

XVI.—*Results of the Observations taken by Mr. R. B. SHAW during his Journey to Yarkand in the year 1870.* Calculated by WILLIAM ELLIS, F.R.A.S., of the Royal Observatory, Greenwich.

1. GENERAL REMARKS.

As regards the index correction of sextant, the values given by Mr. Shaw have been duly applied throughout. For days on which determinations are wanting, no correction has been applied, excepting in a few instances in which the value given on an adjacent day was used. The corrections are small; their omission is therefore of little importance except in the case of lunar distances, in three of which—Sept. 5, Moon and Saturn; and Sept. 20, Moon and Jupiter, and Moon and Sun—on account of the difference between the values determined on Sept. 1 ($-23''$) and Sept. 9 ($+15''$) and between Sept. 19 ($-30''$) and Sept. 22 ($+27''$), no correction was applied.

In the calculation of refraction, Bessel's tables have been used, the barometer and thermometer readings being either directly taken, or assumed, as necessary, from the numbers given in Table X.

2. CALCULATION OF LATITUDE.

The observations available for determination of latitude are meridian altitudes of the Sun, Saturn, and α Aquilæ, and altitudes of the Pole Star out of the meridian. The meridian altitudes require no further remark than that in the case of the sun the lower limb is understood to have been observed. For reduction of the Pole Star altitudes, the error of the watch was determined on each evening from the observations of altitudes always also made of some equatorial or quick-moving star, using in the calculation an approximate value of latitude: the latitudes were then directly calculated. The results of all these observations are given in Table V.

3. CALCULATION OF LONGITUDE FROM OBSERVED LUNAR DISTANCES.

For reduction of these observations the error of the watch was calculated from all available observations, employing not only the altitudes specially taken for the purpose, but also, as seemed desirable, any of those of the objects to which the moon, in the measurement of lunar distances, was referred. On each

day the mean of the watch errors thus obtained (giving weight according to the number of observations in each group) was used for reduction of the several lunar distances, assuming throughout a rate for the watch such as the watch errors seemed to indicate as necessary to be made. In a few cases no altitudes of the Moon, or of the body referred to, were observed; and in some instances the variation between the altitudes observed could not be considered as uniform for proportioning the altitude for the time of observation of distance. The altitudes have therefore been all directly calculated. For three stations there are no observations for latitude, those given by Mr. Shaw are therefore used. They are for Yangee-bazar, $38^{\circ} 19'$; Ooetoghrak, $37^{\circ} 33'$; and Camp Somdo, $35^{\circ} 1'$. For determination of the true distance, the method given by Chauvenet, in his 'Spherical and Practical Astronomy,' was employed. In the cases of the Moon and Jupiter, and the Moon and Saturn, it is supposed that the distance of the *centre* of the planet was observed. The 'Nautical Almanac' distances have been corrected for the error of the Moon's place, as determined from the Greenwich Observations, and the longitudes then deduced in the usual way. The values so obtained are given in Table VI. They show a difference in the results depending on the position of the Moon east or west of the object referred to. The numbers available for determination of an approximate correction for this difference are given in Table VII. The necessary correction being ascertained, the concluded longitudes, as shown in Table VIII., were found.

4. MAGNETIC DECLINATION (VARIATION OF THE COMPASS).

Little remark is here required. From observed altitudes of the sun, his true azimuth has been found for the times of observation of magnetic azimuths; and Table IX. contains the mean value of magnetic declination for each day thence determined. For Khoosh-Maidân and Leh the latitudes given by Mr. Shaw were used ($35^{\circ} 32'$ and $34^{\circ} 10'$ respectively). The resulting values of magnetic declination are not accordant.

5. HEIGHTS OF PLACES ABOVE THE MEAN LEVEL OF THE SEA.

These results are determined from observations of the boiling-point of water. The observed boiling-points were converted into corresponding barometer readings (see Table X.) by the table given at page 78 of vol. ii. of Schlagintweit's 'Scientific Mission to India and High Asia.' The heights were then calculated on

two assumptions:—1. By reference directly to the level of the sea. 2. By reference to Leh. In referring to the level of the sea, the barometer reading at the mean level of the sea was assumed to be 29.92 in., and the temperature of the air 70° . In referring to Leh, the mean barometer reading at Leh has been taken: for July, 19.677 in.; for August, 19.740 in.; and for September and October, 19.763 in. The temperature of the air for July and August (to the 15th) has been taken = 70° ; from Aug. 16th to 31st, = 67° ; from Sept. 1st to 10th, = 64° ; from Sept. 11th to 20th, = 60° ; from Sept. 21st to 30th, = 50° ; and for October, = 40° . These values for Leh are founded on observations made there during the months of July, August, and September, of the year 1856, and which are printed at page 58 of the volume of Schlagintweit already referred to; the height of the cistern of the barometer employed being taken 11,532 feet. (See the same volume, pages 58 and 446.) The heights were in both cases calculated by the tables, pages 71 to 77 of the same volume of Schlagintweit, taking the latitude = 35° , and the average humidity of the atmosphere = 50 (complete saturation being = 100). The results of these calculations are given in Table X. The values for Leh show that Mr. Shaw's single observation produces nearly the same result as that adopted (11,532) for Leh. It will be remarked that there are determinations of heights of some places both in the journey northward and again in returning southward.

*Observations for Longitude, Latitude, Variation of the Compass, and Heights of Places above the Sea Level,
taken by Mr. R. B. SHAW during his Journey to Yarkand in 1870.*

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SHAW'S Observations for Longitude, Latitude, &c.,

TABLE I.—OBSERVATIONS FOR LATITUDE BY MERIDIAN ALTITUDES; AND DETERMINATION OF THE BOILING-POINT OF WATER.

