origin of the Indo-Gangetic Trough, commonly called the Himalayan Foredeep.**"— **Colonel Sir Sidney Burrard, K.C.S.I., R.E., F.R.S.** *Proc. Roy. Soc.*, A, 91, 220–238. (1915.)

"**The Structure of the Himalayas and of the Gangetic Plain, as elucidated by**

Geodetic Observations in India."— R. D. Oldham, F.R.S. *Mem. Geol. Surv. India*, **42**, pt. 2, 1–153. (1917.)
and other papers.

THE literature of the famous Himalayan problem has been enriched in recent years by a series of important papers which need collective notice. Scattered over a wide range of official publications, and demanding for their appreciation an equal knowledge of Geology and Geodesy, an introduction to their study is required ; and it is as such an introduction, rather than as a critical judgment of the problem in its present phase, that this notice is written.

The great alluvial plains of Northern India, which slope so gently upward from the Bay of Bengal and the Arabian Sea that the indistinct watershed north of Delhi is less than 1000 feet above the sea-level, separate two regions of higher land that are in striking contrast, physically and geologically. To the south, the Peninsula is an almost earthquake-free area of ancient crystalline rocks, freshwater sediments, and immense horizontal sheets of lava. Its geological relationships are with South Africa and Australia, fragments of a continent which for long ages remained highly stable and free from compressive stress. To the north, the Tibetan plateau, the snowy Himalaya, the Lesser Himalaya and the Siwalik Hills form four parallel belts which show evidences of strong transverse compression in late geological periods, the last of them being still the seat of origin of violent earthquakes. In the two northern belts crystalline rocks are associated with the uplifted deposits of an ancient ocean, while the Siwaliks are composed of sediments like those of the alluvial plains, though slightly older in geological time.

The plains themselves are formed of material brought down by streams from the high ground, especially from the north. On their southern margin the rocks of the peninsula slope gently away beneath them, frequently projecting through them like islands ; but on the northern margin the Himalayan rocks plunge abruptly down to unknown depths. What geological structure is hidden beneath this northern part of the plains ?

When Everest in 1847 finished measuring that part of the Great Arc of India which crosses the plains from the central station of Kalianpur to Kaliana near the foot of the mountains, he found that the latitude of the latter place, as determined by direct astronomical observation, was less by more than 5 seconds of arc than the latitude as measured geodetically. This was interpreted as due to the attraction of the Himalayas, which by deflecting the plumb-line falsified the astronomical observations, and Pratt (*Phil. Trans.*, **145** (1855), p. 53) set out to verify this by an elaborate calculation. He came to the disconcerting result that the deviation of the plumb line ought to be three times as great as it actually was. Airy (*Ibid.*, p. 101) at once pointed out that if the Earth (as then generally believed) had a thin solid crust supported by flotation on a liquid central mass, every protuberance must be supported by a downward displacement of the liquid, just as with an iceberg or a floating cork ; that therefore there ought to be a defect of gravity beneath a mountain-chain or plateau which would diminish the deflection of the plumb-line caused by the protuberant mass. Pratt, however, rejected the idea of flotation of a thin crust (*Phil. Trans.*, **149** (1859), p. 746), but accepted that of a sub-montane defect of gravity, believing this to be due to deep-seated chemical changes, which actually caused the rising of the surface. He showed also that there was a deflection of the plumb-line towards the ocean at Indian

coast-stations, so that there must be an excess of gravity beneath the ocean hollows. To this relation between surface features and deep-seated variations of gravity he applied the term "compensation."

Here we see a double divergence of view: Pratt for a rigid Earth, Airy for a fluid globe with thin crust; Pratt for a deep-seated tumefaction (like the rising of dough) as the cause of mountains and plateaux, Airy for their formation by some immense surface accumulation of matter of which a very large part sank into the supporting fluid. Airy indeed expressed no view as to how the accumulation came about, and to complete the double contrast we must go forward to 1881, when Osmond Fisher ('Physics of the Earth's Crust,' pp. 142–150) combined Airy's principle of flotation with the geological principle of mountain origin by tangential compression in his theory of mountain "roots," according to which every upward wrinkle was accompanied by a much larger downward wrinkle displacing the more or less fluid sub-crust.

J. D. Dana ('Manual of Geology') put forward the principle of compensation as evidence for the permanence of oceanic and continental areas through geological time; but otherwise little notice seems to have been taken of it by geologists in their theories of upheaval and mountain formation, until Dutton* in 1889 brought it into prominence and proposed the term *Isostasy*. This term was scarcely a happy one, since Dutton's great service was that he took a principle which in the hands of geodesists had been simply static, and made it dynamic by introducing the idea of constant adaptation through geological time. Dutton's paper was a stop-gap, not originally intended for publication, but its effect on geological thought was remarkable.

Isostasy may be defined as a condition of approximate equilibrium in a heterogeneous earth, such that variations in the actual surface from that of the ellipsoid of rotation compensate for (or are compensated by) differences in the density of the crust beneath them. The maintenance of isostasy in face of the geological changes that are known to have taken place in the crust implies some degree of plasticity in the sub-crust, though it is not necessary to adopt the crude idea of a thin crust on a liquid sub-crust.† "The continents will be floated, so to speak, because they are composed of relatively light material; and, similarly, the floor of the ocean will . . . be depressed because it is composed of unusually dense material."

"The adjustment of the material towards this condition, which is produced in nature by the stresses due to gravity, may be called the *isostatic adjustment*. . . . The compensation of the excess of matter at the surface (continents) by the defect of density below, and of the surface defect of matter (oceans) by excess of density below, may be called the *isostatic compensation*."

These quotations are from a memoir by Hayford,‡ who in the early years of the century devised an ingenious modification of the "compartment" method which Pratt had invented for his Himalayan calculations, making it possible by comparatively simple calculations to determine the "topographic deflection"

* "On some of the Greater Problems of Physical Geology," *Bull. Phil. Soc. Washington*, **11**, 51–64 (1892).

† The modern geological conception is perhaps best expressed by Prof. Barrell's "Asthenosphere"—"a thick earth-shell marked by a capacity to yield readily to long-enduring strains of limited magnitude," though transmitting earthquake-waves like a rigid body. "The Strength of the Earth's Crust," *Journ. Geol.* (Chicago), **22**, **23** (1914–15), numerous references.

‡ J. F. Hayford, 'The Figure of the Earth and Isostasy,' U.S. Coast and Geodetic Survey (Washington, 1909), and 'Supplementary Investigation' (1910).

for any station. This may be defined as the deflection of the plumb-line which would be produced by the irregular distribution of the masses corresponding to the known irregularities of the surface, assuming the non-existence of any isostatic compensation. By the same method may be determined the "correction for isostasy" at any station, that is the correction to be made in the topographic deflection on the assumption that the Earth is in perfect isostatic equilibrium. If the deflection so calculated and corrected does not agree with the observed deflection (as shown by the difference between the astronomical and geodetic latitudes of a station) the difference is the "residual deflection" (or "anomaly"), and is the measure of the imperfection of isostasy at the station, unless it can be shown to be due in part to imperfect geodesy (for instance, the use of an inexact spheroid as basis).

Isostatic equilibrium is, of course, very far from being real equilibrium. The plumb-line is still deflected locally, because the compensating excesses and defects of mass are at unequal distances from it; and there are lateral strains set up in the Earth itself. Elevated areas are not saved from denudation nor seas from sedimentation by compensation in the depths, and the effect of these geological actions as well as of those movements under tangential pressure to which the folding and overthrusting of rock-masses bear witness is to disturb isostasy continually. If, therefore, there is even an approximation to isostasy in the Earth, it is good evidence that isostatic adjustment has been taking place during the past.

Hayford and his colleagues of the U.S. Coast and Geodetic Survey showed by the smallness of the "residual deflections" that there was approximate isostasy in the United States. The residuals were smallest if isostatic compensation were assumed to be complete at a depth of about 113·7 (afterwards recalculated as 122) km.* The mass under any given area, from sea-level down to this depth of complete compensation, is the "supporting column" of that area. Hayford mapped the distribution of residuals, but could find no general explanation of them. Gilbert pointed out that Hayford assumed a uniform distribution of the compensating defect or excess throughout the supporting column, and calculated that heterogeneity of the column might produce results comparable to the actual residuals, but that variation in the isostatic level would not. Barrell† came independently to the conclusion that vertical variations of density are a real cause, but not the major cause of anomalies.

Meanwhile much work was being done in India. Burrard (1901) published the results of the previous six years' work in a volume which may well be taken as a classical example of scientific progress by the method of trial and error, as first one and then another explanation of the plumb-line anomalies is tried and abandoned. We need only refer to the final result, the chief of which is that a "hidden mountain chain" or region of excessive density crosses India, parallel to the Himalayas, and about 400 miles from their southern boundary, from near Calcutta through Kalianpur to near Karachi, and that this masks the effect of the Himalayas on the plumb-line. Another small area of high density occurs in the midst of the Punjab alluvium between Multan and Lahore.

These results of plumb-line observations were confirmed by Lenox-Conyngham's pendulum observations (1908).

* "Interpretation of Anomalies of Gravity," U.S. Geol. Surv., Professional Paper 85 C (1913).

† *Op. cit.*, **22**, 313 (1914).

Crosthwait (1912) applied Hayford's methods to India, and showed that there was a far wider divergence from isostasy in India than in the United States. Burrard had divided India into regions according to the direction and amount of the local deflections. Ardent believers in isostasy may have hoped that these distinctions would vanish when "correction for isostasy" had been made; but they still persist. Thus in region 1 (Himalayas) all residuals are negative (northward deflection), and all but one have high values, 13″ to 24″. Region 2 (plains at foot of Himalayas) is a region of rapid transition: there are only four stations, and the residuals range from −11″ to +7″. Regions 3, 4, and 5 (all the rest of the plains, and the peninsula roughly north of the Tropic of Cancer) include 37 stations, of which 34 have positive residuals, the other three having 0, 0, and −1″ respectively. Further south, on the other side of the "hidden range" negative values again prevail except in the extreme south, where there is a transition towards positive.‡ There is thus evidence of a defect of gravity under the plains and an excess under the northern part of the peninsula, not accounted for by either topography or isostatic compensation. Crosthwait (anticipating Gilbert's conclusion) suggested that residuals might be due in part to unequal distribution of mass in the "supporting columns." He regarded the less perfect isostasy of India as due to the much greater disturbances of the crust in late geological times, as compared with North America. "The Earth's crust in India is in a process of settling down and may be, comparatively speaking, in a state of strain." On this Barrell § commented that "upheavals cannot exceed the strength of the crust; and in India, therefore, perhaps may be better observed than in the United States the maximum strains which the Earth is competent to endure;" and as a result of his elaborate studies concluded that the Earth's crustal strength is "twenty, fifty, or even a hundred times greater than that advanced in recent years by the leading champions of high isostasy." Thus we see the pendulum of opinion swinging between belief in fluidity and rigidity in the Earth.

Following on Crosthwait's publication, Burrard (1912) propounded his theory of the origin of the Himalayas. He postulates a sub-crust, contracting as it cools and cracking. The sides of the crack (or series of cracks) move apart. The crust overlying the shrinking northern side is compressed by this movement of the sub-crust, the mountain-folds of the Himalayas being thus produced. The rift is gradually filled with alluvium of low density. Further shrinkage and cracking causes some of this alluvium to be folded, producing the Siwalik Hills.

This theory was so contrary to accepted geological ideas that controversy soon rose over it. If the sub-crust is so plastic that complete isostatic compensation may take place within a depth of 75 miles, can it be so rigid as to form, under tension, a wide rift to a depth of 20 miles? This is one difficulty, but the direction of thrust that folded the Himalayan rocks is another. It had been generally considered by geologists that the direction of pressure in a folded area could be judged (1) by the inclination of the axes of asymmetric folds, which appear as though their upper end had been pushed farther than the lower; (2) by the relative position of more or less horizontally displaced masses, it being assumed that an overthrust is more easily produced than an underthrust; (3) by the curvature in the trend of the folds in plan, it being assumed that the pressure must have come from the concave side of the

‡ All these residuals are for meridional deflections only. The observations of east and west (prime vertical) deflections are too few for generalization.

§ *Op. cit.*, **22**, 313 (1914).

arc. On all these grounds the Himalayas are usually regarded as having been subject to a pressure from the north. Suess, who led the way in the broad treatment of mountain systems, regarded the whole of Asia as subject to a push outwards from a centre in Siberia, mountains being thrust up in a series of arcs along the continental margin. The greatest resistance to this outward movement was offered by the rigid peninsula of India, and this dammed back the advancing earth-waves so that they reached the greatest elevation on the Earth. The alluvium of the plains filled up a great downward buckle or trough in front of the main upfold, a "fore-deep" analogous to the Tuscarora deep in front of the arc of Japan. While Suess's detailed views are not universally accepted among geologists, they do express in broad outline the general opinion. Burrard's idea of an elevation of the Himalayas by a *northward* movement of the sub-crust was therefore a most subversive suggestion. Suess in his latest pronouncement on the Himalayas * (1909) took small account of isostasy, preferring to treat crust and sub-crust as practically rigid, and suggesting that the great mass of alluvium of low density filling the Indo-Gangetic "fore-deep" was sufficient to account for the gravity anomalies.

An attempt to reconcile the geodetic observations with isostasy was made by Hayden (1913). He showed that by taking variable depths of isostatic compensation for different stations the residuals could be reduced to a series of vanishing points. This pretty statistical card-castle collapsed under the criticism of Lenox Conyngham (1914) who pointed out that the whole of Crosthwait's calculations were based on the assumption of a uniform depth of compensation, and that you could not assume different depths of compensation for the same compartment according to whether you were calculating its effect on this station or that. Lenox Conyngham, however, appears to adopt too rigid an attitude in refusing to admit any variation in the depth of compensation: such a variation is accepted as possible by Hayford, Barrell, and other American investigators.

Holland (1913) reviewed Burrard's theory not unfavourably, though with caution, briefly pointing out several "geological and physical considerations that debatably seem to fall into line" with it. Chief of these are (1) the existence of numerous tension-faults in the northern part of the peninsula parallel to the supposed rift, and (2) the great depth at which megaseisms (world-shaking earthquakes) originate, which may seem to justify the belief in a very deep-seated rift.

Oldham (1914) made calculations as to the effect on the plumb-line of a mass of low density such as the Gangetic alluvium appears (on geological evidence) to be—assuming it to fill a trough 100 miles wide with depth increasing from 0 on the south to about 3½ miles on the north (with other possible dimensions considered, as a check). He found that the effects were commensurate with the actual Crosthwait residuals. On the other hand such a rift as Burrard seemed to postulate—5 miles wide and 20 miles deep—would give very different figures. Oldham's calculations however were confined to two groups of stations extending for no great distance north and south of the Himalayan margin. He also assumed that the observed meridional deflections were the meridional components of a real deflection at right angles to the trend of the range; and justified this by reference to Dehra Dun, where observations have been taken both in the meridian and prime vertical, and the resultant (residual) deflection is actually transverse to the local trend. Unfortunately

* 'Das Antlitz der Erde,' vol. 3 (2), pp. 705–708; English translation, 'The Face of the Earth,' vol. 4, pp. 611–614.

there is a station, Jalpaiguri, in his second group where also prime vertical observations have been made, and here the resultant residual (as taken from Crosthwait's map) is 15″ in the direction E. 26° S., whereas Oldham takes it as 7″ normal to the range, which would be about E. 68° S.

Holland (1914) expanded his ideas on the formation of tension-faults in the northern part of the peninsula, remarking that "during the secular subsidence of the northern shore-line of Gondwanaland, accompanied by the slow accumulation of sediment near the shore and the gradual filing away of land above sea-level, there must have been a gradual creep of the crust in a northerly direction," which produced a state of tension and a series of faults parallel to the ancient shore-line (or to the modern Himalaya). He also expressed the opinion "that the break-up of Gondwanaland and the tectonic revolutions that followed show how isostasy can defeat itself in the presence of a sub-crustal magma actually molten or ready to liquefy on local relief of pressure. It is possible that the protracted filing off of Gondwanaland brought nearer the surface what was once the local level of no strain and its accompanying shell of tension." From these quotations we may infer that he regards the Gangetic trough rather as the effect of sinking of the crust under tension accompanied by the rise of liquefied subcrust, than of a tension-rift in a rigid sub-crust as supposed by Burrard.

