

of internal rainfall coincident with the uplift of the country for about 1000 feet.

## REFERENCES.

- CAMPBELL, W. D. 1906. "The Geology and Mineral Resources of the Norseman District, Dundas Goldfield," *Geol. Surv. West. Aust.*, Bull. 21, 140 pp., 1 map (in 2 sheets), 5 pl.
- CHAPMAN, F. 1914. "Australasian Fossils. A Student's Manual of Palæontology," 341 pp., map.
1911. 'Official Year Book of the Commonwealth of Australia,' No. 4, 1230 pp.
- FORREST, JOHN. 1875. 'Explorations in Australia,' viii., 354 pp., 4 maps.
- GIBSON, C. G. 1906. "The Laverton, Burtville, and Eristoun Auriferous Belt, Mount Margaret Goldfield," *Geol. Surv. West. Aust.*, Bull. 24, vi, 79 pp., 13 maps, 26 pls.
- GIBSON, C. G. 1908. "Report upon the Auriferous Deposits of Barrambie and Errolls (Cue District and Gum Creek (Nannine District) in the Murchison Goldfield; also Wiluna (Lawlers District) in the East Murchison Goldfield," *Geol. Surv. West. Aust.*, Bull. 34, 44 pp., 2 maps, 3 pls., 6 photographs.
- JACKSON, C. F. V. 1905. I. "Geological Features and Auriferous Deposits of Mount Morgans (Mount Margaret Goldfield);" also II. "Notes on the Geology and Ore Deposits of Mulgabbie (North Coolgardie Goldfield)," *Geol. Surv. West. Aust.*, Bull. 18, 36 pp., 2 maps, 1 sheet of sections.
- LINDSAY, D. 1893. 'Journal of the Elder Scientific Exploring Expedition, 1891-2. Under Command of D. Lindsay.' Adelaide, 207 pp., 2 maps.
- MATTLAND, A. GIBB. 1908. "Recent Advances in the Knowledge of the Geology of West Australia," *Rep. Aust. Assoc. Adv. Sci.*, Vol. 11, pp. 131-157, pl. 1, 1906. 'Western Australian Year-Book for 1902-04' (thirteenth edition), x, 1283 pp., 73 illustrations, 16 maps and diagrams.
- WOODWARD, H. P. 1897. "The Dry Lakes of Western Australia," *Geol. Mag.*, Dec. 4, vol. 4, pp. 363-366.
- WOODWARD, H. P. 1906. "The Auriferous Deposits and Mines of Menzies, North Coolgardie Goldfield," *Geol. Surv. West. Aust.*, Bull. 22, 92 pp., 2 maps, 6 pls.

## THE INDO-RUSSIAN TRIANGULATION CONNECTION.

By Lieut. KENNETH MASON, R.E.

DURING the International Geodetic Conference of 1909, which met in London, the question of a triangulation connection between India and Russia was discussed, and it was suggested that a link might be effected across the northern boundary ranges of India to the Chinese or Russian Pamirs, and in the early part of the year 1911, the Surveyor-General of India received a request for the Indian triangulation to be carried on to the northern frontier.

By this time, the Russian work, which had been initiated by Colonel Tcheikine from the base Ourtak-Tchoucour-Machali-Goudour, latitude 39° 33', approximately, on the Trans-Alai mountains, had reached the neighbourhood of Pamirski post, about lat. 38° 13', long. 75°.

An Indian Principal Series, started from near Rawal-Pindi in 1909, from the base Nerh-Khagriana, of the North-West Himalaya series, by Mr. J. de Graaff Hunter, had been taken to the neighbourhood of Shardi by the end of 1910, and forward stations were reconnoitred up to the neighbourhood of Gilgit. It had been decided to take this series as far north as this, independently of the idea of making a connection with the Russian work.

During 1911, the late Lieut. H. G. Bell, R.E., who succeeded Mr. Hunter in charge of the detachment, carried this principal series up to Gilgit. Many difficulties were encountered owing to the necessity of an early start; snow lay as low as 8000 feet, and great difficulty was experienced in placing the lamp squads on the hills for the observations from the first station. A bad spell of weather set in when Lieut. Bell was on Liowi H.S., 17,480 feet, and he was detained there from June 13 till June 21, with a minimum temperature of 20° F.