Date.	Place of Observation.	Object Observed.	Meridian Altitude. (Half Observed Angle in Mercury.)	Boiling Point of Water.	Temperature of the Air.	REMARKS.
1870.	[Leh (Ladak), October 23] ..	..	° .. "	Fahr. 192·1	Fahr. 53	Boiling-points taken in steam (Casella's instrument).
July 14	Chagra (near Pangong Lake)	..	..	186·1	62	
„ 15	Masimik Pass .. .. .	..	..	176·0	51	
„ 15	Pangloong .. .. .	..	..	182·4	50	(Mercurial barometer 16·251 in.).
„ 16	Pamzal	SATURN	33 41 30	185·4	81	(Ditto 17·425 in.; air temperature 87·5°).
„ 17	Ditto .. .. .	..	..	186·0	70	Boiling-points taken in water after this.
„ 18	Gogra	SATURN	33 38 30	184·8	62	Semi-correction for Index error of sextant + 30".
„ 19	Hot Springs .. .. .	..	..	184·1	72	
„ 19	Camp below Pass (Junction of Stream).	SATURN	33 30 0	183·0	70	
„ 20	Summit of Pass (Dr. Cayley's)	..	..	178·4	55	Mercurial barometer (as above) 14·9 in.; attached thermometer 62°.
„ 20	Nischoo .. .. .	..	..	180·0	48	Ditto 15·23 in.; attached thermo- meter 73°.
„ 21	Camp in Lingzee-Tung ..	..	..	181·7	50	
„ 23	Camp in Lak-zang .. ..	..	..	182·1	67	
„ 25	Tarldat .. .. .	..	..	183·6	55	
„ 26	Patsalang .. .. .	..	..	182·5	71	

July 31	Káfir Darra (1st Camp) ..	ALTAIR	62 21 15	188.2	60
Aug. 1	Ditto (2nd Camp) ..	.. ..	.. ..	188.9	..
„ 2	Ditto ditto ..	.. ..	.. ..	189.4	68
„ 5	Balakchee .. .. ..	.. ..	.. ..	190.7	65
„ 6	Toghra Soo	ALTAIR	61 59 45	.. ..	..
„ 7	Pilatagach .. .. ..	.. ..	.. ..	192.6	62
„ 8	Camp below Grim Pass (south side).	.. ..	.. ..	190.5	55
„ 9	Top of Grim Pass .. ..	.. ..	.. ..	183.2	46
„ 9	Kichik Yeilák	SATURN	31 13 10	191.1	45
„ 10	En route below ditto, 2 miles	SUN	68 38 15	.. ..	..
„ 10	Tam .. .. ..	.. ..	.. ..	196.5	64
„ 11	Camp Choochoo .. .. ..	.. ..	.. ..	193.2	64
„ 12	Choochoo Pass	SUN	67 53 0	.. ..	..
„ 13	Camp Arpalak .. .. ..	.. ..	.. ..	197.0	73
„ 16	Sanjoo .. .. ..	.. ..	.. ..	200.6	80
„ 16	Ditto .. .. ..	.. ..	.. ..	200.9	70
„ 17	Langar Soolághaz	SUN	65 56 45	.. ..	..
„ 17	Koshtak .. .. ..	.. ..	.. ..	201.6	75
„ 18	Ooeetoghruk .. .. ..	.. ..	.. ..	201.8	85
„ 19	Bora	SUN	64 59 45	202.3	87
„ 20	Kargalik	SUN	64 22 0	204.0	86
„ 21	Poskiam .. .. ..	.. ..	.. ..	205.0	79
„ 22	Yangee-bazar .. .. ..	.. ..	.. ..	205.0	74
„ 25	Yarkand	SUN	62 9 15	.. ..	..
„ 25	Ditto	ALTAIR	60 8 50	.. ..	..
„ 26	Ditto	SUN	61 49 50	.. ..	..
„ 27	Ditto	SUN	61 28 50	205.6	89
„ 31	Ditto .. .. ..	.. ..	.. ..	{ 204.9	86
				{ 205.1	78
Sept. 2	Ditto .. .. ..	.. ..	.. ..	205.8	75
„ 3	Ditto .. .. ..	.. ..	.. ..	205.9	78

At 7 P.M.
At 2 P.M.
Semi Index correction of sextant - 3".

At 6 P.M.
Doubtful observation.

Semi Index correct, sextant - 5".

Doubtful observation (clouds).

Semi Index correct, sextant - 5".
Semi Index correct, sextant - 12".

during his Journey to Yarkand in 1870.

TABLE I.—OBSERVATIONS FOR LATITUDE BY MERIDIAN ALTITUDES; AND DETERMINATIONS OF THE BOILING POINT OF WATER.—*continued.*

Date.	Place of Observation.	Object Observed.	Meridian Altitude. (Half Observed Angle in Mercury.)	Boiling Point of Water.	Temperature of the Air.	REMARKS.
1870.				Fahr.	Fahr.	
Sept. 4	Yarkand .. .. .	..	° ' "	205·9	79	
„ 6	Poskiam .. .. .	..	..	205·1	72	
„ 7	Kargalik .. .. .	..	..	204·5	76	
„ 8	Bora .. .. .	..	..	203·3	60	
„ 9	Ooetoghrak .. .. .	..	..	201·9	73	
„ 10	Koshtak .. .. .	..	..	201·8	73	
„ 11	Sanjoo .. .. .	..	..	201·0	66	
„ 13	Tadlek .. .. .	..	..	195·3	49	
„ 14	Kichik Yeilak .. .. .	..	..	191·8	42	
„ 16	Grim Pass .. .. .	..	..	183·3	43	1 P.M.
„ 17	Pilatagach .. .. .	..	..	193·1	50	
„ 19	Olbek (near Shahidoolla) ..	SUN	54 51 10	192·3	55	
„ 21	Camp Sooget .. .. .	..	..	189·6	47	
„ 22	One mile beyond ditto	SUN	53 49 45	..	..	Semi Index correct. sextant + 13".
„ 23	Chibra	SUN	53 37 30	182·9	48	Ditto ditto + 10".
„ 23	Malikshah .. .. .	..	..	185·1	35	
„ 24	Six miles beyond ditto	SUN	53 26 3	..	..	Ditto ditto nil.
„ 24	Camp by Cayley's Lake .. ..	..	..	183·0	35	
„ 25	Summit, Karatagh Col	SUN	53 14 17	181·4	37	
„ 25	Camp near Shorjilga .. ..	..	..	183·1	33	
„ 26	Khoosh-maidan .. .. .	..	..	184·8	35	Semi Index correct. sextant + 12".
„ 29	Shing-loong	SUN	52 14 25	183·0	33	Observation doubtful.
„ 30	Two miles beyond ditto	SUN	51 54 12	..	..	Index correction nil.
„ 30	Camp Somdo .. .. .	..	..	182·4	36	
Oct. 1	Under Pass (4 miles from Somdo).	SUN	51 39 45	..	..