Burrard (1915) returned to the subject in a paper which is largely taken up with a criticism of the view that the Gangetic trough has been actually produced by the weight of the sediment deposited at the foot of the mountains. To this he urges several objections, the first of which is absolutely conclusive:— If alluvium of density 2·1 has pressed down a floor of density 2·7 to a depth of 20,000 feet, its upper surface should be far higher than it actually is. There has certainly been very loose thinking on the part of some geologists on the subject of sediment-loading and isostatic adjustment. There are well-known cases of masses of sediment of enormous thickness (for instance, the Coal Measures) which show evidence throughout of having been deposited in very shallow water. These have been explained by supposing the weight of sediment to force down the substratum persistently to an extent equal to its own thickness; but this is quite impossible unless the yielding zone below, which allows of isostatic adjustment, is exactly equal in density to each new layer added, and that is precisely what it is not, *ex hypothesi*, least of all under a depressed area. Similarly with the rising of mountains from isostatic adjustment *pari passu* with their denudation. Both processes give an infinite series in geometrical progression with a finite sum; they cannot continue at a uniform rate. If therefore any one holds the view that the Gangetic trough has been produced by the weight of alluvium that now fills it, he is believing a mathematical impossibility. What is possible is that the loading has helped a depression due to other causes. Even this view may come under another of Burrard's criticisms. He points out that the load of alluvium is not uniformly spread, but is piled up at the points of debouching of the Himalayan rivers into the Plains. The depth of the trough however is not similarly localized, but its deepest part (according to Captain Couchman's pendulum observations) is opposite Nepaul, where the rivers are not the largest. But if the floor on which the sediment has accumulated is a northward extension of the Indian Peninsula, it would itself have an uneven surface, and would be sufficiently rigid to bear the unequal loading by strains in its own substance and transmit it in an equalized form to the yielding sub-crust.

Another interesting point made by Burrard is the analogy between the

Gangetic trough and the Tuscarora Deep (off Japan), which has sunk to a depth of 27,500 feet without the help of any load of sediment. This argument would be more convincing if there were better evidence that the Gangetic trough had once been occupied by the sea; but the upraised Siwalik strata that were first deposited in it include no marine sediments, and the chief evidence has hitherto been the existence of closely allied species of freshwater dolphins in the lower reaches of both Indus and Ganges. Burrard refers to the "swatches of no ground" or very deep channels off the mouths of Indus and Ganges as submarine continuations of the rift. That in the Arabian Sea is in line with the Indus depression, but that in the Bay of Bengal is rather parallel to the Gangetic trough than a continuation of it.

In the further part of his paper Burrard explains more fully his own theory, and by not insisting on a depth of 20 miles and width of 5 for his rift, brings the latter more into harmony with what geologists would regard as probable. He incorporates a note by de Graaf Hunter on the conditions of a cooling earth, in which it is argued that there must be a zone or shell contracting more than the zones either above or below it, and therefore in a state of tension: the cracking of this zone and consequent adjustment to it of the crust above are regarded as causes of deformation in the latter. The criticisms which the geologist would make on this argument would be, firstly, that variations in physical conditions, such as density and, above all, thermal conductivity, of different zones of the sub-crust must modify this simple argument; and, secondly, that it has to be shown that the zone of tension is sufficiently rigid to crack, instead of yielding by plastic deformation.

Oldham, in a memoir just received, makes a very elaborate study of the whole question. In this, after a preliminary discussion of the problems awaiting solution and the nature of geodetic methods, he calculates the effects of an imaginary range of simple step-like form, sufficiently near the form of the real Himalaya to give approximately the same gravity-effects. From this he proceeds to determine the real form of the Gangetic trough on the geodetic evidence, and concludes that it is about 20,000 feet deep between 80° and 84°, and again in the Upper Punjab, but not more than 15,000 feet in the longitude of Delhi. This shallowing is probably not due to unequal sinking but to the continuation, across the trough-floor, of the Aravalli Mountains, which appear also to enter into the Himalayas beyond. The greatest depth is not necessarily close to the Himalayan margin, but may be some distance further south. Thus his cross-section of the trough comes to resemble more nearly that given by Burrard. As to the lateral extension of the trough, Oldham finds it to continue to Assam on the east and the Salt Range in the north-west, its southern edge being for the most part concealed under alluvium towards these two extremes: it does not therefore bend round as do the alluvial plains, which overlap it towards the Arabian Sea and Bay of Bengal, but is bounded by a hidden rock-barrier beneath them, the geological evidence here confirming the geodetical. For these reasons Oldham speaks of it as the Gangetic, not the Indo-Gangetic trough.

He then proceeds to discuss the support of the Himalayas, and concludes that there is over-compensation in the Central Himalayas and under-compensation in the outer region, the strains thus produced being well within the limit which the rigidity of the crust can support, on Barrell's calculations. To a further alternation of over- and under-compensated areas under the plains and northern Peninsula respectively, he attributes the geodetic anomalies of the "hidden range" of Burrard. Evidently, however, this provides us with a

generalization on the anomalies, rather than with an explanation of them. Finally, after considering every theory yet proposed to explain the tangential pressures that produce the mountain-folds, he dismisses all as inadequate.

Here for the present the matter rests. It cannot be said that there is any agreement as to how the Himalayas were raised or the Gangetic trough formed, and yet there seem to be signs of reconciliation between divergent views. Much remains to be discovered before a settlement can be reached. More geodetic observations are needed—more among the high Himalayas as urged by Oldham ; new observations at pairs of stations near in position but differing greatly in altitude as suggested (among other proposals) by Barrell ; more prime-vertical observations to combine with those in the meridian. All this the Indian Survey will give us in time, and geodesists in other countries will deal with other mountain ranges. Meanwhile geologists will find scope for the scientific imagination in devising new theories of mountain-formation, since none of the old seems to have survived criticism ; and areas of tension as well as areas of compression will need study, in which geodetic results must be given the attention they deserve.

When we consider the high level of ability shown by this group of authors whose work we have tried to summarize, and remember that all are or have been in the service of the Government of India, we may express the hope that the reputation of the Indian Surveys may be maintained in the future, and that neither the pressing need for investigations of immediate practical value nor the desire for economy may prevent the continuation of work upon these broad problems—work which will assuredly prove eventually to be not devoid of practical importance.

A. MORLEY DAVIES.

REVIEWS

EUROPE

Itinerari Albanesi.— Antonio Baldacci. The Royal Italian Geographical Society, Rome. 1917. *Maps.* 10*s.* 6*d. net.*

SIGNOR Antonio Baldacci undertook his journeys chiefly in the interests of his own science—botany. But the field of exploration afforded by Albania attracted him, as he acknowledges in his preface, not only because of the peculiar opportunities it presented for botanical research work, but also because of his ambition to study at first hand " quel forte virgulto superstite del grande albero etnico adriatico." The result is a book of uncommon interest, narrating in detail the eight journeys he undertook in this little-known part of Europe between the years 1892 and 1902. A man of science before anything else, his book chiefly impresses by its sense of scientific accuracy and acute observations of fact, wherever it tells of places personally visited by the author. At the same time Signor Baldacci's wide and human interests, and his evident enthusiasm which infuses itself into his style, scarcely allow the reader a dull moment. His journeys cover a wide area of Central Albania, south of Berat ; of Epirus ; of the interesting and beautiful country of Pindus and Grammos inhabited by Vlachs ; of the country of the Catholic Mirditi ; and of the Maltsori tribesmen on the border of Montenegro. A general review of Albania, giving an account of the Albanian and Vlach characters, their manners and customs, and of the country's resources, is contained in the admirable introduction. " The impartial student of this primitive soul," he concludes, " from whatever point of view he may approach his subject, cannot but form the

The Geographical Journal

Vol. LI No. 6 June 1918

MY SECOND YEAR'S JOURNEY ON THE TIBETAN BORDER OF KANSU

Reginald Farrer

(*Read at the Meeting of the Society*, 11 *March* 1918.)

THOSE of you who heard me when I previously addressed the members of this Society left me safely established for the winter of 1914 in the city of Lanchow, which is the capital of Kansu. Starting from Lanchow I had in the preceding summer gone up the pass as far as Siningfu, within three days' journey of the great Sacred Lake of the Koko-Nor. From here I struck up into the mountains to the north, and spent the summer working the ranges of the Tatung Alps to and fro. At the end of the summer I returned to Lanchowfu, and thence, across various cross-country roads, went down through Tsinchow Kan to Weihsien, on the extreme southern borders of Kansu, on my way down into Szechwan.

I spent the winter of 1914 in Lanchowfu in a state of enforced idleness, counting every day until the spring once more returned. For winter in North Central Asia is a hard trial; there are days of blazing brilliancy, and bitter nights of hard iron frost; a beautiful climate, a healthy, a wonderful and exhilarating climate, but not for the botanist, who always wants to be out once more to the flora on the hills. Therefore I found those days of winter in Lanchowfu hard to bear, with the cold growing every day more intense, until, in mid-winter, for about a month between December and January, the enormous volume of the Yellow River itself, the Hwang-ho, is frozen so solidly across that you can take carts from one side to the other, as the people do. Gradually the accumulation of ice on either side of the Yellow River grows thicker and thicker day by day, till finally there is only a small channel in the middle, and at last none at all, the whole river being a solid surface of ice. Towards the end of February the break begins; dust-storms occur as the great deserts of Northern Asia awake from their winter sleep, and gradually the frosts relax upon the banks of the river, and you hear the kites buzzing and whistling in the willow trees growing every day more green, until at last you begin to feel that before so very long it will once more be time to start upon the trail for the hills.

I need not tell any one who knows China that all up Western China,

up Western Yunnan, Western Szechwan, Western Kansu, there is an enormous and densely populated belt of Chinese Mohammedans. They are not Chinese in origin at all; they are probably of some Turki race. The legend goes that in the ninth century one of the Emperors of the T'ang dynasty imported these men as mercenaries to serve him in some war, and after they had served their turn they proved, as mercenaries so often do, rather too hard a handful to cope with. They were then established with some difficulty in the western provinces of the interior, in what the Government thought would be a seat sufficiently remote from the centres of civilization. However, these Mohammedan people, having increased to an enormous extent, now constitute a permanent and ever-present political danger. In the fifties of the last century they rose in a rebellion which wiped out of existence all the civilization of Western China to the borders of Tibet, and cost the lives of more than two million of the Chinese population. After that there came a quietus, a moment of repose; but the Mohammedan populations have gathered together again, and there can be no doubt that, sooner or later, the Chinese Government will have to cope with a recrudescence of the Mohammedan peril in Western Kansu. In troubled times, such as those when I visited the frontiers, the problem comes home very pressingly to one; the Chinese are always at loggerheads with the Tibetans; the Mohammedans with the Tibetans and Chinese; so that the lot of the stranger within those divided gates is not always of the easiest, or his path the most secure.

I, with Purdom and my three Chinese servants and our little caravan, took the road up the bed of the Yellow River on March 29, in bitter cold weather, going up through a dreary desolation of country. For all that land round the Hwang-ho is in winter and early spring the very abomination of desolation. You have a waste of pebbly flat fields down by the river, and then on every side crumbling mud-coloured fells, with no blade of grass or sign of any living thing; desolate, serrated, arid, without rain, and without prosperity. Down in the valleys the population remove the stones and try to make little corners for the cultivation of corn and grain; but the only fruit tree they grow is the spiteful thorny jujube. And even so, all they can do is only by means of huge irrigation water-wheels 30 or 40 feet in diameter, which perpetually revolve, raising the waters of the Hwang-ho so that they flow down by inclined channels out on to that stony thankless country.

The earliest of the many interesting monasteries we visited this year is called the White Horse Temple, carved out of the solid side of a tall red sandstone cliff; and down below this grotto, painted pale blue, there is a colossal bas-relief of the Buddha. This is the first Buddhist landmark on the way up to Siningfu. The city of Siningfu itself is the last and most important Chinese city on the north-western frontier; it is the gateway between China and Tibet, and not only the seat of a very

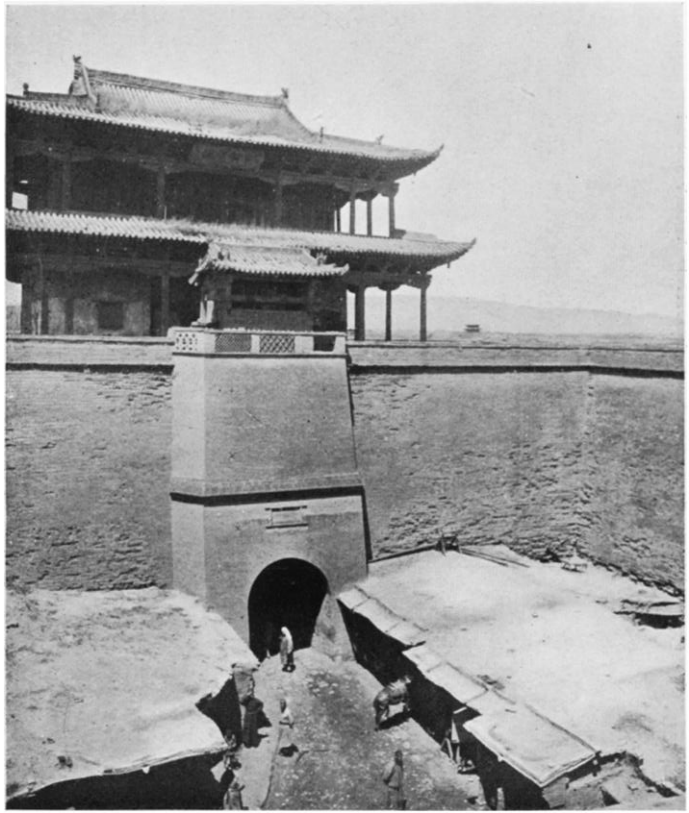
important governor, but is also now the seat of the Viceroyalty of Koko-Nor, that famous Holy Lake, or rather inland sea, which lies up over the Tibetan border, but yet is in the possession of China. It is some generations since there was a Chinese Viceroy appointed to preside over the lonely lands and the perilous wandering tribes of the Koko-Nor. The post was remote and very uncomfortable; in due course of time the governors of Koko-Nor Tibet discovered how very much more profitable it would be to leave those lonely wilds and return to the comparative safety of Siningfu. So that at the time I was there, and for generations previously, the Viceroyalty of the Koko-Nor held its palace safely within the walls of Siningfu, though no one was supposed to be officially aware of the fact.

The city of Siningfu is one of those very few Chinese cities whose walls do not form a perfect rectangle. The reason for this is an ancient and most pathetic one. When the walls of Siningfu were building there came along one day a dragon. The dragon was tired, and he lay down against the wall, and found it so comfortable that he snuggled round and bulged it all out of shape, with the result that to-day the walls have a wavering line along one side. When His Holiness the Dalai Lama came through the city on his famous visit to Peking he had to be hauled over that wall in a basket, the reason being that the Dalai Lama is of such exalted sanctity that on no account can he pass under a doorway or an arched gate. Consequently, all the way up from Lanchowfu to Siningfu you will find all the little wayside arches decapitated, in order that the Dalai Lama might go through without compromising his holiness. When, however, you arrive at Siningfu you will see that the problem of demolishing these walls was such as to baffle the utmost piety; and accordingly they put the Sacred Body in a basket and pulled it up over the wall. When he reached Peking the same problem confronted him, but he probably reflected that the immediate neighbourhood of the old Grand Dowager-Empress was no very comfortable place for indulging ecclesiastical pomps. In any case, he solved the situation there by entering the imperial city by train.