Again, on Zinghi Shish, the detachment met with very bad weather, and the portable lightning conductor, which had been erected over the observatory tent, was struck.

While on the march up the Indus valley, a severe earthquake shock was experienced which caused a cliff to be precipitated into the river. The heat here was so intense that marching could only be undertaken during the early morning and late evening, which offered a marked contrast to the high camps situated on snow.

With a view to reconnoitring a feasible line for effecting a junction with the Russian system, Lieut. Bell and Mr. Wainwright left Gilgit on August 1, the former taking the Darkot route, while the latter reconnoitred up the Hunza valley. Lieut. Bell first visited the Darkot pass, by way of the Yasin valley, examining the peaks in the vicinity, in the hope of finding some possible connection on to the Salisbury and Concord peaks on the Russo-Afghan frontier. He found the extensive glacier, rising on the pass, much intersected by crevasses, and only passable in the very early morning. The highest peak, about 19,370 feet, west of the pass, was found to be quite inaccessible for triangulation purposes, and the neighbouring peaks, though lower, were useless, owing to the high unclimbable peaks to the south and south-east. From Darkot, Lieut. Bell visited the approaches of Garmush, 20,564 feet, but found that the glaciers in the neighbourhood were extremely dangerous, and the slopes very subject to avalanches. The Darkot-Askuman pass was crossed, and a peak ascended with a view to obtaining a more extensive reconnaissance of Garmush and the other peaks of the Sakiz-Jarab range, but the term "glorified Matterhorns" which has been applied to the Karakoram peaks further east, was found to be equally applicable here. In a letter written from hereabouts to me, Lieut. Bell mentioned that he doubted whether the peaks would be accessible for an experienced party of climbers, and that it was a physical impossibility to take an instrument up any one

of them. A move was now made up the Karumbar valley, in the hope of finding a possible line of connection to the Russian stations from here. The lower reaches gave hopes of success, but from Imit northwards the valley closes in, and the mountains rise precipitously from the banks of the river-bed. Progress was slow up the western bank, and the route was further barred by a landslip, which night and day discharged rocks and earth into the river. Further advance became impossible when the Karumbar flooded, for this river, like all others of any size in the Hindu Kush and Western Karakoram, rises to such a size that the fords upon which the route depends become impassable in the summer. The possibility of utilizing this route was, however, never abandoned by Lieut. Bell, should the Hunza valley route fail to yield better prospects of success.

Mr. Wainwright meanwhile made a reconnaissance towards the Kilik pass, and reported that it would be practicable to run a series as far as Misgar, but that it would be advisable from here to branch off up the Khunjerab valley, and effect a link by means of the Kharchanai pass. Owing to the rough track, he advised the use of a smaller instrument than the 12-inch theodolite.

During the summer of 1911, the Russian triangulation had been extended to the Russian frontier, and two stations—Beyik, approximate lat.  $37^{\circ} 18'$ , approximate long.  $75^{\circ} 7'$ , and Taghramansu, approximate lat.  $37^{\circ} 16'$ , approximate long.  $74^{\circ} 54'$ —had been fixed. Owing to the results of Lieut. Bell's reconnaissance, however, since the peaks of the Sakiz Jarab were unsuitable, this method of connection had to be abandoned, and it was decided to make the attempt *via* the Mintaka, Kharchanai, or Kilik passes.

Lieut. Bell was again in charge of the detachment during the summer of 1912, and arrived in Gilgit by May 31. It had been decided to base the connection on a side of the Kashmir Principal Series, in lat.  $35^{\circ} 55'$  and long.  $74^{\circ} 20'$ , from which it would trend northwards to near Chalt, and thence, following the bends of the Hunza river, it would more or less keep to this valley till the passes were reached. From there it was intended to take the series to the Russian stations, Kukhtek and Sarblock, on either side of the Beyik pass, in about lat.  $37^{\circ} 20'$  and long.  $75^{\circ} 10'$ . Lieut. Bell decided to go straight through to the Russian end and work back, while a second squad under Mr. Collins worked up from the neighbourhood of Gilgit.