Oct. 1	Top of "Col" leading on to Lingzee-tung.	..	..	180·9	48	
,, 1	Camp, corner of Lingzee-tung	..	..	181·2	27	
,, 4	Camp, foot of Glacier Pass (south side).	..	..	181·0	22	
,, 5	Camp at turning-point in bed of torrent.	..	..	183·0	28	
,, 6	A mile above ditto	SUN	49 46 20	..	..	Semi Index correct, sextant - 9".
,, 8	Camp 6th, across water-shed beyond lake.	..	..	182·1	30	
,, 9	Three and a half miles beyond last Camp.	SUN	48 30 10	..	..
,, 9	Camp 7th in Chaghdoo-Loongpa (valley).	..	..	183·9	32	
,, 13	Camp Kotelik on Shayok ..	..	..	187·6	29	
,, 13	Three and a quarter miles beyond Kotelik.	SUN	47 12 0	..	..	Semi Index correct, sextant + 7".
,, 14	Miles 5 beyond Camp 11th ..	SUN	47 1 22	..	..
,, 15	Miles 4 beyond Camp 12th ..	SUN	46 48 42	..	..
,, 16	Camp 13th, Dong-yelik ..	..	..	189·7	41	
,, 16	Miles 2 beyond ditto'	SUN	46 30 50	..	..
,, 16	Camp 14th, opposite mouth of Changchenmo Stream.	..	..	190·2	33	
,, 17	Miles 4 beyond Camp 14th ..	SUN	46 18 0	..	..
,, 20	Camp 17th .. ..	..	..	192·6	32	About 8 A.M.
,, 20	Miles 1½ beyond Camp 17th (Tabisa Rocks).	SUN	45 7 30	..	..
,, 21	Camp 18th, "Phagra" .. ..	..	..	193·2	34	7 A.M.
,, 21	Camp 19th (above Digar) ..	..	..	188·6	35	
,, 22	Top of Digar Pass .. ..	..	..	181·0	19	1 P.M.
,, 23	Leh .. ..	..	..	192·1	53	Noon.

The numbered Camps in the above Table are reckoned from the Camp in the corner of Lingzee-Tung (or plain) where the expedition divided: Mr. Forsyth and Dr. Henderson returning to Leh via Chang-chenmo, and Mr. Shaw trying a new route by the Shayok.

TABLE II.—OBSERVATIONS FOR LATITUDE BY ALTITUDES OF THE POLE STAR OUT OF THE MERIDIAN.

Date.	Place.	Object.	OBSERVATIONS FOR TIME.		OBSERVATIONS OF POLE STAR.		Semi Index Correction of Sextant.
			Time by Watch.	Altitude (Half Observed Angle in Mercury).	Time by Watch.	Altitude (Half Observed Angle in Mercury).	
1870.							
July 16	Pamzal	ALTAIR	P. M. h. m. s. 9 58 30 10 2 0 10 3 30	° ' " 53 13 30 53 46 30 54 1 0	P. M. h. m. s. 10 8 0 10 9 45 10 11 50 10 13 45 10 15 15	° ' " 33 48 30 33 50 0 33 50 0 33 51 0 33 51 30	+ 30
,, 18	Gogra	ARCTURUS ..	9 40 40 9 42 45 9 44 30 9 46 20 9 48 10	40 38 0 40 11 15 39 49 15 39 27 45 39 4 20	9 54 15 9 57 30 9 59 30	33 52 45 33 54 45 33 55 15	
,, 23	Lak-zang.. ..	ALTAIR	9 42 30 9 46 0 9 48 0 9 49 45 9 51 45	53 38 45 54 10 30 54 32 0 54 45 15 55 4 15	9 59 15 10 3 15 10 5 30 10 8 0 10 9 30	34 43 45 34 46 0 34 46 30 34 47 0 34 48 5	
,, 25	Tarldat	ARCTURUS ..	9 27 0 9 28 30 9 29 30 9 31 15 9 32 15	40 39 30 40 19 45 40 6 30 39 46 15 39 34 15	9 36 30 9 38 30 9 40 15 9 41 45 9 42 45	34 50 0 34 50 0 34 51 45 34 51 45 34 52 45	
Aug. 1	Kāfir Darra (2nd Camp).	ARCTURUS ..	10 14 15 10 16 30 10 19 0	28 29 55 28 0 15 27 31 45	10 1 45 10 4 30 10 7 30	36 5 30 36 7 0 36 7 30	

Aug.	17	Koshtak	ARCTURUS ..	7 13 15 7 14 50 7 16 40	41 25 30 41 3 45 40 43 0	9 2 15 9 5 30 9 9 0 9 11 45 9 13 40	37 29 15 37 29 20 37 31 15 37 32 45 37 33 5	- 3
„	19	Bora.. ..	ARCTURUS ..	7 57 15 7 59 15 8 0 40 8 2 30 8 4 55	42 18 15 41 54 45 41 39 15 41 15 15 40 59 15	9 56 0 9 58 30 10 0 30 10 3 0 10 4 45	37 40 15 37 41 30 37 42 15 37 43 45 37 44 0	- 5
„	20	Kargalik.. ..	ARCTURUS ..	9 36 15 9 40 15 9 43 45	21 32 45 20 48 0 20 6 30	9 48 45 9 51 15 9 54 15 9 55 45 9 58 0	38 3 0 38 3 45 38 4 0 38 4 0 38 5 55	
„	27	Yarkand.. ..	α CORONÆ BOREALIS.	9 52 30 9 55 15 10 2 15 10 5 50 10 9 15	29 42 45 29 10 55 27 50 10 27 10 45 26 31 30	10 16 0 10 18 30 10 21 15 10 23 50 10 26 30	38 57 50 38 58 45 38 59 30 39 0 15 39 1 20	- 5
„	28	Ditto	α LYRÆ	11 8 20 11 10 40 11 13 0 11 14 45 11 17 0	53 42 45 53 15 0 52 48 15 52 28 20 52 2 55	11 27 10 11 29 45 11 32 50 11 35 15 11 37 30	39 21 50 39 22 23 39 23 25 39 23 30 39 24 17	
Sept.	4	Ditto	ARCTURUS ..	7 23 0 7 25 20 7 26 50 7 28 45 7 30 28	30 46 35 30 20 0 30 2 0 29 40 0 29 20 0	9 25 45 9 28 30 9 31 0	38 55 55 38 56 30 38 56 40	