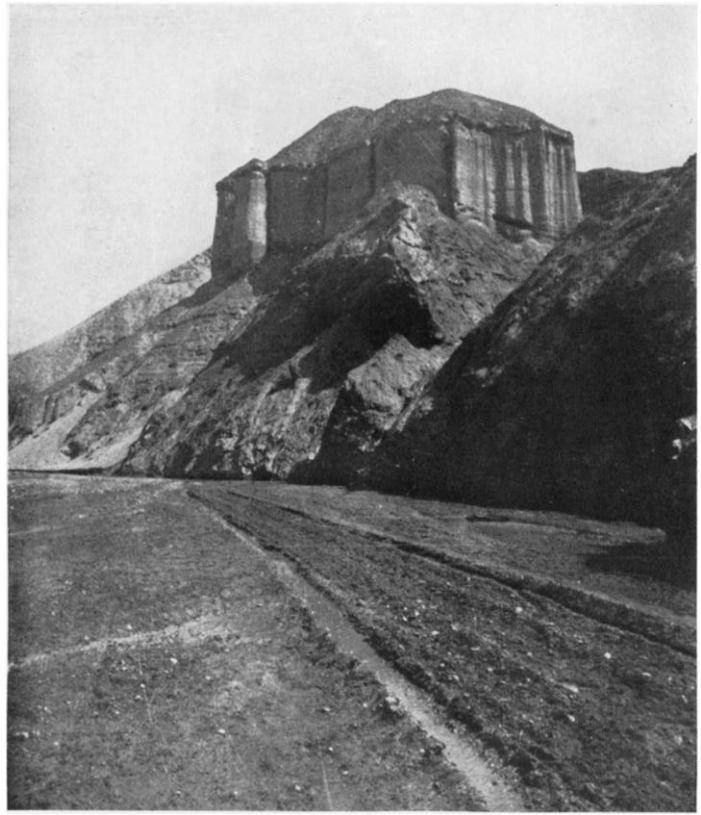
I apologize for tarrying so long in Siningfu. I myself was held up there for no less than a month. It appeared that even April was far too early to visit the heights. There was Siningfu lying sunbaked in the valley of the Sining River among the pale yellow lifeless hills, with no sign of the Alps anywhere near. But even so that country was all so densely wrapped in winter that it was perfectly obvious to me that there was no use in proceeding up into the mountains. So that in Siningfu I was lodged in the small dark inner yard of a Chinese inn, and reduced to spending a month in strolling about the city. The flat roof is characteristic of Siningfu. When you emerge from your ladder through the upper stairway you come out on to a universal flat mud roof, and wander over half the city, peering down into each successive private courtyard until deterred by the limits of

discretion. In each of these little courtyards you will find lilac, jasmine, and beautiful shrubs, and the lady of the house sewing her socks or making her shoes. The Temple of Confucius is the finest building in the city. The woodwork and its roofs are characteristic, of brilliant green tiles, so that you may imagine the effect it makes; and in the distance all round are the outlines, with no suggestion of life upon the universal desolation, of those far dry fells which envelop the city. However, as the days went by, signs of spring began gradually to appear. The lilac began to bloom in the courtyards, and in due course there came into flower one of the most beautiful and important of the shrubs that I have been able to introduce into cultivation. This is a plant which for the first time I found wild in 1914, in a small district on the Southern Kansu border, but which is a very famous and popular culture-species all over Northern China. Until late years it was reserved in Peking for the Palace gardens, for the special pleasure of "that worthy gentlewoman and notable lover of these delights," the Grand Dowager-Empress; but since her death you will find it on sale even in the nursery gardens. *Viburnum fragrans* promises the best results in cultivation in England. It flowers before the foliage in early April—I dare say in England it may be May—with clusters of very brilliant white or soft pink flowers like a white or soft pink lilac, with all the entrancing fragrance of heliotrope. You can well imagine, having been told its habit and range, that it is one of the most hardy and indestructible of all flowering shrubs of northern lands.

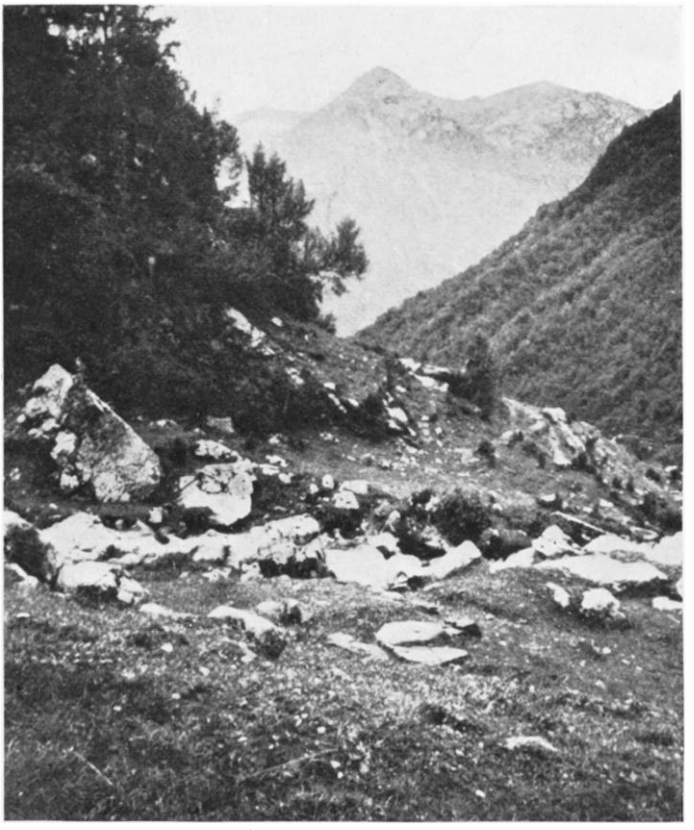
So ended, about May 1, my long delay in Siningfu, and we embarked on our exploration of the Tatung Alps, which, as you know, are a range of mountains very rough and irregularly arranged, which pursues the course of the Tatung River, flowing from north to south-east, away above Siningfu and at the distance of two or three days' journey. I take you down the bed of the Sining-ho, then up the equally barren lifeless valley of the Weiyuanpu-ho, until you come to the little town of Weiyuanpu itself, interesting as being the centre of one of those curious aboriginal tribes which are still to be found scattered here and there up among those mountains which make the vague borderland of China and Tibet. These people are in type very dark and densely hairy, quite unlike the Tibetans and the Chinese. One of them was in my service for the summer: the Chinese call them Tu-ren,—"Children of Earth"—*i.e.* Αὐτοχθονες. Their women, of whom I was never able to secure a successful photograph, because they always run from the camera, are conspicuous for the magnificent clothes they wear. They stride about the country—great strong hussies that they are—dressed in rich robes of scarlet, blue, and grey, with broad leathern stoles adorned with white plaques. And on their heads they wear an erection which I can only compare to the coiffures obtaining in the court of Isabeau de Bavière, or the thing you see on the head of the Duchess in 'Alice in Wonderland,' a top-heavy concoction of bright blue, with a veil of scarlet running across it and falling



EAST GATE AND GATE COURT OF SININGFU FROM OUTER GATE TOWER



ERODED RED CASTLE CLIFFS ON GREAT NORTH ROAD TWO STAGES OUT OF LANCHOW



HIGH UP THE SOUTHERLY VALLEY BEHIND WOLVESDEN HOUSE

WOLVESDEN HOUSE

down behind. You may judge of the picturesqueness of these robes and how anxious I was to obtain a good photograph of them.

Weiyuanpu lies almost at the foot of the Alps, and I now take you into the foothills approaching the pass that leads over from the Weiyuanpu side of the watershed down into the valley of the Tatung River itself. You have to understand that all this land, though it may seem level and dull, and its hills merely insignificant downs, in reality runs extremely high. You can go to greater authorities for the exact heights of Lanchowfu and Siningfu, but above these the country rises steadily though imperceptibly towards the mountains, and when you are at Weiyuanpu you should already be between 8000 and 9000 feet up. It lies on sloping ground, evidently the debouchure of former dead rivers from the gullies of the main range behind. You see signs all about the district of its enormous age, and as you cross along the ribs of the foothills you traverse what are now quite small and insignificant becks emerging into immense deltas very often as much as 3 or 4 miles wide, and now full of stones, giving evidence of a very much more rapid fall from the hills behind in times past.

All this is bare, rather dry land, covered with the scanty scrub of the lemon-scented edelweiss: and when I first entered it, it gave me a sense of depression, in that instead of being limestone, it was obviously of the old azoic rocks on which there is a scantier and much less interesting flora than on the limestone. But there are also occasional masses of dolomitic limestone. On the crest of the pass looking upwards towards the peak which has no name—this is probably Prjevalsky's "Sadisoroksum," to which he gave a height of 13,000 feet—there are many flowers, and in the distance you see the limestone breaking up with extraordinary abruptness out of the main mass of the rock.

There grows here a lovely little flower collected in dried specimens by Prjevalsky, but never before introduced to cultivation. It is *Primula urticifolia*, with flowers of a soft bright pink, growing in the damp shady crevices of the mountain limestone in its rare outcrops in the Tatung Alps. This, I am glad to say, has not only been successfully introduced, but shows every sign of prospering under English cultivation. *Primula Farreriana*, in its way, is an even more splendid plant, and is entirely new. It is also under cultivation, although we are not able yet to be sure how kindly it will take to the conditions of our gardens, considering it is always found, and only found, in the hard crevices on the shady faces of the mountain at great elevations. The flowers are of a very soft lavender-blue, with a dark claret-coloured eye, and of extraordinarily sweet fragrance. The leaves are heavily powdered with white on the under side; and altogether my name-child in this royal race is a very notable and sumptuous introduction.

We now descend on the eastern side, facing a high range, and down into the wooded ravines of Wolfstone Dene, until we come to my summer house during 1915; which, in point of fact, was the third and only possible

residence among a series of four small mud mule-inns built to serve the scanty traffic which comes over the pass between Lanchowfu and Siningfu on the south and Pingfan and the Great Road on the north. Nor let any one rashly blame me for giving pass and valley an English name. Langshihtang is nothing more nor less than "the Valley of Rocks and Wolves"; for which it is less cumbrous, and no less accurate, to speak of Wolfstone Dene, Wolvesden Pass, and Wolvesden House.

I rented Wolvesden House for the exorbitant rent of *2s. 6d.* for six months. I fitted it up and adjusted it, making windows out of spoilt photograph plates, and altogether contrived a summer there of extreme comfort and happiness. We arrived early in the year. In front of the house there was a stony lawn which was full, in time to come, of globe-flowers, pink geraniums, and the hyacinth-scented iris. I will show you now the view as it greeted me on my first arrival there when the hills were still frozen in the first days of May. There you see *Primula stenocalyx* exactly as it was growing on a little crest within a stone's throw of Wolvesden House. Among its uncounted multitudes you get flowers of lavender-blue, combined with the most delicious fragrance. Indeed, it is not quite certain yet whether among the seed I sent there may not be two distinct species. The aneroid—an instrument to which it is sometimes said that I do not pay sufficient attention—reports Wolvesden House to stand at a height of 11,000 feet, a statement which my own heart to a certain extent confirmed by the trouble it gave me during the first fortnight I was there. And hereabouts and down the Dene one gets a form of the primula which is entirely green-leaved, with soft purple flowers, whereas on the passes high up you get what appears to be the same plant with the leaves and stem densely clothed in a white powder which greatly enhances the charm of the blossom. The flower does not greatly differ, but as you collect different forms in both the types you find many that vary considerably in their degree of beauty and roundness of blossom and clearness of tone.

Wolvesden House I made the centre from which I took excursions, working the different valleys and ranges. All round that district there is nothing but absolutely uninhabited mountains, except up in the southerly valley immediately behind Wolvesden House, where there lived one little old Tibetan lady tending her kine from her yak-hair steading on the alp. That little old lady was my first, almost my only visitor, at Wolvesden House. She came down from day to day, grubby but full of charming kindliness, attended by her splendid strapping grandsons; and all through the summer she kept me supplied with the best butter, milk, and cream, inexorably refusing to take so much as a penny in payment. But as the summer wore out and our debt for the butter grew heavier, it at last became clear that she wanted something. What she did want was a glass bottle! She did not want a nasty opaque black bottle such as whiskey lives in, but the nice clear white diamond-like bottle inhabited by gin. And

it so happened that by the mercy of Fate I was armed with both those kind of bottles; therefore I was able to make completely happy the heart of grandmother Aoo. People do not realize over here that the possession of a glass bottle to those on the Tibetan border is what the possession of two diamond tiaras and a jade necklace is to a woman of London or Paris. I have no doubt that grandmother Aoo, who when we left Tibet was the glad possessor of more than a mere brace of bottles, is now spending her life giving garden-parties, and arousing the bitterest enmity of all her neighbours by the display of the treasure she got from us.

Another of my neighbours at Wolvesden House was the great rosy red *Incarvillea grandiflora*, which lives on just those same warm earthy banks near Wolvesden House where the *Primula stenocalyx* grows. Then there is my own aster, *Aster Farreri*, which of all the asters appears to me to be one of the most beautiful, only beaten by the much more magnificent A. Falconeri, which I have so far found nothing like so robust in growth or so perennial in habit.

But when I first reached Wolvesden the aster was still asleep, and it became plain that not even yet was the time ripe for exploring the High Alps. So we resolved to continue on our way down on the other side towards the Tatung river, to make a tour of the big monasteries that lurk among the ranges; and so return at last to Wolfstone Dene by the time that summer should be high on the hills. The Dene runs for some 10 miles, winding deep among the wooded hills towards the warm lands of the Tatung. The rough track climbs and dips above the beck, through the copses. At one point there is a holy well, springing in pools among mossy boulders at the foot of a cliff, on the face of which a frescoed Buddha sits throned in glory.

Here, owing to the influence of the surroundings, the beautiful golden globe-flower of these regions had turned pure white. Of *Trollius pumilus Perfectissimi* there were only those two specimens, growing on a ledge above the holy well; they were collected with great care, they went all down the country to Peking, they spent the winter there, came with me all the way across Siberia, and now, I am thankful to say, are both flourishing in Yorkshire.

After a long and weary wandering down the gullies of Wolfstone Dene we came at last to the Tatung river, and there we saw the arched Tibetan bridge as it spans the water from side to side. The Alps were far behind us, and we were in the hot dry land once more. And all the burning lawns, scorched to brownness by the summer, in early spring are one rose-coloured sheet of *Androsace tibetica*, peppered in pinkness among the scant turf. The great bridge was built by, and is the property of, the monks of Tientang Ssu. They have a toll at each end. It is a rather unsatisfactory construction, and I was always very glad when a heavily laden mule was safely across it and embarked on the further path, which, by a vastly circuitous route, climbs far up and over the whole huge down

beyond before descending at last again to Tientang Ssu in the plain of the river.

But one can take a short cut to Tientang Ssu. And I remember painfully one day when, knowing as I did the hours and hours it took to climb over those downs, and so round the bend and down to the river again, I made up my mind I would follow that short cut. I asked the Chinese, "Is it a good road?" "Oh yes, it is a very good road," they replied. I must confess that I have never been so completely terrified as when taking that "very good road" to Tientang Ssu. Tientang Ssu means the "hall of heaven," and perhaps I may have been too optimistic about my past virtues, but I certainly felt I had indeed taken a very short cut towards the "halls of heaven." In any case, I should never have achieved that journey if I had not had with me one of my best Chinese servants, because the track made its way all down the bare face of the cliff in very small notches, worn smooth as ice by countless generations of bare Tibetan soles. Had he not climbed down ahead of me and carefully arranged my feet in each one of those holes I should probably not have had the privilege of addressing you to-night. The short cut, therefore, is not to be recommended on any account except that of brevity.

In the wooded gorges along the downs you get very beautiful flowers, among them the beautiful Atragene clematis, which you find here and there in the woods on the downs round Chiao Tor, with flowers of a most exquisite pale china blue, and the centre of a waxy, creamy white. This again, you will be glad to hear, was successfully introduced, and appears to be thriving well. From the top of the downs you descend at last upon Tientang Ssu, which, as I say, means the Monastery of the Halls of Heaven. It lies in a perfectly flat plain of grass, as it might be a great race-course. The monastery itself stands back in the bay of a series of red sandstone precipices, while the hills behind, in a semicircle, shelter it from all the cold winds. Consequently, it is one of the warmest and most fascinating places I have ever stayed in. The monastery is more like a town of little low white-washed houses, with here and there big churches rising up in their midst; and all in front of it extends a perfectly flat grassy plain which in May and June is one blue sheet of *Iris ensata*, in the Tibetan form, of pale china blue with creamy markings on the falls, so sweetly scented that as you wander through the dense swishing jungles of it you might be walking through a field of hyacinths in Holland, the scent is so exactly the same. I can assure you that if anybody wants a place of warmth and comfort and peace away from the disquietude of Europe they may do very much worse than make for the "Halls of Heaven." In Prjevalsky's accounts the name of the place appears as "Cheterton." This I had long suspected, but one day as I was sitting with an old monk outside the monastery I heard him murmur, "Chorten Tang," and thus I learned that while the "Hall of Heaven" is the Chinese name for the monastery, Chorten Tang, or "Hall of the Chorten," is its

Tibetan equivalent. Chorten Tang is obviously what had been meant by "Cheterton." The Pilgrims' Path marks the precincts of the monastery, the whole circle of it being about 4 miles. In the afternoon of a summer's day you see the monks and all the pious population of the neighbourhood making the round, visiting the shrines, telling their rosaries at the appointed places. There go the monks or acolytes at their devotions, or some woman who wishes to have a baby performing devotions around the shrines. The lady puts on her best clothes, with stoles of leather, and on her back the Holy Scriptures strapped. She makes her pilgrimage, kneeling and bowing from point to point. Sometimes you see a monk or acolyte performing the very common penance of the Tibetan devout, in which you make your pilgrimage by means of prostration. You raise your hands to your head, you then fall forward with your hands outstretched as far as they can be; then you get up, raise your hands again, and flop forward once more, and so continue. It used to interest me to watch the little boys. While the old monks were watching all went well, but when they started to read their Bibles or diverted their attention the little boys would look cautiously round and take a surreptitious jump.