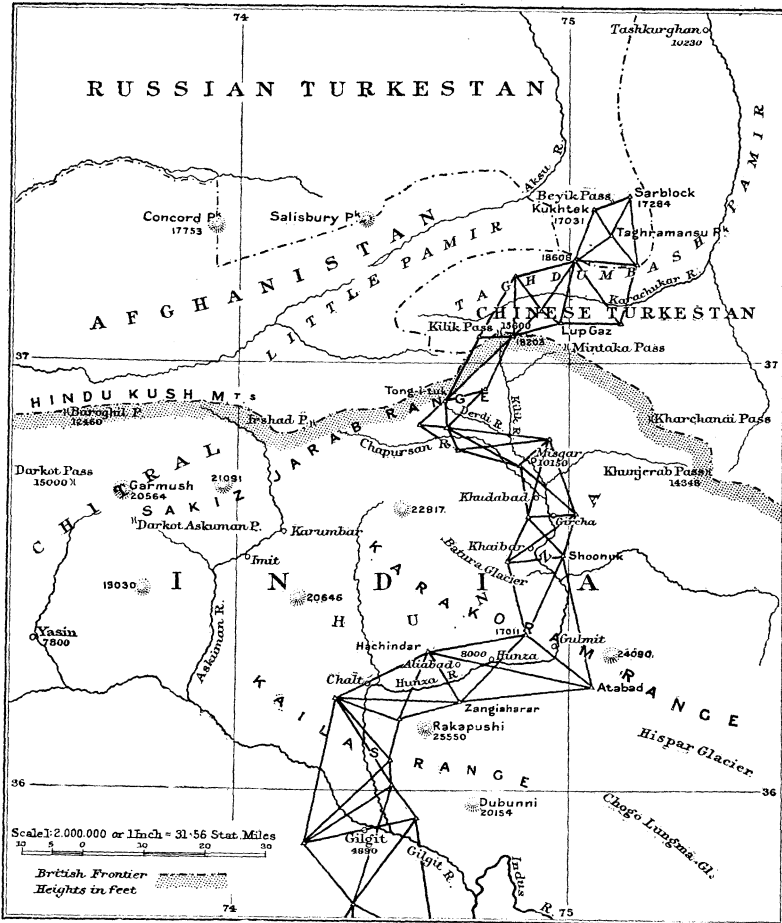
The year was a disastrous one for the Survey. Early in June the various detachments left Gilgit, but the weather was very unfavourable, and while on Yashochish hill station, on the Great Himalayan range, the camp of Mr. Abdul Hai was wrecked by lightning; his servant was killed and his recorder was severely burnt, while he himself received a bad shock which necessitated his return to Gilgit. This district is notoriously bad for electrical disturbances, and very different from the regions of the Karakoram, which, as has been observed by the Duke of the Abruzzi, are

very free from storms. Mr. Collins now carried on the triangulation from Gilgit towards Hunza, when, on July 28, he had to take over charge of the detachment owing to Lieut. Bell's death.

The latter, with Mr. McInnes, had travelled *via* the Hunza gorge to the Pamirs, crossing by the Mintaka pass to the Taghdumbash. After detailing Mr. McInnes for the work of reconnaissance towards the Kilik

THE INDO-RUSSIAN TRIANGULATION CONNECTION.