during his Journey to Yarkand in 1870.

TABLE III.—LUNAR OBSERVATIONS

Civil Date.	Place.	Name of Object.	OBSERVATIONS FOR TIME.					
			Time by Watch.			Altitude (Half Observed Angle in Mercury).		
1870.								
Sept. 1	Yarkand	SUN	P.M.			°	'	"
			h.	m.	s.	11	38	12
			5	15	30	6	48	0
			5	40	20			
		α LYRÆ ..	10	19	45	58	52	55
			10	23	55	58	4	20
			10	27	45	57	21	7
			10	30	55	56	45	20
			10	34	30	56	4	0
.. 4	Ditto	ARCTURUS ..	7	23	0	30	46	35
			7	25	20	30	20	0
			7	26	50	30	2	0
			7	28	45	29	40	0
			7	30	28	29	20	0
.. 5	Yangee-bazar (ferry over the Yarkand River). (Latitude 38° 19').	ARCTURUS ..	7	56	45	22	52	40
			7	59	30	22	20	5
			8	1	20	21	58	35
			8	3	30	21	31	40
			8	5	50	21	5	20
.. 9	Ooetoghrak (Latitude 37° 33').	MOON (lower limb).	9	15	35	31	21	15
			9	19	7	31	49	0
			9	20	45	32	1	57
			9	22	45	32	16	45
			9	25	0	32	34	12
			9	27	30	32	52	30
		α ARIETIS ..	10	56	48	43	11	17
			11	0	0	43	50	0
			11	2	28	44	19	45
		ALTAIR ..	11	17	55	38	46	45
			11	20	10	38	22	5
			11	22	30	37	55	55
		CAPELLA ..	12	44	50	37	18	40
			12	46	30	37	46	20
			12	48	10	38	2	30

FOR LONGITUDE.

OBSERVATIONS FOR LONGITUDE.										REMARKS.				
Time by Watch.			Altitude of Moon (Half Observed Angle in Mercury).			Name of Second Object.		Altitude of Second Object (Half Obs. Angle in Mercury).			Distance.			
P.M.			°	'	''			°	'	''	°	'	''	
h.	m.	s.												
5	15	30	SUN	11	38	12	Sun and Moon lower limbs.
5	20	15	34	46	30	75	30	0	Distance nearer limbs.
5	25	35	..	..	..	..	..	..	..	..	75	30	50
5	27	40	..	..	..	..	..	..	..	..	75	31	30
5	30	0	Observation doubtful from lowness of Sun.
5	34	10	34	7	30	..	..	..	..	..	..	..	..
5	40	20	SUN	6	48	0	
7	5	20	25	57	32	Full Index correct, sextant - 23
7	13	0	ALTAIR ..	52	45	15	Distance Moon's further limb from Star.
7	25	15	..	..	..	..	..	..	..	..	66	21	35
7	29	28	..	..	..	..	..	..	..	..	66	19	30
7	32	25	..	..	..	..	..	..	..	..	66	18	10
7	34	38	..	..	..	..	..	..	..	..	66	17	35
7	37	15	..	..	..	..	..	..	..	..	66	16	10
7	42	10	ALTAIR ..	56	15	30	Stopped by clouds.
7	45	8	20	46	0	..	..	..	..	..	37	15	15
9	10	10	α PEGASI	
7	17	30	27	32	42	Distance planet and Moon nearer limb.
7	24	35	..	..	..	SATURN ..	26	55	0	..	29	7	40
7	30	45	..	..	..	..	..	..	..	..	29	9	20
7	34	8	..	..	..	..	..	..	..	..	29	9	30
7	36	35	..	..	..	..	..	..	..	..	29	10	50
7	40	45	..	..	..	..	..	..	..	..	29	12	0
7	44	0	..	..	..	..	..	..	..	..	..	..	..
7	48	40	..	..	..	SATURN ..	25	6	15	..	..	..	..
7	51	8	25	15	0	..	..	..	..	..	..	..	..
10	59	45	α ARIETIS	43	47	1	Full Index correct, sextant + 1
11	20	12	ALTAIR ..	38	21	35	Distance Moon's nearer limb and Altair. (Full Moon).
11	36	15	..	..	..	..	..	..	..	..	54	48	0
11	43	10	..	..	..	..	..	..	..	..	54	49	50
11	47	30	..	..	..	..	..	..	..	..	54	50	40
11	49	40	..	..	..	..	..	..	..	..	54	51	10
11	52	15	..	..	..	..	..	..	..	..	54	52	0
12	1	50	52	27	27	Distance of α Arietis and Moon nearer limb. (Full Moon).
12	5	5	..	..	..	..	..	..	..	..	52	26	40
12	7	35	..	..	..	..	..	..	..	..	52	25	20
12	11	15	..	..	..	..	..	..	..	..	52	24	10
12	13	55	..	..	..	..	..	..	..	..	52	23	0
12	19	55	..	..	..	ALTAIR ..	26	57	55	..	..	..	..