Leaving Tientang Ssu, in due course we made our way up the Tatung River and over by the rope ferry (impracticable in the summer floods), and back again towards the other side of the range and the noble Abbey of Chebson Ssu, traversing high on the mountains along the pass which leads from Gan-Chang down to the uplands of Weiyuanpu, and so at last along over the ribs and deltas of the Alps and their dwindled becks, to Chebson. Chebson (which is Prjevalsky's Chobsen, Chebsen, Cheibsum) lies in a green hollow of the open downs. It is a modern growth, but rich and powerful, with a very fine (but jerry-built) main church surrounded by a wide cloister precinct. The guest-cloisters, upper and lower, are spacious and stately to match, and all round are the separate private houses of the various dignitaries. The Abbey of Chebson Ssu is much wealthier and more illustrious than that of Tientang Ssu, and while I was there a very august Living Buddha was in residence, guarded by a retinue of soldiers from Peking. The whole atmosphere was one of wealth and leisure, such as one could only compare to some well-endowed Oxford college. They put up their honoured guests not only free of charge, but also at the end of your visit present you with a tip. Several hundredweight of perforated pence, amounting in value to about 2*s.* 6*d.*, were pressed upon me by the sub-Prior, and, after much hesitation, I had at last in courtesy to accept the offering and go my way with profound thanks.

A peculiar feature of the decoration of the monasteries in these parts is a dark band which is composed of brushwood densely packed and then cut off short, which gives the effect of a solid belt of rich brown. Round the main church stretches a wide lawn, hedged by the gallery of the cloister, with a set of invocation wheels running the whole way round.

As you go turning these wheels (a modern donation) their hollow clank clanking reverberates in the ample peace. The church itself is a great block of rose-red brick, curiously suggestive of a big country house, were it not for its elaborate roof and roof-ornaments of brushwood, dark on the red, and adorned with bucklers of gold bearing sacred signs. Even the dragon-mouthed waterspouts are of gold, or gilded. Within, the church is filled with a cold glacial smell of incense, butter, and sanctity: its bulk towers up in a clerestory in the middle of the mass, with a roof running round, enclosed by long galleries full of libraries and stores.

I did not ever see the highest dignitaries of the place; one hardly ever does. But I made great friends with the Prior and sub-Prior, who used to come every night to my rooms. Here, after the fatigues of the day, an occasional whiskey and soda was not found wholly unacceptable, in fact, at the hour when it was found least unacceptable these old men would infallibly turn up and loiter round, and murmur in wistful tones, "Foreign wine, foreign wine." I was inclined to accede to their request but Purdom restrained me, saying, "No, they are holy men; they have taken the vow to abstain from alcohol," so that I never dared offer them anything. And so they always used to go away sadly, unconsoled, rubbing their stomachs, and still murmuring, "Foreign wine, foreign wine." However, you will be glad to hear that they won their point in the end. I suppose the ecclesiastical mind always runs in very much the same groove in every creed and climate. For they hit at last upon the admirable apostolic idea of requesting a little wine for their stomachs' sake, after which, from a purely medical point of view and quite successfully, I was able to prescribe alcohol to the required extent.

We now go back to Wolvesden, on our way up to the great heights of the Alps above. One of the commonest sights that you meet with in the alpine herbage is what I call the lamp-shade poppy (*Meconopsis integrifolia*), with fine pale yellow silk-like flowers, much prettier in its kitten stage than when fully developed. Sometimes it is 4 feet high, and looks very lumpish and enormous. On one occasion, away up in a fold of the fell, its masses were so pale and large that I took them, from afar, for baby donkeys.

Now we are climbing up on the Alps above Wolvesden, which lies about 2000 feet down in the gorge. Allowing Wolvesden to be 11,000 feet, I should put these heights at about 14,000 feet, if not more. The world here is a mere waste of desolate scree and snow, with very little vegetation at all, but here and there occurrences of one very precious thing, another new Primula—the Little Queen, *P. Reginella*—which I have only found growing at great elevations on the rims of grass-tussocks and along the lines of cool boulders. There is another treasure of those heights also, *Androsace mucronifolia*, with flowers of milky-white and golden eye, and an entrancing scent.

From a crest which I call Crest Royal, we dropped over on the other

side into a wide grassy hollow about 3 or 4 miles across. This dip is all moorland turf, and in early August, as far as you can see in every direction, it is one shimmering radiance with the pale blue bells of the harebell poppy, soft lavender-blue. And they make a picture which, though I have seen many beautiful pictures in alpine regions, cannot, I think, be beaten by anything I have ever seen anywhere in the world. When I saw them in early August in that region there was nothing that one could say before such beauty, so incomprehensible and inexpressible. I had Purdom with me, and we were both perfectly quiet in the face of such a spectacle. I wondered to myself what he was feeling, or how at last he would try to put into words the pain of a pleasure so intense. Then, after the silence had grown too heavy, he turned to me and said in a half-whisper, "Doesn't it make your guts ache?" It was exactly right: no other words could have nailed the truth so absolutely.

We ascended above the Alps to what I call the Clear Lake, and on the edge of that lake, at some 15,000 feet, I pitched my tents for the time necessary to explore. All that region is the abomination of the most complete desolation. There is hardly any life there. But one of the beauties that does exist is the bright blue poppy, blue as the sky of a frosty dawn, covered all over with such sharp spines that when you go to collect it you need to put on the thickest gloves that you have.

I crossed the shingle side of reddish rock on the far side of the Clear Lake, and there found an interesting thing. When I got to the middle I heard the roar of a river down beneath, but there was absolutely no sign of its presence nor of its entering the lake below. It is still a problem in my mind as to where the water was going.

We also found another form, perhaps a different species, of the thorny azure-blue poppy. And among other children of those high desolations was one of the most glorious delphiniums, probably *D. Pylzowianum*, with flowers of an intense violet-purple. On Wolvesden Pass it grew in dense masses, in little bushes about 9 inches high and a foot across, in such multitudes and so thickly that for several miles away you could see it all up the pass like a purple haze, among which there rose up the azure-blue spikes of the celestial poppies.

There was also the pure blue gentian (*G. triflora*), which in August grows so abundantly over all the Alps that it covers them with a pale milky sheet of colour. We found a brilliant golden saxifrage, too, and a new primula (*P. gemmifera*), with an exquisite fragrance and flowers of a soft pale pink, growing commonly among the loose earth and stones on the open places of the Alps.

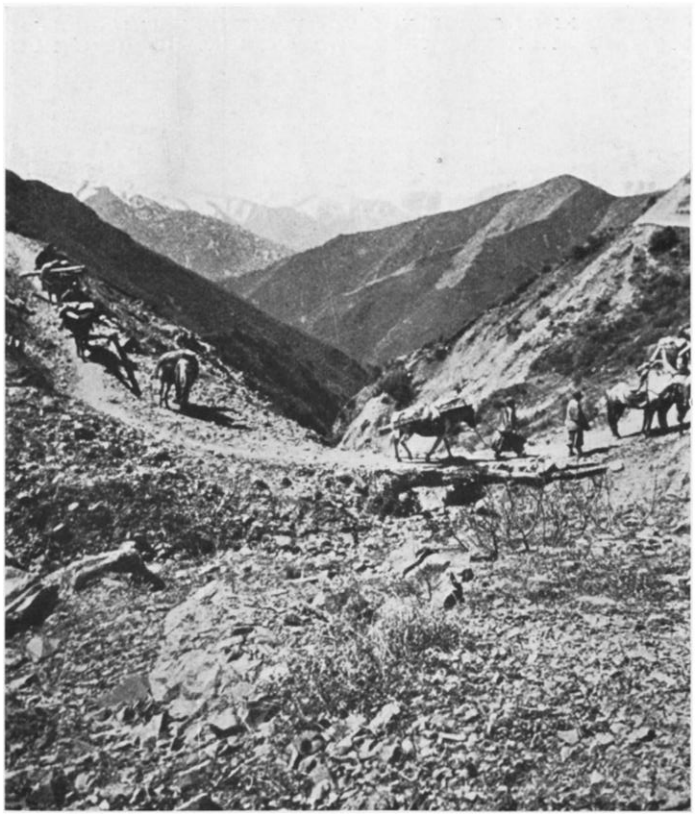
So at length we went down into Wolvesden once more, and up the southerly valley behind the house, the rocks of which are covered with *Isopyrum Farreri*, which is one of the most beautiful plants I saw the whole time I was there, or, indeed, anywhere. It grows in the crevices of the limestone rocks at any elevation from 9000 to 14,000 feet, with

flowers of a very rich iridescent lavender-purple with a golden centre. That again, I am glad to say, is very successful under cultivation here.

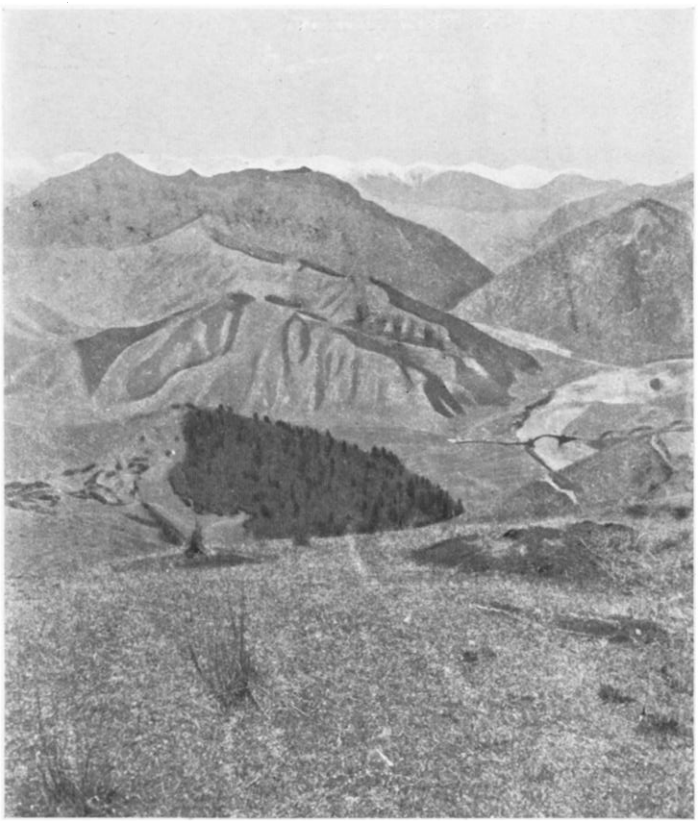
The summer coming to its close, we moved away down from Wolvesden on our way to Tientang Ssu, and thus back to Lanchow. I show you the morning scene of my last visit to Tientang Ssu, which I spent in the house of the sub-Prior, a most benevolent person, as also was the Prior. In the distance one can see the sun-burnt hills and the spurs of woodland through which the Tatung makes its way, at the point of juncture with the stream from Wolfstone Dene.

After a day or two of dry river-beds and hot bare lands we crossed over a series of high green downs rarely rising to much more than 9000 or 10,000 feet, on which I completely despaired of finding any more plants. And yet there on the crests at two points I found *Gentiana Farreri*, which is the most triumphant record of my expedition. I had already found my own gentian in Wolvesden and on all the Alps, but never in anything like such abundance. On these little saddles the plant was growing so densely that at no point could you put your foot upon the ground without squashing half a dozen blossoms. And when I tell you that these are of the most violent Cambridge blue, that they shine at you from half a mile away across the field, you will judge *Gentiana Farreri* a treasure worth having, and a treasure still more worth having in that, unlike most of its kind, it turns out to be one of the most vigorous, satisfactory, hardy, and prosperous in the whole race, so much so that from my own seed of 1914 I have seen a plant of it at Edinburgh 3 yards across with something like three hundred sumptuous great trumpets out at once, remaining open alike in rain and shine.

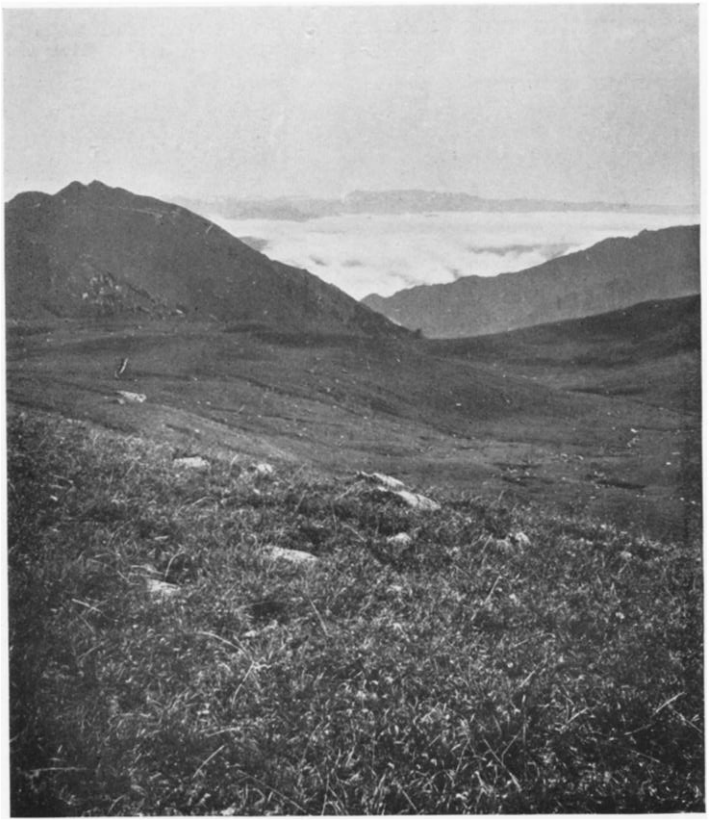
In due course I left Lanchowfu towards the beginning of October, on my way down across the loess lands of Central Kansu towards the borders of Szechwan and Shensi. Close to the borders of Szechwan we found a very delightful place called White Waters, one of the most picturesque Chinese country towns that I have ever struck. There you have a town tower, very close to the yard of the inn in which I was actually living. Down there the smells are so intensely suffocating that I myself took refuge in the stable loft. At the same time I should like to add that you only get this disadvantage when you have left the clean, open windy lands of the north and come down to the summer warmth of the southern country, with houses made of wood, and every disadvantage of dense population very much accentuated. Below Paishuikiang (Bei Shui Jang) occurs a dull little range—or set of ranges—rising not more than 8000 feet, called the Tapa-shan (Da Ba S'an), which form a sort of connecting link between the Tsinling-shan and the mountain fringe of the Tibetan highland. And as soon as I set eyes on it I knew all my hopes of finding a new species of primula were to be disappointed. I despaired, however, too soon. As day after day we crossed little ridge after little ridge, I kept my eyes open, and one fine morning I came upon the home of a new primula which is so like



ON THE HIGH PASS BETWEEN GANCHANG AND CHEBSON: WOLVESDEN FAR DOWN VALLEY IN MIDDLE DISTANCE



DA-TUNG ALPS AND COURSE OF WOLFSTONE DENE TO JUNCTION WITH DA-TUNG HO ABOVE BRIDGE



HIGH BASIN IN THE DA-TUNG ALPS, THE HOME OF MECONOPSIS QUINTUPLINERVIA: GADJUR RANGE IN DISTANCE

ASTER FARRERI *Sp. nova*

Primula sinensis that I thought at first it could be no other, but it proved, in point of fact, to be a new species. Coming from so far north, it has the horticultural interest of not only being likely to be much hardier than the southern species, but the scientific interest of being second in a group hitherto represented by one species only. The flower had, of course, all gone, but from the very scanty seed I was able to collect I have grown specimens living in the open in the winter at Ingleborough, which certainly never happened in the case of *Primula sinensis*.

Now we leave behind us the loess lands and the clear cold north, and the neighbourhood of the great Tibetan highlands, and came into a warm summer country of red earth, very like certain parts of the French Riviera. At Paoning (Bao-ning-fu) on the Kialing-ho (Ja-ling Jang) River we chartered a boat in order to achieve the rest of the pilgrimage down the stream to where it joins the Yangtze Kiang at Chunking. The boat carried a complement of nine rowers, besides the skipper, his nephew (who was an idiot), his wife, and his little daughter. Then there were my own servants. We drifted down the river, a little disturbed now and then by the trouble that was seething all over China, until finally, for the sake of moral effect, I camouflaged the camera in the bow of the boat to pretend it was a machine gun.