To illustrate the paper by Lieut. Kenneth Mason, R.E.



pass, Lieut. Bell proceeded to the Russian stations on either side of the Beyik pass on the Russo-Chinese frontier, and met the Russian triangulation party under Colonel Tcheikine on the pass. He completed three stations, and ascended a fourth, but found some difficulty in observing from it to Lup Gaz. He therefore moved his camp back to the latter station with a view to finding out whether the ray was visible. He had not

been very fit for the last few days, and had been over-exerting himself. On July 19, when at his camp on Lup Gaz hill station, he awoke in very great pain, and finding that he became no better, he had himself carried down to his base camp in the Lup Gaz Jilga. He remained here for a few days, and on the morning of the 24th, sent a note to Mr. McInnes asking him to come and take over the observations. Mr. McInnes received this when in camp near the Kilik pass on the following morning, and immediately left for Lup Gaz, traversing the Pamir from the Kilik to Lieut. Bell's camp, a distance of nearly 40 miles, the same day; he arrived in the evening to find Lieut. Bell very weak. The latter refused to allow Mr. McInnes to sit up with him, urging that he must be very tired, and should go and lie down and rest after his long ride. It was characteristic of him absolutely. He knew the gravity of his case, for he went into a few details of the work, and asked Mr. McInnes to go up the station the next day, and get through as much of the work as he could, but he tried to look on his illness as cheerily as he could, saying that he hoped soon to be fit enough to carry on again. He assured Mr. McInnes that he would call him if he wanted anything during the night, but about midnight he passed away alone. It is hardly necessary to add after what has been said, that the ultimate success of the work was due almost entirely to the energy and devotion of Lieut. Bell. During his short stay on the Pamirs, he had earned a reputation for unselfishness and self-sacrifice, and I found this year that he had been held in very high esteem. On his death I personally lost my dearest friend, and I had known him intimately for many years; he was a daring mountaineer, and absolutely fearless, and his loss to the Service and to Geography is incalculable.

This disaster delayed the work very largely, and by the end of the season, a late one as Pamir summers go, the triangulation had only been completed from the Gilgit side to a point some little way below Hunza. Mr. McInnes finished the reconnaissance of the Pamir section, but the work done in the Hunza gorge showed that a departure would have to be made below Misgar, in order to obtain suitable figures. As the crow flies, there remained about 70 to 80 miles to be traversed by the triangulation, but the actual length of the chain was nearer 120 miles. Of this, some 75 miles had been reconnoitred and the stations built, and with the exception of the two stations near the Kilik pass these were subsequently found suitable.

During the early part of 1913, I was given charge of the detachment to complete the connection. All through the season we were luckier than last year; and, owing to an earlier start and fine weather on the passes, we reached Gilgit a fortnight earlier. The detachment, which had marched up in three separate squads in order to facilitate transport, concentrated at Aliabad, Hunza, on May 20, after leaving a main depôt at Gilgit. The distribution of the work was arranged in a somewhat similar manner to last year's scheme. Mr. Collins was to work up the Hunza river, Mr.

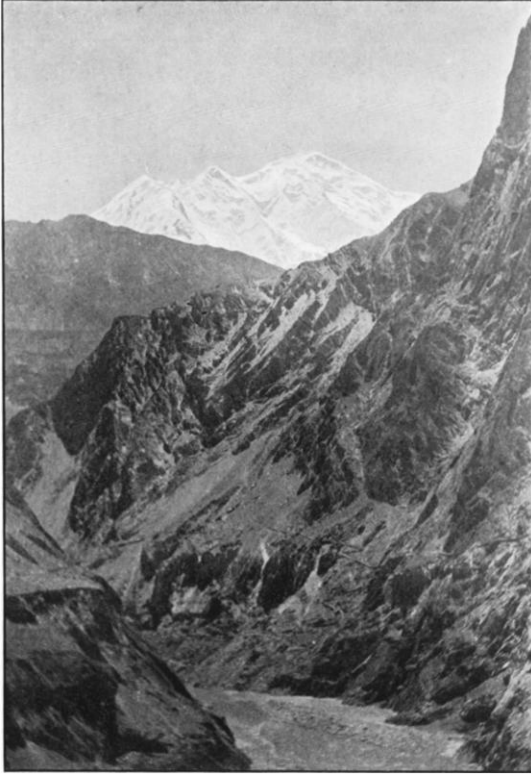


FIG. 1.—RAKAPUSHI FROM NEAR TASHOT, HUNZA OR DUMANI.