TABLE III.—LUNAR OBSERVATIONS

Civil Date.	Place.	Name of Object.	OBSERVATIONS FOR TIME.					
			Time by Watch.		Altitude (Half Observed Angle in Mercury).			
			A.M.					
			h.	m.	s.	°	'	"
1870.								
Sept. 19	Camp Olbek, near Shahidoolla ..	SUN (lower limb).	9	0	10	42	12	30
			9	2	40	42	35	40
			9	4	31	42	53	17
., 20	Ditto	MOON	4	51	10	59	26	12
			4	53	15	59	48	47
			4	55	0	60	8	30
		SUN (lower limb).	7	33	45	27	10	0
			7	35	30	27	29	35
			7	36	55	27	45	30
			7	38	30	28	3	10
			7	40	16	28	23	25
., 22	One mile beyond Camp Sooget ..	SUN (lower limb).	P.M.			32	29	0
			2	53	12	32	10	30
			2	54	40	31	55	0
			2	55	48	31	42	5
			2	57	23	31	25	0
., 30	Camp Somdo, near head of Karakash River. (Latitude 35° 1').	SUN (lower limb).	4	12	35	17	4	0
			4	13	55	16	48	0
			4	15	25	16	35	0

The barometric pressure and temperature may be gathered

FOR LONGITUDE—continued.

OBSERVATIONS FOR LONGITUDE.										REMARKS.				
Time by Watch.			Altitude of Moon (Half Observed Angle in Mercury).			Name of Second Object.		Altitude of Second Object (Half Obs. Angle in Mercury).			Distance.			
A.M.			°	'	"			°	"	°	'	"		
h.	m.	s.	°	'	"			°	"	°	'	"	Full Index correct. sextant - 30'	
8	52	0	52	29	47	..	..	..	..	..	..	..		Moon's upper limb.
9	2	27	..	..	..	SUN	..	42	33	49	..	..	..	Sun's lower limb.
9	51	50	..	..	..	..	..	..	..	..	77	0	35	
9	55	55	..	..	..	..	..	..	..	..	77	0	32	
10	4	0	..	..	..	..	..	..	..	..	76	56	40	Distance Sun and Moon's nearer limbs.
10	7	10	..	..	..	..	..	..	..	..	76	56	2	
10	16	20	..	..	..	..	..	..	..	..	76	52	10	
10	19	30	..	..	..	..	..	..	..	..	76	50	35	
10	22	40	..	..	..	..	..	..	..	..	76	50	0	
10	25	0	34	5	0	..	..	..	..	..	..	..	..	Moon's upper limb.
10	32	0	..	..	..	SUN	..	53	8	0	..	..	..	Sun's lower limb.
4	53	8	59	47	50	JUPITER	..	..	..	..	..	..	..	Moon's lower limb.
5	0	15	..	..	..	..	..	..	..	..	24	20	40	
5	4	25	..	..	..	..	..	..	..	..	24	22	10	
5	8	5	..	..	..	..	..	..	..	..	24	23	35	Distance Moon's further limb from planet.
5	10	33	..	..	..	..	..	..	..	..	24	24	10	
5	12	50	..	..	..	..	..	..	..	..	24	25	15	
5	15	20	..	..	..	..	..	..	..	..	24	25	45	
5	19	10	..	..	..	..	..	..	..	..	24	27	30	
5	23	37	65	13	20	JUPITER	..	..	..	..	..	..	..	Moon's lower limb.
9	53	40	50	16	15	..	..	..	..	..	..	..	..	Moon's upper limb.
9	56	30	..	..	..	SUN	(l. l.)	49	45	0	..	..	..	Sun's lower limb.
10	1	15	..	..	..	..	..	..	..	..	65	12	15	Distance Sun and Moon's nearer limbs.
10	6	10	..	..	..	..	..	..	..	..	65	10	5	
10	8	0	..	..	..	..	..	..	..	..	65	9	45	
10	9	55	..	..	..	..	..	..	..	..	65	8	55	
10	11	50	..	..	..	..	..	..	..	..	65	8	0	
P.M.														
12	8	0	46	50	15	..	..	..	..	..	..	..	..	Full Index correct. sextant + 27'
12	10	10	SUN	(l. l.)	53	6	15	
12	18	40	..	..	..	..	..	..	..	..	39	38	42	Distance Sun and Moon's nearer limbs.
12	21	55	..	..	..	..	..	..	..	..	39	37	48	
12	23	50	..	..	..	..	..	..	..	..	39	37	45	
12	26	10	..	..	..	..	..	..	..	..	39	36	2	
12	29	25	..	..	..	..	..	..	..	..	39	34	30	
12	34	15	..	..	..	SUN	(l. l.)	51	41	35	..	..	..	Sun's lower limb.
12	41	40	40	16	30	..	..	..	..	..	..	..	..	Moon's upper limb.
12	49	50	..	..	..	SUN	(l. l.)	50	15	0	..	..	..	Sun's lower limb.
12	53	40	..	..	..	..	..	..	..	..	39	24	35	Distance Sun and Moon's nearer limbs.
1	8	45	..	..	..	..	..	..	..	..	39	15	45	
1	16	45	..	..	..	..	..	..	..	..	39	12	0	
1	29	10	..	..	..	..	..	..	..	..	39	7	30	
1	31	30	..	..	..	..	..	..	..	..	39	5	30	Ditto do.
1	32	50	..	..	..	..	..	..	..	..	39	5	0	
1	37	45	..	..	..	SUN	..	44	28	20	..	..	..	Sun's lower limb.
4	26	30	..	..	..	..	..	..	..	..	71	14	35	Full Index correct. sextant + 10''
4	29	40	..	..	..	..	..	..	..	..	71	15	37	
4	32	45	..	..	..	..	..	..	..	..	71	16	35	Distance Sun and Moon's nearer limbs.
4	34	30	..	..	..	..	..	..	..	..	71	16	50	
4	35	50	..	..	..	..	..	..	..	..	71	17	42	

from the Boiling-points and temperatures given in Table I.

TABLE IV.—OBSERVATIONS FOR VARIATION OF THE COMPASS.