We are now very near the end of our journey. We have arrived at Chungking and the Yangtze River. The skipper's little daughter put on her best clothes, black satin and scarlet socks, in order to pay us her last visit of ceremony. And the expedition then petered out into steamers and trains; and for the next three days we came down the famous gorges of the Yangtze, of which I had heard so much that I had really half undertaken that long journey in order to have a chance of seeing them. And though they are undoubtedly very beautiful and impressive, the last three pictures I show you will enable you to judge for yourselves whether they are worth the three months' cross-country journey of hard travelling which I undertook in order to go back that way to Hankow and Peking. Really one of the most impressive things about the Yangtze is the extraordinary narrowness of that river, considering which its volume is something un-understandable. While you could easily in places throw a stone from one side to the other, its surface calm is somehow more terrible than the noise and uproar of any other river, and its depth is such that a steamer will not only disappear but never be found or got into touch with again.

And I will not take you further. The concluding stages of the journey brought the climax of the depression that had increasingly overclouded my return. I would say to you, as I have said to many others, that the great drawback of all these expeditions is not the setting out upon them, but the deepening melancholy which attends their conclusion, as day by day you draw further away from the peace and lonely loveliness of the great ranges, back towards the frets and furies of that devastating and bankrupt futility to which we are pleased to give the name of civilization.

Before the address the PRESIDENT said: The unexplored and unexploited corners of the world are getting so few and far between that it is a real joy to us geographers to hear of any country so remote, so interesting, so full of most unpleasant possibilities to travellers therein as that about which we shall hear to-night from Mr. Farrer. This is not the first time Mr. Farrer has addressed this audience. What he told us when he was here before only makes us all the more anxious to hear the sequel of his journey. What he will tell us to-night is his experience of the second year that he spent in that remote region on the Tibetan frontier which we may call Central Kansu.

(*Mr. Reginald Farrer then read the paper printed above, and a discussion followed.*)

Viscount BRYCE: Although I feel in duty bound to obey the President's call, I must confess that my knowledge of the region which Mr. Farrer has described to us in so graphic and vivid a way is entirely confined to those Yangtse gorges of which he only gave us a glimpse. I did not succeed in getting any nearer to that very strange and romantic land whose flora and physical features have been so well rendered to us by the slides we have seen. With reference to the Yangtse gorges I feel that you will hardly derive an adequate impression of their beauty from the few views Mr. Farrer gave us; if he had given us a greater number you would have seen that there is an extraordinary variety, and that here and there they present river scenes of great beauty and sometimes of grandeur. In some places the woods come down to the banks, and the scenery is varied at other spots by rocks rising out of the stream. The only impression I could obtain of the flora of China besides what I saw along the Yangtse Kiang was with regard to the plants growing on both sides of the Great Wall to the north of Peking. There it interested me, coming from the south, to see in a few places the same species and, to some extent, the same genera, growing over the grassy mountains traversed by the Great Wall, and those with which we are familiar in the flora of Scotland, of Norway, and of the higher parts of the Alps. I must congratulate Mr. Farrer on the extraordinary beauty and interest of the plants he has discovered. Some of you may have had the good fortune to see the drawings and coloured pictures which he brought home of a good many of those plants, and which were shown at the gallery in Bond Street about a year ago. Beautiful as these photographs are in giving you an admirable conception of the form of each plant and of the general character of it and the spots where it is found, you would need, in order to appreciate their extreme beauty, to see the coloured pictures which were shown in that gallery. I very much hope that he may be able to give those who are interested an opportunity of seeing them again, because many of you will have your curiosity whetted to-night, and you will be desirous of seeing them with the full charm of colour. A rather interesting observation which was made long ago came to my mind to-night in looking at those plants, and noting the great heights at which they grow. It is almost the only part of the world, I should think, in which you would find plants growing at a height of or about 14,000 feet; I have never seen that, except in dwarf species, either in the Andes or the Himalayas—and when you get to these great heights the small alpine plants attain a vividness and intensity of colour which you hardly see anywhere else in the world. One generally thinks of the Tropics as a region in which the greatest amount of brilliant flower colour is to be found. But when one traverses the forests of Brazil he finds that nearly all the fine coloured blossoms are at the tops of the

trees, and when one is in the heart of the forest one sees nothing of any brilliance at all. If you want to get an idea of brilliance of colour you have to go to the alpine regions and there see what the strong sun and keen air of those great heights is able to evoke in the way of colour in plants. There are many questions which Mr. Farrer's interesting description prompts me to put, but I ought not to detain you by addressing more than one or two to him. I should like to ask him what he thinks is the greatest height of any of the mountains he visited in this part of Kansu, and at what height he believes the line of perpetual snow to lie, a point always very interesting because the snow-line is so much affected by the volume of rain or snow that falls. I would also ask whether the trees in the forests of this part were mostly conifers; and if so, whether they belong to west European types or to those types more frequent in western America and Japan. I think he did in one place mention a forest of coniferous trees, but if he could give us some general idea of what the types of trees are it would be a valuable addition to the botanical information he has given us. I conclude by again expressing not only the great obligation lovers of botany and lovers of geographical exploration have been placed under by Mr. Farrer's most adventurous journeys and illuminative descriptions, but also the pleasure which those who love their alpine gardens feel in the prospect that, in due course, they may have additions thereto from the beautiful flowers which may be reared in such gardens from the seeds Mr. Farrer has brought back.

Capt. A. W. HILL (Assistant Director, Royal Botanic Gardens, Kew): It is with great interest that I, and I am sure everybody present, have listened to Mr. Farrer's lecture to-night, illustrated with such beautiful photographs. I am only sorry that he has not shown us a greater number of photographs of the plants of these regions, because one knows that he has only shown us a very small proportion of the remarkably interesting plants which he has discovered. In the genus Primula especially he has not only introduced us to a great number of new forms, which we shall be glad to grow in our gardens, but from the scientific point of view his discoveries are of very great interest. They increase our knowledge of the wide range of this genus, with its many species closely allied to one another, and afford a striking example of the extraordinary variety in form and habit, which can be found in a single group of plants. It is unfortunate that Professor Bayley Balfour of the Royal Botanic Garden, Edinburgh, is not here this evening, because he would have been able to deal with the subject of Primulas with the authority of a master, since he has worked through Mr. Farrer's material of the genus. I think it was in Mr. Farrer's hearing before he went to China that a distinguished horticulturist and traveller said that China was played out as regards botanical discovery. But you will agree with me that this is very far from being the case, and that Mr. Farrer has been amply repaid for all the trouble and pains he has experienced by the discoveries he has made. The photograph of *Viburnum fragrans* he has shown reminds me of an almost equally beautiful plant, *V. Carlesii* from Korea. As Mr. Farrer himself remarks in one of the papers he has written on his travels, it is a very far superior plant to a much advertised and rather widely grown member of the genus which looks more like a "rusty pew-opener in distressed circumstances" than a plant to be desired for our gardens. I must also refer to one other group of plants, the sky-blue poppies (Meconopsis), which it is the aim of all gardeners to try and grow, and over the cultivation of which they no doubt suffer very great trouble, anxiety and pain. At Edinburgh you can see them in all their beauty, but at Kew,

unfortunately, owing to London smoke and fog, it is often with the utmost difficulty that we are able to grow them at all in reasonably decent condition. Still there are a fair number of types amenable to our conditions, and Mr. Farrer's novelties are those we are naturally anxious to try and cultivate along with those we already possess. Not only his Meconopsis and Primulas, but also a great number of the other plants he has found are very desirable garden plants. There was one plant, and that was the Primula very similar to the common cultivated Primula of our greenhouses, *Primula sinensis*, to which Mr. Farrer referred. Thanks to Mr. Farrer we now have the plant at Kew, but I am afraid the fog that took place about six weeks ago has destroyed the flowers. This plant has been found by Professor Balfour to be a new species which he has named *P. rupestris*, and it is still, therefore, a matter of very great interest to discover—and we hoped that Mr. Farrer had done so—the original wild form of the cultivated Chinese Primula of our greenhouses. It was introduced into England from China in 1820, and, like so many cultivated plants, its history is lost in antiquity. No doubt Mr. Farrer's new Primula is very closely allied to it, but now all we can ask of Mr. Farrer is that he shall go back to China and try and discover the wild type, and also solve many of the other botanical problems which still await solution.

Sir FRANCIS YOUNGHUSBAND: I have not had the pleasure of actually travelling in the part of Tibet which Mr. Farrer has described to us, but as a traveller I should like to express my envy of the manner in which he has been able to bring home to us the beauties of what he has seen. We travellers have seen most beautiful things in Nature, and we pine to be able to describe them to you when we come back, but, alas! we have not the ability to be able to do it as Mr. Farrer has. I think most of us describe them as Mr. Farrer's companion described the sight of the harebells. I hope as time goes by we shall have more lectures like this, which will bring home to people here in London all those beauties of Nature which we long to be able to describe. I think in the old days we spent so much of our time in the dreary business of observing, surveying, and making maps, but in the future the aeroplanes and airships will do the map-making for us, and the actual traveller will be able to devote himself to really understanding and bringing home to us the nature of the country and its people. Although I was not actually in Mr. Farrer's part of the country, yet thirty-one years ago I was within a few hundred miles of it when crossing from Mongolia to Turkestan, from China to India. One or two of the things Mr. Farrer described brought home to me my travels. For instance, that point about the bottle. I had an exactly similar experience, only not with the Tibetans, but with the Mongols. On one occasion I was throwing away a lime-juice bottle, when I was brought up by my Chinese servant, who told me that I must not be so extravagant and wasteful but reserve it for the big Mongols, which we did. I even found my Chinese servant hoarding up my brown paper and palming it off upon the innocent Mongols as tobacco! Mr. Farrer has written a most charming book entitled 'The Eaves of the World.' He gave it that title because the part of the country with which he deals is known by the name of "the roof of the world." But I should like you to understand that the people who have given that name to the high region have not our idea of a roof. Mr. Farrer has shown you that the roofs are in those parts perfectly flat. The region where I saw the name given was in Chinese Turkestan at Kashgar, when after going over a perfectly flat plain for weeks and weeks you suddenly see in front of you a great range of snowy mountains, and that range is what the people there

call the roof of the world, because when you go up on to it you get a series of level spaces which resemble the flat roofs. It is that kind of roof—an upper storey—that they mean when speaking of the roof of the world. Mr. Farrer showed us a picture of a bridge which had been made by the monastery. This I thought a very fine example of the same kind of bridge that we see in Kashmir and all over the Himalayas, the cantilever system, a bridge built on precisely the same principle as the Forth Bridge. That particular bridge, I think, is as fine a one as I have seen made of wood by these primitive people. I should like to say one further word of congratulation to Mr. Farrer and thank him for having been able to bring home so vividly to us the beauties of what he has seen, and make us really live amongst those hills, and understand the people as they are.

The PRESIDENT: You all probably remember what is the position and the shape of the Province of Kansu in China, how it extends a long arm up to the north-west between Mongolia and Tibet, and it is through that long arm that the great trade routes of the past ran to Siningfu and Kashgar. This great route running north of Chinese Turkestan to the west is an historic trade route, one of the oldest in the world. From Siningfu starts the pilgrims' route to Lhasa, through the old Buddhist cities which have long since passed away, so that Sining must ever have been a great travelling centre. To-night Mr. Farrer has taken us north of Sining, where he has touched on a very little-known country. To my mind the most interesting part of the Province of Kansu is south of the city, because it is there, where China faces Tibet on the west, that we have never been able to put anything like a definite limit to Tibet. We do not know where the boundary is between Tibet and China, and I am not surprised to hear from Mr. Farrer that nobody does know. There is an intermediate band of Mohammedan Chinese extending all the way up that frontier; on the one side of them there are the Tibetans, on the other the pure Chinese; and the Tibetans and Chinese hate each other as close neighbours generally do. Here is a curious geographical feature. Just at that particular part of Western Tibet there are no great rivers flowing from the Highlands. As you know, all the great rivers of China and Burma find their source in the central plateau of Tibet, and flowing eastwards in the first instance, they diverge either to the north-east like the Yellow River or like the Yangtze they change to a southerly direction, finally taking a course eastward through China; whilst a remarkable collection of rivers, including the Mekong and the Salwin, running in narrow troughs separated by precipitous mountain ridges, strike southwards to Burma. So that just at that particular part of Western Kansu or Eastern Tibet, there are no roads following valleys leading up to the plateau. Consequently, it is about the most out-of-the way corner of Asia that any man could possibly wish to reach, which makes it all the more interesting. Also it is interesting for another reason. It is there in that neighbourhood, both north and south of it, that there exist certain tribes whose ethnographical status we have never been exactly able to place. We know very little about them; we are very anxious to hear more. At present no really scientific ethnologist has brought back any account of them. These are the people who live in the big loop of the Yellow River to the north and those others who live in the very similar loop of the Yangtze to the south. These isolated tribes (Ordos and Lolos) are entirely independent of China, and nobody seems to know what their connection may be with the Chinese inhabitants who surround them. There is just one question relative to Mr. Farrer's botanical studies which I should like to ask him, and that is how he

accounts for the prevalence of blue in the colour scheme of the flowers at these altitudes. I have often observed in the Himalayas—and it does not matter much what part of the Himalayas—that as you gradually mount higher and higher there are distinct zones of colour, and when you reach high altitudes the colours are never blue, but almost invariably yellow with an occasional touch of scarlet, or, like rhododendrons for instance, they may be pure white or light violet. It seems that in the part of High Asia where Mr. Farrer has been the prevalent colour is blue, and of an intensity which is unusual anywhere. That is a puzzle to me.

Mr. R. FARRER : I am glad to think that I am the only person here present who has visited those regions, because it minimizes the number of questions that have been put to me to-night. I have heard some very interesting remarks ; I have not been tormented by questions which in my ignorance I may not be able to answer. To deal with the questions raised : I should say the highest point in the Tatung Alps runs to some 16,000 feet ; and that the vegetation continues to within about 1000 feet of the summits, though you will easily understand that at such an altitude vegetation is small and insignificant, very often extremely insignificant. But the real flora of horticultural interest ceases between 15,000 and 15,500 feet. The snow-line in those ranges appears to me to run extremely high. In the main Minsan, which I visited in my first year, it was about 18,000 feet. There seems to be no perpetual snow-line at all ; and it was only far south, on the great mountainous masses above Sungpan (which run to about 19,000 and 20,000 feet), that there was visible in July and August a solid bulk of everlasting snow. But through the Tatung and Minsan I would almost say snow does not lie in summer, although their height is from 16,000 to 18,000 feet. Then, with regard to the trees in the woods in the bleak northern land, I should say that such woodlands as there are chiefly consist of the same as our own, or very similar. I do not claim to be a master with regard to the Coniferæ, and indeed I believe there is none such now living, but the woods, when you ever came across them, were largely composed of a dark spruce, with here and there the white birch and in this northern region a few pines ; but not a great abundance of the beautiful red birch which ranges up from the Indian borders of Tibet through the Alps of Western China and Chinese Tibet, and across China to Japan. At the same time I would point out that the district I visited in my second year was in many ways an unsatisfactory one. It was neither quite one thing nor the other. There are, as it were, two main belts of botanical distribution in the north temperate zone, one of which runs across Northern Europe, Russia, Siberia, Manchuria, and Hokkaido, ranging up to the Arctic Circle and down to the Altai and the Kwen Lun ; the second which runs, roughly speaking, from the Levant away through the Himalaya, and then up the borders of Western China and Tibet until, so to speak, the ascending wave of the southern portion meets the descending wave of the northern. My second year was passed on the meeting-point, where the northern flora had lost half its richness, and so had the southern flora ; so that you therefore met only a, comparatively speaking, dull flora, as is evidenced by the fact that while in 1914 I got two new species of Meconopsis and I do not like to estimate how many of Primula, in the northerly, bleaker, colder, dryer, poorer climate and country, I got no new species of Meconopsis at all, and only some two or three new species of Primula. With regard to the blue of the flowers, I am afraid on that point I can give no answer. Perhaps I may have conveyed a false impression, perhaps I am wrong in my own impression, or perhaps I talked too exclusively

about such flowers as dazzled me with the brilliance of their blue and purple, and ignored all the innumerable dull little yellow weeds that grow universally over the screes and stones on the higher Alps all the world over.

The PRESIDENT: I am sure you will all wish to join in a very cordial vote of thanks to Mr. Farrer for a most interesting address, one of the most interesting I have ever heard in this hall.