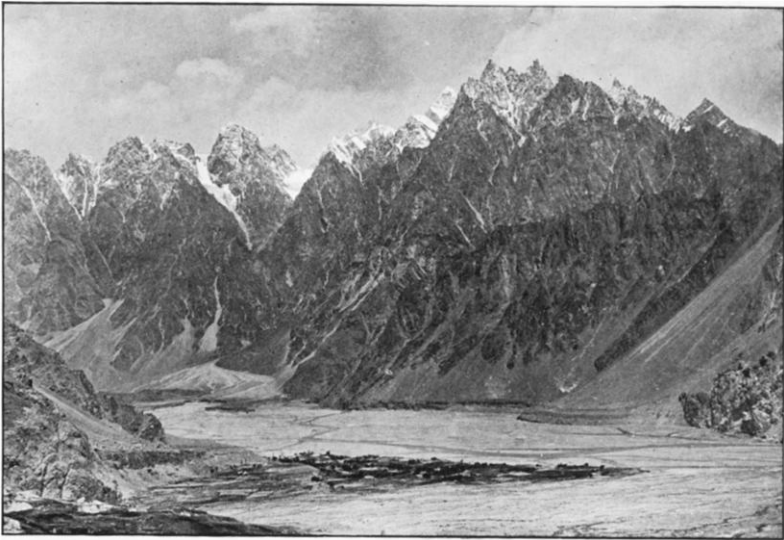


FIG. 2.—PASU AND THE HUNZA GORGE, WITH MOUNTAINS OF SHOONUK.



FIG 3.—VIEW SOUTH FROM KILIK WEST H.S., SHOWING ON THE RIGHT THE MOUNTAINS OVER WHICH THE TRIANGULATION WAS CARRIED. THE V DEPRESSION ON THE LEFT IS THE HUNZA GORGE AT MURKUSHI.



FIG. 4.—KILIP EAST H.S. (ABOUT 19,000 FEET).

McInnes to reconnoitre in the country between Khudabad and the Kilik, while my detachment proceeded straight to the Pamirs, to the point where Lieut. Bell had left off. Captain R. W. G. Hingston, I.M.S., who had been attached to the party, accompanied the latter detachment, with a view to studying the natural history of the district, and rendering any medical assistance that might be required.

Mr. Collins' detachment commenced work about the end of May, visiting his two last stations of 1912, Zangiahara and Hachindar, the former on the northern slopes of Rakaposhi, the latter on the hills above the right bank of the Hunza river (Fig. 1). Helio squads were placed there, and Mr. Collins then proceeded up the Hunza valley. He found that his next station, Atabad, on a spur of the mountain for which Sir Martin Conway obtained the formidable name, Mount Boiohaghurdooanasur—which means in the Burishushki \* language, "Where only the horse of a demon can go"—too difficult to climb at this early season. So he decided to continue up the valley, and return at a later season. Between Atabad and Gulmit, the valley narrows to a precipitous gorge, where the Hunza cuts its way through the main axis of the Karakoram, and the summer road, carried high up across the face of a cliff, a thousand feet or so above the river, is only laid on pegs driven into the rock, and is distinctly sensational. Mr. Collins' next stations were on either side of the river just south of the village of Khaibar, that on the left bank, being on the rocky peaks of Shoonuk (Fig. 2), while the other was on the northern boundary wall of the long Batura glacier. This detachment completed the triangulation up to the junction of the Chapursan and the Kilik rivers, including four more stations besides those already mentioned, namely, Kirilgoz and Sirsar on either side of the river at Gircha, and Tehri Sar and Raminj Sar at the mouth of the Chapursan valley. It then marched down the Hunza and completed the observations at Booriharar and Atabad, making a total of eight stations, of which the average height was 15,090 feet.

Mr. McInnes' detachment marched direct to the Chapursan and rapidly selected the stations up this valley. Like the majority of the longitudinal valleys of the mountain barrier, the valley is not very precipitous, particularly in its lower reaches. The difficulty arose when the question of connecting on the work from here to the Pamirs came to be settled, and Mr. McInnes climbed a large number of hills before he succeeded in even finding one that would range through to the north, and this necessitated a change of two stations near the Kilik pass. After first reconnoitring Hark mountain † from the south, he brought his detachment to Bun-i-kotal, south of the pass, and we discussed the possibility of

\* Or Burishaski. See 'Tribes of the Hindu Kush,' Biddulph.