Date.	Place.	Time by Watch (For Interval).	Sun's Altitude (Half Observed Angle in Mercury).	Magnetic Bearings.	REMARKS.
1870. Aug. 25	Yarkand .. .. .	..	° 61 34 45 61 49 50 61 34 45	168° 5 [177° 7] 187	On meridian.
„ 31	Ditto .. .. .	..	13 17 15 11 56 42 10 36 6	265 266.5 267	On prime vertical.
Sept 14	Kichik-Yeillák	H. M. S. 11 39 38 11 44 30 11 47 20 11 50 45 11 52 10	55 57 43 55 35 47	.. 186.25 186.5 187.5	Semi Index correct. sextant + 5". By short double altitude near the meridian. (Doubtful observation).
„ 19	Camp Olbek	11 27 30 11 41 0 11 44 15 11 47 40	54 48 0 54 15 0	.. 184.5 185.75	Semi Index correct. sextant - 15". Ditto
„ 22	One mile beyond Camp Sooget ..	11 42 45 11 51 30 11 53 10 11 56 55 12 4 30	53 48 55 53 20 0	180.5 181.5 183.25	
„ 23	Chibra	11 41 23 11 42 40 11 46 0 11 49 20 11 51 15	53 36 50 53 29 45	176.25 177.25 179.25	Semi Index correct. sextant + 10".

Sept. 24	Six miles beyond Malikshah	11 41 0	53 25 0	..	Index correct. Nil.
		11 43 0	..	179	
		11 47 0	..	180·25	
		11 51 0	..	183·25	
		11 53 0	53 14 35		
,, 25	Summit of Karatagh Col	11 38 50	53 13 35		
		11 41 20	..	180	
		11 46 20	..	182	
		11 48 50	53 5 50		
,, 27	Khoosh-Maidân (Latitude 35° 32').	9 25 0	43 44 35		
		9 26 0	..	134	
		9 27 0	44 0 40		
,, 29	Shing-loong	12 1 0	52 9 55	..	Meridian altitude. Semi Index correct. sextant + 12".
		12 2 0	..	182·25	
		12 3 0	52 7 55	..	
		12 4 0	..	182·5	
		12 5 0	52 5 27	..	
		12 6 0	..	182·75	
		12 7 0	52 3 10	..	
		12 8 0	..	183·6	
		12 9 0	52 0 0	..	
		12 10 0	..	183·75	
,, 30	Two miles beyond Shing-loong ..	11 48 0	51 54 12	..	Meridian altitude. Index error. Nil.
		11 50 0	..	177	
		11 58 0	51 48 17	..	
		12 0 0	..	181·75	
		12 2 0	51 44 0		
Oct. 24	Leh (Ladâk) (Latitude 34° 10').	11 52 0	43 50 0		
		11 54 0	..	179	
		12 0 0	..	181	
		12 2 0	43 40 30		

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The above Observations were taken with a prismatic compass placed on a stand which was made perfectly horizontal by means of a spirit-level; and well removed from any iron.

TABLE V.—RESULTS of the OBSERVATIONS for LATITUDE.

Month and Day. (Civil).	Name of Place.	Object Observed.	Resulting Latitude North.	Mean of Separate Results.
1870.				
July 16	Pamzal	Saturn ..	34 14 53	} 34 14 59
.. 16	Ditto	Pole Star	34 15 4	
.. 18	Gogra	Saturn ..	34 17 58	} 34 18 53
.. 18	Ditto	Pole Star	34 19 47	
.. 19	Camp below pass (junction of stream).	Saturn ..	34 26 27	
.. 23	Lak-zang	Pole Star	35 5 20	
.. 25	Tarladat	Pole Star	35 17 40	
.. 31	Kâfir-Darra (1st Camp) ..	α Aquilæ	36 16 51	
Aug. 1	Kâfir-Darra (2nd Camp) ..	Pole Star	36 19 58	
.. 6	Toghra Soo	α Aquilæ	36 32 24	
.. 9	Kichik Yeilâk	Saturn ..	36 43 32	
.. 10	En route below Kichik Yeilâk 2 miles.	Sun ..	36 43 59	
.. 12	Choochoo Pass	Sun ..	36 53 46	
.. 17	Langar Soolâghaz	Sun ..	37 17 8	
.. 17	Koshtak	Pole Star	37 22 28	
.. 19	Bora	Sun ..	37 35 28	} 37 33 59
.. 19	Ditto	Pole Star	37 32 29	
.. 20	Kargalik	Sun ..	37 53 34	} 37 54 2
.. 20	Ditto	Pole Star	37 54 30	
.. 25	Yarkand	Sun ..	38 25 9	
.. 25	Ditto	α Aquilæ	38 23 33	
.. 26	Ditto	Sun ..	38 23 47	
.. 27	Ditto	Sun ..	38 23 51	} 38 24 41
.. 27	Ditto	Pole Star	38 25 36	
.. 28	Ditto	Pole Star	38 25 38	
Sept. 4	Ditto	Pole Star	38 25 15	
.. 19	Olbek (near Shahidoolla) ..	Sun ..	36 26 23	
.. 22	1 mile beyond Camp Sooget ..	Sun ..	36 17 14	
.. 23	Chibra	Sun ..	36 6 7	
.. 24	6 miles beyond Malikshah ..	Sun ..	35 54 20	
.. 25	Summit, Karatagh Col	Sun ..	35 42 39	
.. 29	Shing-loong	Sun ..	35 8 42	
.. 30	2 miles beyond Shing-loong ..	Sun ..	35 5 44	
Oct. 1	Under Pass (4 miles from Somdo).	Sun ..	34 56 50	
.. 6	A mile above Camp at turning point in bed of torrent.	Sun ..	34 54 24	
.. 9	3½ miles beyond last Camp (6th)	Sun ..	35 1 32	
.. 13	3¼ miles beyond Kotelik ..	Sun ..	34 48 57	
.. 14	5 miles beyond Camp 11th ..	Sun ..	34 37 17	
.. 15	4 miles beyond Camp 12th ..	Sun ..	34 27 39	
.. 16	2 miles beyond Dong-yeilak ..	Sun ..	34 23 19	
.. 17	4 miles beyond Camp 14th ..	Sun ..	34 14 7	
.. 20	1¾ miles beyond Camp 17th (Tabilsa Rocks).	Sun ..	34 19 14	
Aug. 17	Langar Soolâghaz .. Sun ..	"Doubtful observation."		
Aug. 25	Yarkand Sun ..	"Doubtful observation (clouds)."		
Sept. 29	Shing-loong Sun ..	"Observation doubtful."		