THE FOREST REGION OF NORTH-EAST RUSSIA AND ITS IMPORTANCE TO GREAT BRITAIN

E. P. Stebbing

Read at the Meeting of the Society, 25 March 1918.

I HAD an opportunity of spending some time in Russia during the past summer and autumn, and I propose to deal to-night with one part of my experiences in the country. It will be readily understood that few could visit Russia during the difficult times she is passing through without devoting some time to a study of the extraordinary political conditions which have existed in the country since the revolution, and endeavouring to gauge their effects economically upon this country. The investigation which took me to Russia necessitated my remaining some weeks in Petrograd and the neighbourhood, and I had opportunities of seeing for myself and of appreciating the great difficulties which confronted the Provisional Government—a Government that contained many elements of great promise—in their efforts to introduce order out of chaos. The importance of a settlement in Russia which shall not be a German settlement is undeniable, in the interests of Russia herself, of Western Europe, and the Near East; but I do not propose to deal with it to-night. One question occupying the attention of the Provisional Government at this period was the winter fuel supply of the capital, and this has a bearing on future remarks I have to make. Owing to the shortage of oil and coal supplies, due to the great disorganization, and to the fact that the needs of the railways had to receive first consideration, it had become evident that Petrograd must depend this winter chiefly on wood fuel. This fuel, chiefly birch, is brought to the capital in big barges by way of the rivers and canals. By the end of September Petrograd presented the appearance of a huge wood depôt, the public squares, such as that of the Winter Palace, and of St. Isaac, the Champ de Mars, and the courtyards of the houses, being filled with immense fuel-stacks. It appeared doubtful, however, whether enough had been got in to tide over the winter.

One of the objects I had in view in going to Russia was to visit if feasible a part of the north-east region and study the conditions, as affected by the revolution, of this great forest tract: a region almost unknown to us in this country—in fact, save to an exceptional few, quite unknown. Its importance as a large timber reserve for the northern markets of

the exigencies of the war is not a patch on the amount of absolutely untapped forests which exist in the world at large. Mr. Stebbing has brought to our notice one of the enormous forest regions which is still comparatively open to exploitation, and there are others in other parts of the world where one is surprised that hitherto no attention to forestry or timber-cutting has ever been given. I know one very extensive region in South America, south of Valdivia, where there are untapped forests almost covering Southern Chile. And, moreover, that is country which is unusually well supplied with large and rapid rivers, penetrating the forests, which would afford every facility for exportation. I am speaking of a time about ten or twelve years ago. Since those days something may have been done, but at the time when I was in that part of the world the reason given me, why no use whatever was made of those forests, which are full of valuable timber including a great variety of ornamental woods, was that it was absolutely cheaper for Chile to import lumber from Norway than to cut its own wood. That is a state of things that I imagine cannot last long. There were very few places that I can remember where timber industry was attempted. In Tierra del Fuego there were one or two busy saw-mills ; another flourished in a colony on the Atlantic coast where a really good business was instituted, at a Roman Catholic Missionary Station. The mission was supported entirely by timber-cutting. Incidentally, Mr. Stebbing has reminded us that we may hereafter wish to institute a regular trade with Archangel and that ice-free port, Alexandrovsk. So that we were not much too soon when, as a Society, we called the attention of the Government to the importance of retaining command of Spitsbergen ; and if we are to preserve free communication for the import either of timber or other produce, we must certainly retain command of that route and hold those northern seas from Spitsbergen. I will ask you to join in thanking Mr. Stebbing for his excellent address.

THE POSSIBILITY OF AERIAL RECONNAISSANCE IN THE HIMALAYA

Dr. A. M. Kellas

Read at the Afternoon Meeting of the Society, 18 *March* 1918.

IF conquest of environment constitutes progress, the introduction of the aeroplane marks a great advance in the history of mankind. The Royal Geographical Society is for the present mainly concerned with the evolution of aerial navigation from the point of view of its use in exploration, and, when normal times arrive, may almost certainly look for a rich harvest in that direction. Allowing for the certain development of speed, safety, and weight-carrying capacity of aerial machines, how practicable explorations such as the following would appear from the purely scientific point of view ! The aerial traveller might start from Gibraltar and explore the territory of the fanatical tribesmen of Southern Morocco with impunity, obtaining material for mapping the country and the western Atlas Mountains. From Egypt as base he might survey thousands of square miles of the Eastern Sahara ; from Aden and Egypt he might investigate

the deserts of Arabia; from the coast of the Guianas he might fly over the malarial jungles to the cordillera of Southern Venezuela, and perhaps discover a convenient landing-place on the Tumac Humac; he might survey the desert of Gobi from the Siberian Railway; or, finally, he might get a bird's-eye view of such portions of the polar area as are not the "Home of the Blizzard."

A few tracts on the Earth's surface, however, might seem to offer special difficulties. The illimitable forests of Brazil, the hurricane lands of Western Antarctica, the immense height and icy crests of the Himalaya, might cause the most adventurous airman to pause before attempting their exploration. It is with the last-named area that we are concerned this afternoon, and the subject for consideration might be stated as follows: Is it possible to fly over the Himalaya, and if so, what arrangements could be made for aerial reconnaissance of that region?

With regard to the possibility of flying over the Himalaya, the only point which need be considered at this stage would be the height to which an airman would have to rise to cross the main range—the Great Himalaya—which, as seen from the plains to the south, tower up as a gleaming wall of snow and ice. Consider, first, direct passage over the range. Excepting the peaks above 24,000 feet, of which only about eighty are so far known, and assuming that an airman would fly as a rule at least 1000 feet above the mountains to lessen the danger due to the winds that often sweep across the ridges, then it might be said that an airman could cross the range when flying at from 23,000 to 25,000 feet without having to deviate more than 5 to 10 miles from his direct alignment on account of great peaks. Burrard's interesting tables and charts show this conclusively. He gives:

Peaks above	27,000 feet ...	6
,, ,,	26,000 feet ...	17
,, ,,	25,000 feet ...	50 approx.
,, ,,	24,000 feet ...	80 ,,

Assuming 23,000 to 25,000 feet as an approximate elevation which might be required for clearing the main range, there is, from the argument adduced in a former paper by the author, which included considerations of physiological difficulties involved in climbing the loftier Himalaya, no reason to doubt that an airman could negotiate that altitude satisfactorily (see *Geog. Journ.*, 49, p. 26, Jan. 1917).

Without going into the arguments brought forward in that paper, the fundamental facts may be summarized thus:

1. Altitude sickness (*Hypoxæmia*) is due to a deficiency of the oxygen required for promoting normal tissue oxidization.

2. The oxygen supply available varies directly with the atmospheric pressure which at sea-level will on the average balance a column of mercury 760 mm. high. At the top of Mount Everest (Chomo Langmo,

29,141 feet) the pressure is nearly 250 mm. at 0° C., only about a third of an atmosphere. These numbers do not however represent relative alveolar oxygen pressures (*loc. cit.*, Table VI., p. 42), which would be approximately one to a fourth and not one to a third.

3. Experiments in air-chambers and the experience of balloonists indicate that ascents above 25,000 feet, where air only is breathed, would be hazardous. It was pointed out, however, that this conclusion did not apply to the climber, whose alveolar oxygen pressure, *i.e.* the pressure of oxygen in the ultimate ramifications of the lungs, rose as he ascended, relatively to his carbon dioxide alveolar pressure, although both naturally steadily diminished with increase of elevation; at the same time his blood suffered an acidosis which aided the diminished carbon dioxide in adequately stimulating the respiratory centre in the *medulla oblongata*. It was pointed out, too, that the number of red blood-corpuscles—which act as oxygen carriers—steadily increased per cubic millimetre if time were given for acclimatization.

The problem of the climber at high altitudes is therefore different in some respects from that of the airman. In the case of the airman the results indicated by experiments in air-chambers would hold during flight if a wind screen rendered the atmosphere immediately round him nearly stagnant. But this would rarely be the case, and the air would tend to get packed into his lungs by his motion, thus raising his alveolar oxygen pressure. It would probably be found, however, that even an airman in first-rate training would feel the want of oxygen if he flew at an altitude of 20,000 to 22,000 feet for some time; and many men might do so at 15,000 to 18,000 feet, or even lower. The airman has the advantage over the climber that he expends energy at a slower rate, the latter doing comparatively hard work in raising his own weight.

4. Experimental work in air-chambers and balloons, during which air admixed with oxygen was breathed, indicated clearly that altitudes higher than the loftiest Himalaya might be reached with proper precautions. Paul Bert breathed such a mixture at a pressure of 240 mm., corresponding approximately to an altitude of 32,000 feet; while Aggazotti breathed a mixture of carbon dioxide and oxygen at a pressure of 120 mm., which would correspond to an altitude of nearly 50,000 feet. These facts should allow airmen to fly at very high altitudes if they are provided with oxygen and proper inhalers. If the height were much above 30,000 feet special care would be required, since two balloonists, Berson and Süring, although provided with oxygen, became insensible at about 35,000 feet.

5. A well-known British airman (Mr. H. G. Hawker) was reported in the Press to have reached 24,408 feet in a Sopwith fighting biplane. Unfortunately I do not know whether the reading of his aneroid was confirmed by a laboratory test after landing, and from my own experience while climbing I confess to doubting the accuracy of any aneroid readings above 20,000 feet, unless so confirmed afterwards.

NORTHERN SLOPE OF WESTERN PART OF KANGCHENJHAU MASSIF, FROM NEAR GYANTSHONA (16,000 FEET).

Unexplored valley in Tibet north-west of Jongsong Peak, showing possible landing-place at 19,000 feet. Note: the picture is taken from 21,500 feet, and there is a precipitous fall to about 19,000 feet beyond the near edge running across the foreground.

6. The maximum height so far attained by any climbers was 24,600 feet, reached by the Duke of Abruzzi's party in the Karakoram Himalaya.

The above summary seems to indicate clearly that there is no physiological difficulty in flying for some time at 25,000 feet if there is a plentiful supply of oxygen and suitable apparatus for utilizing it to the best advantage. As regards the horizontal distance which an airman might have to travel at 23,000 to 25,000 feet, it would as a rule not be greater than 10 to 15 miles, unless he were moving along the range instead of crossing it. There are, of course, exceptional areas with a tangled mass of ridges, where it would be difficult to find a satisfactory landing-place.

It must be pointed out, however, that in order merely to make a transit of the Himalaya it would not as a rule be necessary to pass over the summit of the great range. There are many deep gorges carved by the rivers, several of which rise in the Zaskar and Ladakh ranges to the north of the Great Himalaya. Utilizing passes, which are frequently on spurs of the main range connected with the river defiles, it might be possible to cross the range without rising above 19,000 feet (or less). The gorges of the Teesta, Arun-Kosi, Karnali, and the headwaters of the Ganges, the Vishnuganga, Dhauli, and Bhagirathi can be cited as examples. There might, however, be very troublesome and gusty winds through these gorges at sundown, becoming sometimes of hurricane strength. The practicability of the pass routes for easy flying would greatly depend upon the season of the year.

Any summary of personnel and material must be brief, as the author does not pretend to be competent to deal with many of the practical problems involved. For high altitude work only men of good constitution and in first-rate health and training should be employed. As a slight test of endurance, they might be expected to be able to walk 20 to 25 miles in say eight to ten hours over a rough ground without serious fatigue.

A factor in design would be to make a machine, the wings of which could be lowered and raised, or temporarily dismantled; otherwise the wind might often upset the stationary plane, which in many situations could not be screened. As I have previously pointed out, however, a gale of 50 miles per hour at 19,000 feet has only about half the lifting effect of wind of the same velocity at sea-level.

Preliminary experiments should elucidate difficulties connected with wind, clouds and weather; possibilities of alighting and starting at high altitudes; and possibilities of acclimatization to reduced pressures under different conditions.

The wind would vary greatly with the season of the year. During the monsoon, which may last from the middle of June to mid-September, the airman would probably experience a strong southerly wind in many regions, which might last from sunrise to sunset, and in certain districts, as in Sikhim, would help the transit of the range from the south if an early start were effected. With the first snows of winter, which may fall

any time in September or October, the dynamic aerial equilibrium between the atmosphere over the Tibetan plateau and that over the plains to the south of the Himalaya may become much more stable. Mr. Freshfield, in his first near circuit of Kangchenjunga, carried out in September 1899, expressly states that they were not troubled by wind, and had many cloudless days. This fine weather was apparently due to the heavy fall of snow of about a metre in depth in north Sikhim and southern Tibet on September 25 of that year. The author has never experienced weather of that type during the monsoon, when clouds frequently form on the mountains at from 5 to 10 a.m.; but has enjoyed a few fine days, with considerable wind disturbance, however, after a fall of over 2 feet of snow in September 1909.

From these experiences, and information given by various writers, it would appear that the months of October and November, after southern Tibet has had its area under snow greatly increased, would probably be finer weather for survey work than during the summer. There might, however, be keen winds, for I can hardly conceive of the air remaining quiescent over such a lofty region for any length of time. My own experience in certain areas during the monsoon has been that it was not only windy all day, but sometimes during the whole night as well. One great disadvantage of October and November would be the obscuration of mountain contours by the mantle of fresh snow, which might make photographs of secondary value. The temperature of the air, also, would be low, which would be disadvantageous for camping or flying. It must be noted, however, that the experiences of the British Mission to Lhasa in 1904, and those of Dr. De Filippi in 1914, indicate that under suitable conditions exploration of the Himalayan area may be effected towards the end of the year.

The month of September, when the monsoon is abating, and the month of May before it begins, might be found best of all. In the former month, one would have a moderate atmospheric temperature, possibly clear days, the snow very little below the summer level and frequent fine cloud effects. But while cloud banners and curtains would give magnificent scenic displays, they might not be appreciated by the airman anxious to secure photographs for survey work. The problem of flying through cloud will have to be faced and solved. If an aerial trans-Himalayan post were arranged from Calcutta to Lhasa, and thence to Pekin and Tokyo, the ascent through great cloud strata during the monsoon might cause trouble if the horizontal position were not maintained. From the hills north of the Pindari river I have looked south to the foothills, where cumulo-nimbus seemed piled on cumulo-nimbus to a minimum thickness of 25,000 feet. Strong electrical discharges seemed to be taking place between the cloud layers, and the airman in such a system would be in an awkward plight unless he could maintain his horizontal position. Such accumulations may however be exceptional, and it is possible that even

in the monsoon the airman would generally be able to rise above the cloud strata, which, as a rule, might not be more than a few thousand feet thick.

From easily accessible summits on the northern flank of the Great Himalaya, one has often looked on a rolling sea of mist, the height of which seemed to vary from 20,000 to 25,000 feet. But cloud strata of considerable density may form at and above 30,000 feet. Sometimes, within half an hour of sunrise, peaks of 25,000 feet which have for a few minutes been quite clear became enveloped in a cloud bank extending thousands of feet above them.

The problem of landing and starting at great altitudes is of considerable difficulty. Landing on snow would be easy on many mountains, but to get off again would be another matter. The airman surprised by engine stoppage might be expected to look out for the biggest and smoothest snow-patch on which to effect a landing. On many mountains of the Himalaya there are large fields of snow almost inaccessible; and once landed an aviator might find himself marooned. But the writer happens to be acquainted with many places above 20,000 feet where an aeroplane could land upon snow with a possibility of getting off again. On Chumiomo, at about 22,400 feet, it might just be possible. On the northern Jonsong saddle there is a beautiful situation for camping at about 21,500 feet, and another at 24,000 feet, on both of which landing would be practicable. On Pawhunri near the summit (23,180 feet) it would not be advisable to land, although easily possible at 20,000 feet. The best place I know between 22,000 and 23,000 feet for carrying out experiments on landing and starting at moderately high altitudes is the summit of the Kangchenjhau (22,700 feet), near the Tibetan border about 100 miles north of Siliguri (which is on the plains at the edge of the hill region), and about 600 miles due north of Calcutta. As an airman could probably fly from the plains of Siliguri to the base of the mountain in less than two hours, and ten days would be considered fast travel on the roads, while most travellers would take about fourteen days, allowing for difficulties of coolie supply and transport, the annihilation of space and time by aerial navigation is well exemplified.

Photographs of this mountain show its suitability for experiments of the nature suggested. The first shows the whole massif, and indicates that the main summit is a snow-dome at the end of a precipitous ridge. Note the great line of precipices on the north. The second shows the south face, also nearly perpendicular. The easiest way up is from the east; and while it is easy to walk up if the snow is in a satisfactory condition, it is hardly a convenient route for bringing down a derelict aeroplane. The summit is a snowy plateau with an extensive view commanding on the south the bulk of Sikhim, and on the north a great part of southern Tibet. It slopes gently in three directions to the edges of precipices, but extends westwards after a slight dip as a long ridge. Probably it would easily give 250 to 300 yards or more as a starting run.