† Hark mountain, or Tong-i-tuk, is situated on the watershed between the Derdi valley and the Hark, which is the last and most northerly tributary of the Kilik river from the west, and joins this river at Bun-i-kotal.



effecting a link across these mountains.\* Hark mountain, 19,135 feet, is extremely difficult to climb from the north, and Mr. McInnes, who decided to tackle it from the south, and left us at the pass on July 2, did not succeed in getting his instruments up until the 22nd; this mountain is called Tong-i-tuk from the south.

After making a station on Tong-i-tuk, Mr. McInnes again had difficulty in finding another hill from which he could join on to this station and the Kiliks, and the final connection was not completed, owing to unfavourable weather, until August 25. Mr. McInnes observed from five stations, of which the average height was 17,616 feet.

The Pamir detachment, which came with me, left Hunza on May 23, and after marching up the Hunza valley, reached the Taghdumbash Pamir *viâ* the Mintaka pass, on June 3. Reconnaissance was carried out to ascertain that Lieut. Bell's stations had not been lost during the winter, the signallers were placed on their posts, and we marched to the Russian station of Sarblock. A bad spell of weather set in which lasted a week or so, and delayed the observations, so that only three stations were completed by the end of the month. Early in July, after meeting Mr. McInnes at the Kilik pass to arrange with him the details of the link, the party was again held up for some days and nights on Kilik east hill station, 18,203 feet,† and was hardly able to leave the Whympers tents (Fig. 4 shows the observatory tent on this station). When the weather again cleared, the work was hurried on, but was delayed somewhat by a signaller and his mate going sick and being unable to show a helio. The recorder met with an accident, but Captain Hingston very kindly undertook his duties in addition to his own. In spite of these troubles, however, by the end of July, the triangulation had been carried to the Kilik pass from the Russian end, and on August 5, was completed at Mr. McInnes' southern stations, making a total of ten stations, averaging 17,716 feet.

The weather in these parts is very unfavourable to triangulation. Nearly half the days had seen snow falling, but on many of them work was possible at some time or other. Owing to the strain on the eyes of observing on hills covered with a mantle of snow, I suffered from an attack of snow-blindness, and, after this, frequent rests were essential on the hill stations, and work in camp of an evening became troublesome. One of the greatest difficulties, however, was the rationing of the detachments, which in the case of the Pamir section numbered over 100 men. The Pamirs produce nothing but milk, sheep, and goats, and the latter were ruinously expensive. We bought for this detachment alone, 200 maunds (16,000 lbs.) of *ata* (flour) before leaving Hunza, but some of this was to be sent up later; the Hunza authorities delayed the despatch of this convoy, and it eventually arrived within reach of two days' march, three weeks late, when the detachment had been on half rations for some days,

\* Fig. 3 shows this country as seen from Kilik West H.S.

† Aneroid height, 19,300 feet; 1100 feet too high.

and had only four days' half rations left. Luckily the detachment did not realize that the depôt camp was empty. Again, towards the end of the season, owing to a promise from the Amban of Tashkurghan, on which we had been counting, and which he was unable to fulfil owing to the arrival of Chinese troops, we were again thrown on half rations for a fortnight, and eventually left with only four days' half rations.

On August 25, Mr. McInnes connected through to the two Kilik stations from the Indian series, and the connection between India and Russia was at last complete.

The chain connecting the Russian stations with those of the Indian Principal Triangulation near Gilgit, consists, as may be seen on the sketch-map (p. 667), of seven quadrilateral figures in which the diagonals were uninterrupted rays, two other four-sided figures in which a central station had to be inserted, and eleven single triangles. The number of stations, including those from which it emanates and those on which it closes, is thirty-three. The average height of the stations is 16,222 feet. The highest is Tong-i-tuk, 19,135 feet. This station was climbed by Mr. McInnes.