TABLE VI.—RESULTS of the OBSERVATIONS for LONGITUDE from LUNAR DISTANCES.

Month and Day (Civil).	Name of Place.	Object to which Moon was Referred.	Whether the Moon was East or West.	Resulting Longitude. East.
1870.				
Sept. 1	Yarkand	Sun ..	East ..	76 53 45
„ 1	Ditto	α Aquilæ	West ..	77 30 30
„ 5	Yangee bazar (ferry over the Yarkand River).	Saturn ..	East ..	76 45 15
„ 9	Ooetoghrak	α Aquilæ	East ..	77 13 45
„ 9	Ditto	α Arietis	West ..	78 11 0
„ 19	Camp Olbek, near Shahidoolla	Sun ..	West ..	77 58 54
„ 20	Ditto ditto	Jupiter	East ..	77 27 15
„ 20	Ditto ditto	Sun ..	West ..	78 22 0
„ 22	1 mile beyond Camp Sooget ..	Sun ..	West ..	78 11 45
„ 22	Ditto ditto ..	Sun ..	West ..	77 45 28
„ 30	Camp Somdo, near head of Karakash River.	Sun ..	East ..	78 8 0

The longitudes contained in the last column of the preceding table show that when the moon is east of the object referred to, the result appears to be less than when the moon is west. The materials available for determining the amount of difference are as follows:—

TABLE VII.—DIFFERENCE of RESULTING LONGITUDE depending on the POSITION of MOON.

Place.	Position of Moon.	Resulting Longitude from Table VI.	Excess of Result. Moon West.
Yarkand	East ..	76 53 45	' "
Ditto	West ..	77 30 30	36 45
Ooetoghrak	East ..	77 13 45	
Ditto	West ..	78 11 0	57 15
Camp Olbek	East ..	77 27 15	
Ditto	West ..	78 10 27	43 12
		(mean of two determinations)	

The mean of the three results contained in the last column of this table is 45' 44", half of which, or 22' 52", gives the approximate correction to be subtracted from single determinations of longitude, moon west, and added to single determinations moon east. Thus the following final results for longitude are obtained:—

TABLE VIII.—CONCLUDED LONGITUDES FROM LUNAR DISTANCES.

Name of Place.	Position of Moon.	Resulting Longitude from Table VI.			Correction to Single Determinations.	Concluded Longitude. East.
Yarkand	East	76	53	45	.. ..	77 12 8
Ditto	West	77	30	30	.. ..	77 12 8
Yangee bazar (ferry over the Yarkand River).	East	76	45	15	+22 52	77 8 7
Ooeetoghruk	East	77	13	45	.. ..	77 42 23
Ditto	West	78	11	0	.. ..	77 42 23
Camp Olbek, near Shahidoolla	East	77	27	15	.. ..	77 48 51
Ditto ditto	West	78	10	27	.. ..	77 48 51
		(mean of two determinations)				
1 mile beyond Camp Sooget ..	West	77	58	37	-22 52	77 35 45
		(mean of two determinations)				
Camp Somdo, near head of Karakash River.	East	78	8	0	+22 52	78 30 52

Note.—In the “lunar observations for longitude,” the first altitude of Capella on Sept. 9, observed for determination of watch error, gives a discordant result, and has not been used. The watch time was probably set down one minute too large.

TABLE IX.—DETERMINATIONS OF MAGNETIC DECLINATION (VARIATION OF THE COMPASS).

Month and Day (Civil).	Name of Place.	Deviation of the North end of the Needle to the East.
1870.		
Aug. 26	Yarkand	2 15
„ 31	Ditto	5 16
Sept. 15	Kichik Yeiläk	2 16
„ 19	Camp Olbek	4 45
„ 22	1 mile beyond Camp Sooget	4 35
„ 23	Chibra	5 37
„ 24	6 miles beyond Malikshah	3 11
„ 25	Summit of Karatagh Col	2 35
„ 27	Khoosh-Maidän	3 42
„ 29	Shing-loong	3 10
„ 30	2 miles beyond Shing-loong	3 53
Oct. 24	Leh	4 20

Aug. 26 Yarkand The date has been altered from Aug. 25, as given by Mr. Shaw.

Sept. 15 Kichik Yeiläk .. “Doubtful observation.” The date has been altered from Sept. 14, as given by Mr. Shaw.

Sept. 27 Koosh-Maidän .. It has been assumed that the observations were made before noon of Sept. 27, civil reckoning.

Sept. 29 Shing-loong The first observed altitude is marked “meridian altitude,” but the calculation shows that such was not the case, neither does it agree with the meridian altitude given in Table I.

TABLE X.—HEIGHTS of PLACES above the MEAN LEVEL of the SEA calculated from OBSERVATIONS of the BOILING-POINT of WATER.