The state of coherence of the snow might cause trouble: very low temperatures give a powdery snow peculiarly intractable, similar to that which Scott encountered on the Antarctic Barrier on his last journey. Until 8 to 10 a.m. or thereby in September the surface is covered with a thin crust, which will easily bear a man, but presumably not an aeroplane. The snow is deep and comparatively soft beneath the surface film—an ice-axe can usually be driven in up to the hilt without difficulty—and therefore would require either rolling or compressing with a heavy stamp, until firm enough to give the necessary resistance to the moving plane.

A further complication which might cause trouble during a preliminary experiment is want of acclimatization to high altitudes. The airman flying from the plains of India to the summit of the mountain would be at a grave physiological disadvantage as compared with the climber reaching the top from a camp at say 19,000 feet. In the case of the climber, as indicated in the previous paper and already referred to, his alveolar oxygen pressure would be nearly a maximum for the altitude, and his blood would have undergone such an acidosis that washing out the carbon dioxide by the rapid breathing which necessarily occurs at high altitudes during exertion, would not cause a tendency to faint, the altered blood-condition affording the necessary stimulus to the respiratory nerve centre. He would also have greatly increased the number of his red blood-corpuscles per cubic millimetre by becoming approximately acclimatized at 19,000 feet. In the case of the airman flying from sea-level, this would not be the condition of affairs. He might reach this ridge near the Tibetan border within two hours of leaving the plains at Siliguri, and would probably be using oxygen for the last half-hour. On landing on the summit and stopping the inhalation of oxygen, he might feel quite well while quiescent; but if he carried out any hard work, as in compressing the snow, he might be attacked by mountain sickness, and might even faint if he persevered in his efforts.

It is quite possible that by repeated trial flights from sea-level to 22,000 to 25,000 feet, using oxygen only when absolutely necessary, the alveolar epithelium might be educated to make the most of a minimum supply of oxygen, but while experiments in this direction are desirable, it would be unnecessary to make them exhaustive at this stage, as the proper investigation of the effect of preliminary high flights, and of landings at great heights, with and without attempts at partial acclimatisation to altitude, would involve a somewhat complicated series of researches, the nature of which was vaguely outlined in the previous paper.

An airman who had camped for some time at 15,000 to 19,000 feet would probably be in a much better condition to undertake serious work above 22,000 feet, and experiments might be carried out both from sea-level and the latter altitudes. It is obvious, however, that any airman alighting at 22,700 feet for experimental purposes, should be supported by climbers, who might have a tent pitched on the summit, and have prepared

the snow for the aeroplane, and the path for the take-off run. The climbers' camp could be on rock *débris* at 19,000 feet only about a couple of miles from the summit; and they might from such a station form a camp on the top of the mountain, throwing up a large snow-bunker to the south, the direction of the prevailing wind from May to October. In such a camp it might be possible to carry out experiments on acclimatization to high altitudes, and find the diet most suitable for mental and physical work above what is generally regarded as the maximum height for permanent acclimatization (17,000 to 18,000 feet).

As mentioned in my first paper to the Society (*Geog. Journ.*, September 1912), the mental inertia above 20,000 feet is considerable, and there is a distinct dislike to carrying out work which involves a continued mental strain, such as estimation of red and white corpuscles, etc. I am confident, however, that such estimations can be carried out at altitudes above 23,000 feet, if the worker is in first-rate training. Experiments during a fortnight to a month at 22,700 feet would extend the results obtained by Haldane and his collaborators on Pike's Peak (14,109 feet) and by Barcroft and his co-workers on the Peak of Teneriffe and Monte Rosa.

It must, however, be clearly indicated that camping for a prolonged period above 22,500 feet, which one regards at present as considerably higher than the limits of permanent acclimatization, is not to be carried out without careful consideration and preparation. A week would probably be safe enough in the case of a trained man thoroughly acclimatized at say 17,000 to 19,000 feet and provided with satisfactory food. A prolonged sojourn might, however, result in gradual degeneration of nerve centres due to deficient oxygen-supply, and if deterioration proceeded beyond a certain point, it is questionable whether it could be properly remedied after descent; that is to say, the mental ability might be permanently diminished. The experimenter camping at high altitudes would therefore do well to test his mental and physical capacity daily. The former could be readily noted by finding the time required to carry out a complete blood-count, or to perform long arithmetical and algebraic calculations. Barcroft, in a suggestive paragraph regarding apparent temporary changes of entity due to altitude, says, "At Col d'Olen (10,000 feet) I have heard two clever and distinguished physiologists pause to discuss whether or no 4 times 8 made 32." I cannot state that I have observed anything of this kind at 20,000 feet, the highest elevation at which blood-counts were made in the Himalaya; but it is possible that the time taken was excessive. The summit of the Kangchenjhau is admirably situated for keeping the physical capacity in good order, as a walk for about 2 miles along the ridge is possible without descending much (if any) below 22,000 feet.

As a preliminary to the above, a base camp might be chosen to the north of the main chain between the Great Himalaya and the Ladakh range at an altitude of from 15,000 to 17,000 feet. Such a position

would offer great advantages. The average height of the trough between the main chain and the Ladakh range is probably above 14,000 feet, or even 15,000 feet, which would give a useful pedestal from which to rise to over 20,000 feet when surveying. There are many comparatively flat areas which would make landing-places after preparation. The advantages of acclimatization at such an altitude would be considerable. Airmen in thorough training should require very little oxygen below 22,000 feet, if properly acclimatized at 15,000 to 17,000 feet. The summer weather to the north of the Great Himalaya is quite different from the monsoon weather south of the mountains. Although the crests of the main chain may be enveloped in mist after 6 to 10 a.m., a few miles to the north the sky may be quite clear (cf. *Geog. Journ.*, September 1912). The mists come up from the south, and even during the monsoon if ascents were made at dawn, one or two hours' survey work might be possible before the mountains became seriously obscured.

The problems to be solved are complex, and the territory to be investigated very extensive, so that the time required for even a macroscopic survey would be considerable. At present we are unacquainted even with the east and west extensions of the Great Himalaya itself. In the west we do not know whether the range ends with the Nanga Parbat (26,620 feet) group of mountains east of the Indus, or continues west of that river; and we are equally ignorant of its eastern extension beyond Gyala Peri (23,460 feet) and Namcha Burwa (25,445 feet) where the Brahmaputra breaks through the chain. According to Kingdon Ward the main chain probably bends south-east and becomes the Irawadi–Salwin divide; but any discussion of the geographical problems still to be solved in the development and relationships of the immense crustal folds of which the Great Himalaya forms the chief would unduly lengthen this paper, and cannot be considered in the present communication.

Before the paper the CHAIRMAN said: Dr. Kellas, who is to read the paper on this occasion, is no stranger to this Society or to these meetings. He has unique experience in two sets of interests that are very seldom found together. He, as a great mountaineer, spent much time in climbing in the Himalaya and has ascended almost as high, if not higher, than any other Englishman. He has been in the upper regions of the atmosphere, so far as terrestrial support is available, at heights above 22,000 feet. He is an eminent physiological chemist, and has studied the problem of the influence of highly rarefied air on the human frame, not only in the laboratory but also on the mountains themselves. With this equipment he is particularly qualified to deal with the fascinating question of the probable use of aeroplanes for making reconnaissances in the high mountain regions of the world. At the present time we are looking forward to the close of the war for a great increase in the scientific use of aviation, and there is no department where it could do more than in the inaccessible portions of the Earth's surface, whether in the Polar regions or high mountains. The preliminary conditions which govern the possibility of using this new means of exploration will be developed by Dr. Kellas.

(*Dr. A. M. Kellas then read the paper printed above, and a discussion followed.*)

Admiral MARK KERR (Deputy-chief of the Air Staff): I think the lecture was extraordinarily interesting, but I fear that exploration by aeroplane will not be carried out in the next hundred years. There are several things which render it practically impossible. Exploration on the flat can be done, but you have several things to contend with in the heights. First of all, you would have to have a very large machine to fly the distance and carry the weight that is required. You get a great loss of lift at high altitudes. And in addition to the quantity of fuel you require, there are provisions, warm clothing, and various other necessities for going a long flight and staying in the place for any time that make it absolutely necessary to have a very large machine. Aerodromes for the small machines are not in these days considered to be safe unless there are at least 800 yards each way, so that you can land in any direction, according to the wind. When you come to the large or giant machine you will want an aerodrome even larger, and you will want a hard and smooth surface. We all saw in the one or two aerodromes which the lecturer picked out just now the footprints of the people in the snow. I ask those who have not flown to imagine going into that suddenly on a motor bicycle at 50 miles an hour. I do not think you would want to trouble about stamping the ground down to get off again. You see there are so many things which come in when you have heavy machines. We have difficulties now, and many aerodromes in this country, properly prepared and laid out, cannot be used in the winter because directly they get wet you cannot get off them at all. I was a short time ago in a country a thousand miles off when the enemy came over; our big machines, not as big as we should want for this expedition, could not get off the ground because there had been rain the day before; it was impossible to get speed up to rise because of the mud. You have also another thing to consider—If you start an airman off up into the hills, especially at that height, you get clouds. Instruments are being invented for keeping direction through clouds and keeping level without difficulty, but where you are going and where the cloud is going is quite another thing, and to find an aerodrome, even though you had one on the heights of the Himalayas, is like looking for a needle in a bundle of hay. A ship at sea may meet a current which will take it out of its course 20 miles in twenty-four hours, and that is a big current; in the air you may be 50, 60, or 100 miles out in one hour. There is little known about the air coming across the Atlantic, but I was a few years ago going to fly the Atlantic with a friend of mine, who has since been killed, and I got all the study I could. As far as is known there is a westerly wind at a certain height and an easterly return wind a little above it. When you are up high you cannot see which way the waves are going (and you have to keep a good height for the voyage), so you have not the faintest idea whether you are in the westerly wind which is carrying you from America to England and putting 40 miles an hour on to your speed, or whether you are in the easterly wind which is taking 20 or 30 miles off it; a difference of perhaps 70 miles an hour. Then you may have a pressure or cold snap up north which entirely changes it, and instead of going directly across you are going off south or north of your course. Up to the present we have had no navigation instrument which can give one's position correctly: no doubt that will come in time; but even that would not be accurate enough to enable you to find your way among the peaks of the Himalayas. I am not at all pessimistic on the subject of the air in the future. I have always been extremely optimistic. But there is one thing we have not yet seen our way to cope with, and that is to be able

to land a big machine and get it off in a small space. You must have a prepared aerodrome. If you could get a machine to land even at 30 miles an hour, one lump or one rock in the soft ground, if you ran into it, would certainly turn you over. To sum up, you have these difficulties to overcome. You must have a big machine to land in a small space; you have to be able to find your aerodrome; you must have a machine that will land on soft ground in spite of its weight, which does not sound likely, and after that you must have something you can get up again on. So that I fear the air will not help you very much for making a survey up in the tops of the Himalayas for some time. Apart from the other things, we have difficulties now in the winter of getting machines started in the cold. Those are overcome by apparatus which, I fear, we shall not be able to get up in the heights; and the airman would have to fly there without having any of that apparatus. There are also difficulties of lubrication in extreme cold. And when you come to think of it, nobody goes out with a very light heart if he knows that if anything goes wrong there is only one landing-ground within 100 miles, and if he does succeed in landing without breaking his neck he has no hope of having the machine in a fit condition to get up and get home again.

Mr. FRESHFIELD: I regret that Dr. Mill should so early in the discussion have called on me rather than on one of the experts in aircraft we have with us this afternoon. But since I am appealed to as a mountaineer and an old President of the Alpine Club of which Dr. Kellas is one of the most distinguished members, I may take the occasion to give him a word of warning. He will, I think, be well advised not to repeat his lecture before the Alpine Club, for it involves a rank heresy in the view of a body which holds that the final purpose of mountains is to be climbed by our own limbs and without the aid of mechanical appliances. The only plea I can put forward in extenuation of Dr. Kellas' heretical proposal is that a very similar one was entertained by no less a person than the founder of scientific mountain exploration, H. B. de Saussure, as long ago as the year 1785.

In that year, when he was contemplating the ascent of Mont Blanc, which was to be effected two years later, his great friend the Prince de Ligne wrote to him recommending that information on the winds and meteorological conditions at great heights should be gleaned from aeronauts. Dr. Saussure replied in the following terms (26 September 1785): "En gravissant avec tant de fatigues ces rapides rochers (the Aiguille du Goûter) j'enwiois le sort des aeronautes qui s'élèvent à de si grandes hauteurs en retenant commodément assis dans leur gondoles et je pensai même que l'on pourroit tenter l'usage de cette voiture aérienne pour se transporter sur les cimes inaccessibles comme celle du Mont Blanc. Mais je crois que cela sera bien dangereux parce qu'on est sujet dans les hautes montagnes à des coups de vent violents et irréguliers qui pourroient jeter la machine et la fracasser même contre des rocs escarpés et il faudroit d'ailleurs avoir des moyens de direction bien surs pour arriver à des points aussi précisement déterminés."

With this reference, perhaps of some historical interest, I would dismiss the profane suggestion of using flying as a substitute for climbing and turn to the uses of aircraft in mountain exploration, and as an aid in the mapping of the recesses of the great chains. From this point of view I cannot but hold Admiral Mark Kerr's observations are too pessimistic. The distances in most cases between possible good landing-places near the mountains are far from prohibitive. It is not more than 60 miles, as a man flies, from the plains of India to the top of Kangchenjunga, and as much again on to the plains of Tibet or

the wide uplands of the Tingri Maidan behind Mount Everest. When last year I discussed possible attempts on Mount Everest after the war with General Rawling, whose loss we so deeply regret, one of the ideas we entertained was that from a base camp established on the Tingri Maidan aircraft might be employed for reconnaissance of the environs of Mount Everest and the unknown ranges of Nepal lying south and west of it. This, I maintain, is a practical proposal, and I will venture to prophesy it will be carried out by some of our younger airmen, to whose skill and love of adventure it would be hard to set limits. There is much encouragement for this view to be derived from what has already before the war been done in Europe. The Alps have been flown over, not once or twice but often. The snowy fastnesses of the Bernese Oberland have been well photographed on the flight. In the case of less well-known and thoroughly explored ranges such flights would be of essential topographical and cartographical service if only as reconnaissances. Every student of cartography knows that the early government surveys in Europe, the French in Dauphiné and round Mount Blanc, the Austrian in Tyrol, and the Russian in the Caucasus either misrepresented or did not represent at all the glacier region. In Western Europe the progress of mountaineering has supplied the information needful for much correction; in the Caucasus this has not so far been the case. Had aircraft been available I and other English mountaineers and our map constructor, Mr. Reeves, would in the eighties of last century have been spared much labour in unravelling the intricacies of the crest of the Caucasian chain. In this task Signor Sella's bird's-eye panoramas taken at great heights were of singular use. To our amusement several of our corrections were ignored by the next German traveller, who naturally preferred the authority of a "survey" to that of "mere climbers."

On the whole then, while allowing that any attempts to alight in the heart of snowy ranges may be an adventure fraught with peril and only to be undertaken in very exceptional cases, I believe that aircraft may prove most useful auxiliaries in the exploration of the undiscovered places of the globe, and, amongst them, of "the storehouses of the snow" which have been hitherto concealed from human eyes.