The average length of the sides of the triangles is 8637 miles, and the co-ordinates of the Russian stations as computed from the Indian side are—

	Height. Feet.
Russian west, lat. $37^{\circ} 17' 32''$ .97, long. $75^{\circ} 00' 12''$ .19 ... ..	17,031
Russian east, lat. $37^{\circ} 18' 58''$ .92, long. $75^{\circ} 04' 41''$ .17 ... ..	17,284

Besides the work of triangulation, Captain Hingston and I took a series of photographs on the extended stereoscopic base system, for the subsequent compilation of a map by stereo-photography, by the method devised by Captain Vivian Thompson, R.E. This cannot hope to be an absolutely complete map, as the topography had to be treated as of very secondary importance, and no reconnaissance was possible, but it is to be hoped that in addition to an accurate map of those parts photographed, much light will be thrown on the question of the easterly extension of the Northern Hindu Kush range. I do not believe that the Sarikol range extends south of the main Karachukar river, nor does it connect on with the Aghil range at all, and this range is possibly an extension of the northern Hindu Kush and old northern Karakoram ranges, the latter range having now been cut so much into granite blocks and isolated massifs by the headwaters of the Hunza river, that it has lost all appearance of a present-day range. Some observations were made of geological interest, and rock specimens were brought back from both Hunza and from the Pamirs by the detachment. These have since been classified by Mr. J. Coggin Brown, of the Geological Survey of India.

A Botanical collection was also made of all plants met with, but these comprised only 48 species, the Pamirs not being at all rich in flora. The collection is now being classified at the Royal Botanic Gardens, Sibpur,

Calcutta. It seems probable that two or three of the plants collected are of new species.

Captain Hingston also made a very complete zoological collection of the fauna of the Taghdumbash and of the district included by the road between here and Bandipur, which he is now working out, and in addition made a series of hæmatological observations at various altitudes ranging up to about 18,500 feet, which seem to throw some light on mountain distress. As regards the latter, the whole detachment was remarkably free from any ill effects from altitude, though loss of appetite was experienced after remaining at an average height of approximately 15,000 feet for two months with constant work on hand.

In addition to these results, Captain Hingston took a series of observations to cirrus clouds for the Meteorological Survey of India, as often as they were visible.

In conclusion, I have to record my deep indebtedness to the Hon. Mr. Stuart Fraser, Resident in Kashmir, to Major A. D. Macpherson, Political Agent at Gilgit, and to Sir George Macartney, His Britannic Majesty's Consul-General at Kashgar, without whose extreme kindness and sympathy, the work could never have been carried out; to Mr. H. H. Hayden, Director of the Geological Survey of India, and to Dr. Gilbert Walker, Director-General of Observatories, for their assistance and kindness; and lastly to my fellow-workers and faithful coolies, who never failed to lighten the work to the best of their power.

---

#### DR. F. DE FILIPPI'S ASIATIC EXPEDITION.

DR. F. DE FILIPPI sends from Leh, Ladakh, the following account of the scientific work from November 5, 1913, to March 31, 1914 :—

A plan to make a gravimetrical station to the south of Skardu, on the range which girds from this side the Deosai plateau, was mentioned in the former report (*Geographical Journal*, January, 1914, p. 32). This was successfully carried out between November 6 and 17. The station was made at Wozel Hadur, a narrow terrace in the vale of Burgi La, at an altitude of 14,042 feet, beyond which it would have been impossible to pitch the tents, owing to the steepness of the ground and to the deep snow.

The pendulum observations were made in a large tent with three walls, which had been especially devised, and which answered the purpose very well. These were followed by the magnetic observations, and regular readings were taken of barometers and hypsometers, pilot-balloons were sent up, and determinations of the intensity of solar radiation were made with Ångström's and Abbot's pyrheliometers. In addition to the photographic work for topographical purposes, Lieut. Antilli took telephotographic panoramic views (on November 8 and 12) of the Karakoram ranges from a peak to the east of Burgi La, at an altitude of 16,600 feet.