Month and Day (Civil).	Name of Place.	Observed Boiling-point.	Corresponding Barometer Reading.	Observed Temperature of the Air.	Resulting Height.	
					As referred directly to the Mean Level of the Sea.	As referred to Leh.
1870.		°	Inches.	°	Feet.	Feet.
July 14	Chagra (near Pangong Lake)	186·1	17·461	62	15,282	14,916
„ 15	Masimik Pass	176·0	13·962	51	21,376	21,142
„ 15	Pangloong	182·4	16·103	50	17,347	17,137
„ 16	Panzal	185·4	17·197	81	16,056	15,430
„ 17	Ditto	186·0	17·423	70	15,484	15,008
„ 18	Gogra	184·8	16·974	62	16,086	15,719
„ 19	Hot Springs	184·1	16·713	72	16,713	16,211
„ 19	Camp below Pass (junction of stream).	183·0	16·319	70	17,361	16,883
„ 20	Summit of Pass (Dr. Cayley's)	178·4	14·735	55	19,947	19,668
„ 20	Nischoo	180·0	15·267	48	18,801	18,614
„ 21	Camp in Lingzee-Tung ..	181·7	15·855	50	17,782	17,572
„ 23	Camp in Lak-zang	182·1	15·995	67	17,874	17,435
„ 25	Tarldat	183·6	16·533	55	16,701	16,427
„ 26	Patsalang	182·5	16·139	71	17,699	17,205
„ 31	Kâfir Darra (1st Camp)	188·2	18·274	60	13,956	13,622
Aug. 1	Kâfir Darra (2nd Camp).	188·9	18·552	64	13,588	13,294
„ 2	Ditto	189·4	18·753	68	13,341	12,995
„ 5	Balakchee	190·7	19·283	65	12,503	12,199
„ 7	Pilatagach	192·6	20·080	62	11,311	11,049
„ 8	Camp below Grim Pass (south side).	190·5	19·200	55	12,485	12,312
„ 9	Top of Grim Pass	183·2	16·390	46	16,776	16,710
„ 9	Kichik Yeilâk	191·1	19·448	45	11,988	11,946
„ 10	Tam	196·5	21·803	64	8,993	8,711
7h. P.M.						
„ 11	Camp Choochoo	193·2	20·338	64	10,970	10,686
2h. P.M.						
„ 13	Camp Arpalak	197·0	22·033	73	8,782	8,380
„ 16	Sanjoo	200·6	23·746	80	6,682	6,210
„ 16	Ditto	200·9	23·894	70	6,432	6,091
6h. P.M.						
„ 17	Koshtak	201·6	24·241	75	6,053	5,648
„ 18	Ooetoghrak	201·8	24·341	85	5,997	5,462
„ 19	Bora	202·3	24·593	87	5,714	5,149
„ 20	Kargalik	204·0	25·465	86	4,691	4,144
„ 21	Poskiam	205·0	25·990	79	4,064	3,614
„ 22	Yangee-bazar	205·0	25·990	74	4,042	3,657
„ 27	Yarkand	205·6	26·309	89	3,755	3,168
„ 31	Ditto	204·9	25·937	86	4,156	3,611
„ 31	Ditto	205·1	26·043	78	4,000	3,562
Sept. 2	Ditto	205·8	26·416	75	3,581	3,243
„ 3	Ditto	205·9	26·470	78	3,532	3,156
„ 4	Ditto	205·9	26·470	79	3,537	3,148
„ 6	Poskiam	205·1	26·043	72	3,975	3,677
„ 7	Kargalik	204·5	25·726	76	4,346	3,991
„ 8	Bora	203·3	25·103	60	4,963	4,814
„ 9	Ooetoghrak	201·9	24·391	73	5,859	5,537

TABLE X.—HEIGHTS of PLACES above the MEAN LEVEL of the SEA calculated from OBSERVATIONS of the BOILING-POINT of WATER—*continued.*

Month and Day (Civil).	Name of Place.	Observed Boiling Point.	Corresponding Barometer Reading.	Observed Temperature of the Air.	Resulting Height.	
					As referred directly to the Mean Level of the Sea.	As referred to Leh.
		°	Inches.	°	Feet.	Feet.
1870.						
Sept. 10	Koshtak	201·8	24·341	73	5,918	5,595
„ 11	Sanjoo	201·0	23·943	66	6,343	6,131
„ 13	Tadlek	195·3	21·260	49	9,550	9,516
„ 14	Kichik Yeiläk	191·8	19·741	42	11,534	11,562
„ 16	Grim Pass	183·3	16·426	43	16,658	16,607
1h. P.M.						
„ 17	Pilatagach	193·1	20·294	50	10,863	10,799
„ 19	Olbek (near Shahidoolla)	192·3	19·952	55	11,398	11,267
„ 21	Camp Sooget	189·6	18·833	47	12,913	12,845
„ 23	Chibra	182·9	16·283	48	16,997	16,817
„ 23	Malikshah	185·1	17·085	35	15,422	15,447
„ 24	Camp by Cayley's Lake	183·0	16·319	35	16,689	16,681
„ 25	Summit Karatagh Col	181·4	15·751	37	17,704	17,648
„ 25	Camp near Shorjilga	183·1	16·355	33	16,591	16,610
„ 26	Khoosh-maidan	184·8	16·974	35	15,604	15,622
„ 29	Shing-loong	183·0	16·319	33	16,652	16,669
„ 30	Camp Somdo	182·4	16·103	36	17,076	17,046
Oct. 1	Top of "Col" leading on to Lingzee-tung.	180·9	15·578	48	18,236	17,953
„ 1	Camp, corner of Lingzee-tung.	181·2	15·682	27	17,626	17,628
„ 4	Camp, foot of Glacier Pass (south side).	181·0	15·613	22	17,647	17,708
„ 5	Camp at turning-point in bed of torrent.	183·0	16·319	28	16,558	16,588
„ 8	Camp 6th, across watershed beyond Lake.	182·1	15·995	30	17,145	17,126
„ 9	Camp 7th in Chaghdo-Loongpa (valley).	183·9	16·640	32	16,098	16,090
„ 13	Camp Kotelik on Shayok	187·6	18·039	29	13,832	13,942
„ 16	Camp 13th Dong-yeilak	189·7	18·874	41	12,765	12,764
„ 16	Camp 14th, opposite mouth of Changchenmo stream.	190·2	19·077	33	12,357	12,469
„ 20	Camp 17th	192·6	20·080	32	10,937	11,111
8h A.M.						
„ 21	Camp 18th, "Phagra"	193·2	20·338	34	10,610	10,770
7h. A.M.						
„ 21	Camp 19th (above Digar)	188·6	18·432	35	13,334	13,385
„ 22	Top of Digar Pass	181·0	15·613	19	17,588	17,687
1h. P.M.						
„ 23	Leh	192·1	19·868	53	11,494	11,389
noon.						

Kâfir Darra (2nd Camp), Aug. 1. The temperature of the air was not recorded. The value used (64°) is the mean of the next preceding and next following values.