Major T. ORDE LEES, R.F.C.: The question of aerial reconnaissance in the Himalaya must depend on the possibility of establishing an aerial base at some convenient but considerable altitude. This might be between 15,000 and 19,000 feet. Practical considerations of rarefication and temperature would render it difficult to run an air-station at such altitudes with machines having engines of the normal type. The internal combustion engine has a physiology of its own analogous to that of a human being. In place of metabolism and an opsonic index, it has a volumetric efficiency which drops in inverse ratio to the height attained. Normally its food or fuel consists of sixteen parts of air by volume to one part of petrol vapour. At sea-level air measures 13 cubic feet to the pound; at 15,000 feet the same volume of air weighs only 0·65 lb., and at 20,000 approximately only half a pound. This means, therefore, that the proportion of molecules in a cylinder full of air diminishes relatively as the altitude of the aeroplane increases; hence at 20,000 feet the thermal efficiency of the charge drops to only 50 per cent. of what it is at sea-level, and so the horsepower of the engine is halved. Up to the present no satisfactory method of maintaining the efficiency at high altitudes, by forcing air into the cylinders under pressure, has been devised, and the cost of experiments in this direction would be prohibitive for a private

enterprise. It might at first be thought that the loss of horsepower would be compensated for by the reduction of head resistance ("drift"), due to the attenuation of the medium in which the aeroplane is supported, but this would be more than outweighed by the increase in size of the machine necessary to establish the reaction by which the aeroplane flies. The slight increase in density, owing to the reduction in temperature, does not effect a volumetric increase of more than 2 per cent. It is easily demonstrable that it would need very large machines to rise off the ground at high altitudes, and the obvious retort that machines fly daily at 17,000 to 18,000 feet does not dispense with the question at all, as land and rising are quite different propositions from mere flying. There are good grounds for saying that no existing machine would ascend from a plateau at 17,000 feet, and only with difficulty at 15,000 feet. It is, of course, possible to make machines capable of those performances, but only as the result of costly experiments. The requirements of aerial reconnaissance of the Himalayas necessitate prolonged flight at high altitudes—in other words, a long petrol range. As an aero engine consumes about sixteen gallons per hour, the idea of having the base at a low level would seriously curtail the petrol range. There is no doubt that an air-station at 15,000 feet would be a most valuable experimental station, but the cost would make it prohibitive to private enterprise. Forced draught, increased compression ratio, larger aeroplane, bigger and higher-pitched propeller, would be some of the lines of research, while suitable devices for the possibility of landing on snow would need careful and costly elimination. The problem of carburation at high altitudes has, however, already been successfully solved by the Claudel-Hobson and Zenith altitude controls. With regard to landing on snow, it is the common experience of the mountaineers that, in certain lights, every underfeature becomes invisible; experiments in this direction would, therefore, be especially costly. As temperature drops from 1° F. for every 273 feet rise, we may expect temperatures low enough to make "starting up" at least a matter of much difficulty, probably necessitating a hydrogen gas supply. It may be of interest to add details of two of the supposed highest aeroplane records. Hawker in 1916 attained a height of 24,000 feet. In 1914 the German Lieut. Oelrich attained a height of 25,750 feet. This was officially announced, but never ratified by the International Aeronautic Federation. It is, however, generally accepted as approximately correct. From the above considerations it would seem that the cost of evolving an efficient machine capable of being operated from a high altitude station, for the purpose of reconnaissance in the Himalayas, is beyond the limits of the funds of any privately organized expedition, but the actual possibility of eventually evolving a machine capable of achieving all the lecturer has indicated is not disputed.

Sir THOMAS HOLDICH: Dr. Kellas must know the Himalaya as well as I do, but possibly he has not experienced some of the difficulties that I have in dealing with atmospheric effects while surveying. The days when you can depend on seeing anything, particularly in the higher Himalaya, are very few indeed. It would be quite impossible for any man, starting in an aeroplane for a reconnaissance to take photographs, to say whether he would be able to see his way home. If Dr. Kellas confines his proposal to crossing the Himalaya, I do not think that is by any means impossible. But he would have to choose his route at the eastern end, passing over the Chumbi valley, following much the same route as our troops when they went to Lhasa. But what would he reach? Only Tibet. No doubt there is plenty of flat ground in

Tibet where he could land, and where, owing possibly to the general absence of snow, he could get off again. But the only reconnaissance of any use would be to make a start from one of the stations near the southern foot of the hills, and by a rapid flight into the Himalaya in an aeroplane fitted with photographic apparatus, particularly in the direction of Nepal, one might really get valuable results, though only a rapid reconnaissance. The airman would have to make a start early and be back by night. There would be no great altitude involved ; he would be able to see a great deal of country which we have never been able yet to see, and of which probably for many years we shall not be able to get anything like a reasonably good map, on account of political difficulties.

Captain SWINTON, R.E.: There are one or two points not touched upon, especially the very great difficulty of finding any pilot who could fly a machine in the wind currents that must certainly exist at those altitudes. I came across a case recently of an American pilot who had been flying the mountains in Mexico. On one occasion he came rather suddenly to a valley over a ridge in the bright sunlight, and he found himself, as he said, in a kind of inverted waterfall of hot air, which raised him several hundred feet and turned him upside down, to finish in the crater of an extinct volcano ; but fortunately he managed to make a landing the right way up. I should think that kind of thing might be expected in the Himalaya. A margin of 1000 feet between the machine and the mountains underneath would be rather small, and one would have a very considerable chance of getting into a bump or hole and having a crash before one could recover. No existing machine will go to 30,000 feet, and it seems to me there is not sufficient margin between the mountains and the upper limit of practical flying of to-day. Until we have a special form of aeroplane, we can hardly hope to negotiate successfully these frightfully mountainous countries, except as an exhibition flight or one of very great urgency.

Major G. I. TAYLOR, R.F.C. : I should like to say a little about the technical side of flying at these heights. In the first place, I do not think that there would be any great difficulty in the navigation. Admiral Mark Kerr said that it was impossible to tell in flying at great heights in which direction you are going. This is more true at sea than it is over land, because there is no fixed point at sea to use in estimating one's speed. I think it is perfectly possible to make navigating instruments which will enable you to determine your position to within 6 miles.

Admiral MARK KERR: I was referring to flying in the clouds.

Major TAYLOR: Even over the clouds I think it would be possible. The other question is that of landing. At the end of 1915 we experimented at Farnborough with a machine fitted with the skids referred to by Major Lees, and found it perfectly possible to rise and land on snow with them. I think if machines are fitted with skids it should be quite possible to land on snow without knowing beforehand whether it is hard or soft. But the real difficulty, to my mind, in landing on snow which you do not know, is that it is impossible to tell at what angle the snow is lying. Every one who has done any ski-ing knows that one cannot tell by looking at snow from above how nearly flat it is. One would be almost certain to crash an aeroplane in landing on a slope, if one could form no idea how the ground sloped till one touched it.

As to distance, to get up 20,000 feet one would have to fly a horizontal distance of about 100 miles anyhow, and machines can now be made which will fly 200 or 300 miles at that height. I do not really see any reason why one should not be able to make a survey starting from a distant low-level station,

provided one cares to fly within 1000 feet of the mountains. That seems to me to be much the best plan. I do not believe it would be possible to land at those heights, because the photographs we have seen shown this evening do not, as far as I could judge, exhibit snow-slopes flat enough to land on; and besides, the landing speed at those heights would be more than $1\frac{1}{2}$ times as great as it is near the surface. But, technically speaking, I see no insuperable difficulty in flying at those heights and making a photographic survey.

Mr. FRESHFIELD: May I point out that when this scheme was first discussed with General Rawling, the suggestion rather was that an aeroplane should fly up to the flat country north of Everest, and having a good base there should be used in exploring, and to a certain extent, in a rough way, mapping the Everest group. There was no suggestion of these attempts at peaks, or anything of that kind. Something of that sort would be the way to first make attempts, and it might be worth while, after what we have heard, if a mountaineering party cared to do it, to back themselves up to that extent by aircraft.

Lieut. GRANT (Admiralty Meteorological Service): From the climatic standpoint the problem is interesting and complex. It is not difficult to fly over mountainous ranges at a great height, where the winds are practically horizontal. But experience, both in this country and in the Adriatic, etc., shows that in alighting in a mountainous country danger always arises, partly from eddies due to cross winds blowing along the valleys and partly from vertical currents. Such currents are rarely encountered except in mountainous regions, and the present type of machine is apt to lose its stability when it meets them. In snow-covered mountains also considerable katabatic winds are formed (especially on clear nights) through the chilled air pouring down into the valleys. Such storms commence abruptly and are of considerable violence. (In the Adriatic a corresponding type of conditions is known as "the Bora.") They have little or no relation to the barometric pressures. Under such conditions the present type of machine is apt to lose its stability. While every precaution should be taken, in the event of the proposal being proceeded with, to render the first attempt successful, no amount of critical discouragement should be allowed to lead to the abandonment of the enterprise.

The CHAIRMAN: I never remember a meeting of the Royal Geographical Society at which the project of a proposed expedition was received with a more unanimous negative on the part of those best competent to judge, except on the occasion when Dr. Fridtjof Nansen put before us the project of drifting across the Arctic Ocean in the *Fram*. I hope that will be a happy augury of the suggestion that Dr. Kellas has made. As to landing airships or aeroplanes on high mountain plains: I was told in the year 1913, and did not believe a word of it, that the main object of a German meteorological expedition, which had been camped for several years on the plains at the base of the higher slope on the peak of Teneriffe, was to establish a base for aircraft in the event of a war with this country, in order that they might harass the converging traffic from South Africa and South America round the Canary Islands. I was told that by a Spaniard in an official position. He was quite serious in the matter. I did not believe it then, but I am inclined to believe it now. That also, I think, is an indication that it may not be impracticable to land aeroplanes and get off again from high mountain regions. I will ask Dr. Kellas to reply.

Dr. A. M. KELLAS: I have been greatly interested in what has been said by the various speakers, but some of the criticisms have been under a

misapprehension. The plan, as outlined, was to fly over the mountains or through the gorges, and carry out survey work from the north side of the main range, where the summer weather is comparatively good. With regard to the landing in snow, that was something extra, and was primarily in connection with experiments to protect the airman, who might be forced by engine trouble to land in awkward positions. Those who have read the paper will remember that what was stated—I am afraid I did not emphasize the point sufficiently—was that the use of aircraft would be for crossing the range, and bringing supplies, and in doing as much survey work as possible. As I pointed out, I was quite incompetent to deal with the matter from the aeronautical point of view, and I have been greatly interested in what I have learned regarding the difficulties of landing in snow at a high altitude, and starting again. But these are problems which will be worked out in part, I trust: the science of aeronautics is in its infancy. If it is possible to land at 15,000 or 20,000 feet and start again after a reasonable race, I do not see that the difficulties are insuperable.

THE SOUTH-EAST FACE OF MOUNT KENYA

Captain G. St. J. Orde Brown, R.A.

SUCH exploration as has already been done upon Mount Kenya appears to have been largely confined to the northern and western aspect of the mountain. Mackinder and Gregory both attacked it from those sides, while the more recent Roosevelt expedition also largely neglected the south-east slope. The following notes are made without claim to scientific value, but in hope that they may be of use to subsequent explorers wishing to investigate the least-known side of this very interesting mountain.

The characteristics of the south-east aspect may be summed up as follows: A network of rivers spreads from the mountain like the sticks of a fan, all eventually finding their way into the Tana River. The gorges in which these rivers run are all far deeper and much rockier than those of the rivers on the other sides of the mountain; the country is decidedly more wooded, and numerous signs exist of an age recently passed when the forest was of a much greater extent. This very broken nature of the country naturally tends to perpetuate and accentuate peculiarities of all sorts, both of the inhabitants and of the flora and fauna. It may therefore fairly be claimed that the south-east side of the mountain is really the most interesting portion.

The expedition upon which I made the following notes was conducted from the eastern side of the mountain, while my general course was towards the peak, but with a trend which brought me eventually almost due south of the peak at the highest point which I reached. It must be explained that the local natives, although they do not live at a greater height than 6000 feet, frequent the forest up to 10,000 feet, or even more, native tracks being found fairly well kept at an even greater height. These are used occasionally as short cuts by men wishing to cross spurs

out into new regions, leaving much of the land in the older districts uncultivated, or wasted their energies in the vain endeavour to force the old staples upon ground little suited for them. With the rapid diminution of new lands new methods must be adopted. For the supply of their ever-growing needs the people of the United States must find out what productive qualities exist in the areas that have been discarded in the early reconnaissance development, and, by suitable means, draw out the full measure of such productive power. Already the "dry farmer" has shown what can be done in the great arid region of the west, both by revising the tillage methods and by choosing a different set of plants or special varieties of plants grown elsewhere. The wet lands—especially the south-east—offer a different problem. It is calculated that such lands, now useless because too wet, probably cover 80,000,000 acres, and though much may be done by drainage, this does not obviate the need of a wise selection of crops. Besides the familiar rice, celery, cranberries, or onions, there are other crops admirably suited for cultivation in these wet lands, particularly certain species of *Aroidaceæ*, such as the "dasheen," with "tuberous roots a good substitute for potatoes, and claimed to make a flour better than wheat." The hill-lands, again—in New England and elsewhere—which have been pressed into flat-land uses with melancholy results, are excellently fitted for some crops. Thus the limestone soil of the Ozark Mountains is "beloved of alfalfa and many of the nitrogen-gathering legumes, and is suited too for raising the finest of peaches, apples, and strawberries." On the still steeper and more broken slopes, tree crops of great value—olives, nuts, the persimmon, the Chinese Tung-oil tree, the cork-oak, etc.—can be grown. With the present diminished man-power it is all the more necessary to shift the burden upon nature by so adapting culture as to utilize natural resources to the uttermost. Various other writers in the United States have shown what is being done towards increasing the food supply by the cultivation of products other than wheat, and have even discussed the possibility of replacing this as a bread-making staple by such products.

OBITUARY

Mr. John Claude White, C.I.E.

JOHN CLAUDE WHITE will be remembered for his work in Sikkim and Bhutan and on the borderlands of Tibet. Originally an engineer engaged in the construction of roads on this frontier, he spent the greater part of his service under the Government of India as a political officer in Sikkim. For this particular post he was eminently fitted. He was one of the few fortunate instances of an officer finding his way into precisely that position for which he was by nature specially adapted. He was a man of great simplicity of character, kindness of nature, and solidity of purpose; a lover of nature and a lover of simple peoples. And he found himself in that part of the world in which Nature manifests herself in fullest abundance, and he found himself, too, among a people as simple and natural as their surroundings. Nowhere is nature on a grander scale than in Sikkim; nowhere is there a greater profusion and variety of plant and animal and insect life. And there are few people more primitive than the Lepchas. Deep in the rich forests of Sikkim, far removed from civilized life, and in the close presence of the glorious Kangchenjunga, he made himself a beautiful home, and here he reigned supreme for the best years of his life, gradually attaching the people to him by his genuine solicitude for their

welfare and by the firmness of his authority. By degrees he established order, and saw that justice was evenly dispensed. And, always an engineer, he, as far as might be with the limited means at his disposal, cut rough lines of communication through the dense forests, along the precipitous mountain-sides, and across rivers fed by a rainfall which exceeds 300 inches in the year.

But White's duties lay not with the people of Sikkim alone: they also lay with the Tibetans on the border. For all the earlier period of his service these Tibetans had been extremely troublesome neighbours—intractable and unreasonable. They had invaded the territory of the chief of Sikkim, and refused to acknowledge the boundary which the Chinese on their behalf had fixed in conference with the Indian Government. They had thrown down boundary pillars erected jointly by British and Chinese officials. They had blocked all commercial intercourse with Tibet. They had brought their flocks to graze on the Indian side of the border. And they had refused all ordinary methods of negotiation. White was deputed by the Government of India on several occasions to meet them and come to some amicable arrangement, but none was possible till a mission was despatched in 1903-4 to Lhasa itself. In this mission White was appointed a Joint-Commissioner, and at its close performed what was probably the most valuable service in his career. The Tongsa Penlop of Bhutan accompanied the mission to Lhasa, and became specially attached to White. Bhutan adjoins Sikkim, and the chief had known him by reputation for many years. When the two met on the way to Lhasa they founded a firm friendship. The Tongsa Penlop had rendered valuable services to Government, and to show their appreciation the British Government despatched White to Bhutan in 1905 to invest him with the order of knighthood of the Indian Empire, and to establish formal relations with him. This duty White carried out with conspicuous success, with the result that our relations with Bhutan are now on a reliable and friendly footing.

White had, however, to pay the penalty of his long service in this beautiful but health-exhausting region. He had had to endure for years both the steamy enervating heat of the tropical forests in the lower valleys and the piercing cold of the arctic highlands. By the time he retired his health was completely broken, and he eventually succumbed to the strain it had suffered. But his work endures, and all who follow after will benefit by it.

F. E. Y.

MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1917-1918

Seventh Afternoon Meeting, 6 May 1918.—The President in the Chair.

PAPER: Notes on Construction of a General Map of Africa, 1/Two Million. Mr. A. R. Hinks.

Eleventh Evening Meeting, 22 April 1918.—The President in the Chair.

ELECTIONS.—Henry James O'Brien Bedford-Jones; Captain Henry Akerman Desmond Collins; Major Edward Brian Barkley Hawkins; H. W. Holland; Comtesse Mabel de Lesdain; Rev. B. J. Ratcliffe; Lieut. Charles Augustus Rheault, Royal Canadian Dragoons; Major Geoffrey Ingram Taylor, R.A.F.

PAPER: The Transkei. Miss M. H. Mason.