XIX. The Bakerian Lecture.—*On the Influence of the Moon on the Magnetic Declination at Toronto, St. Helena, and Hobarton. By Colonel* Edward Sabine, *R.A., Treas. and V.P.*

Received and Read November 17, 1853.

THE success which attended the endeavour to detect the influence of the moon on the pressure of the atmosphere, by a suitable arrangement of the hourly barometrical observations at St. Helena*, naturally suggested the idea that the influence of the moon on the direction of the magnetic needle, supposing such an influence to exist, might be manifested by an analogous arrangement of the hourly magnetical observations at that station; inasmuch as the magnetical disturbances due to other causes, and liable to mask so small an effect as that which might be anticipated from the moon, were, like those of the barometer, of inconsiderable amount at St. Helena when compared with those at many other stations.

An examination of observations of the Declination made at Milan, whilst M. Kreil was Director of that observatory, led him, in a memoir read in February 1841 to the Royal Bohemian Society of Sciences, to announce his belief that the moon does actually exercise an influence on the magnetic direction at the surface of our globe, cognisable by a variation in the Declination depending on the moon's hour-angle, and completing its period in a lunar day. M. Kreil has since confirmed the discovery thus announced by investigations based on a more extensive series of similar observations made under his direction at Prague, and discussed,—1st, in the 'Magnetische und Meteorologische Beobachtungen zu Prag' for 1841; and 2nd, in a memoir presented to the Imperial Academy of Sciences at Vienna in June 1850, and published in the Transactions of that Academy in 1852.

Meanwhile, in the course of the discussion of the results derivable from the Observations at the British Colonial Observatories, I had selected for a primary examination of this subject the series of hourly observations of the Declination at St. Helena, extending from September 1842 to August 1847 inclusive; and having determined on the process through which the observations should be passed, the work of reduction was commenced, and though occasionally interrupted by more pressing duties, was resumed from time to time, and was at length completed for the five years in the early part of the summer of 1852. The result was conclusive, in so far as a variation depending upon the moon's hour-angle was systematically and consistently manifested; but this variation differed so considerably in many important particulars, as

* Philosophical Transactions, 1847, Art. V.

well as in amount, from the conclusions which M. Kreil had derived from the Milan and Prague observations, as to make it plain to perceive that a knowledge of the phenomena at many different parts of the globe must be obtained, before a general theory of the nature and character of the moon's magnetic influence could be arrived at by inductive reasoning. Having, therefore, in my possession a similar series of hourly observations at Toronto and Hobarton, which stations might with St. Helena be deemed to a certain extent representatives of the phenomena in the middle latitudes of the two hemispheres and in the tropics, I thought it best to retain the conclusions at St. Helena until they should be accompanied by those at Toronto and Hobarton. I took with me, however, to the Belfast Meeting of the British Association in September 1852 an abstract of the St. Helena results, and showed them to several persons interested in magnetical researches who attended that meeting.

The investigation has since been completed for the three stations, so far at least as regards the magnetic *Declination*, and the results form the subject of this communication; to be followed, should circumstances permit, by the results of a similar investigation into the corresponding phenomena of the Inclination and Total Force. It has appeared the most convenient arrangement to treat the stations separately, and to take them in the order of their succession from North to South; commencing therefore with Toronto.

Toronto.—The results at this station are obtained from six years of hourly observation, extending from July 1842 to June 1848 inclusive. The observations were received at Woolwich in the form of Monthly Returns, in which the scale-reading of the Declinometer at every hour of mean Göttingen Time was inserted in tables of double entry, having the hours in vertical columns and the days in horizontal lines, with the daily means in the last vertical column, and the monthly means at the different hours of solar time in the bottom horizontal line. The process at Woolwich commenced by marking for omission all those disturbed observations, whensoever occurring, which exceeded a certain limit on either side of the monthly mean in the same month and at the same hour. When a disturbance was so considerable as materially to affect the amount of the monthly mean at the bottom of the page, a fresh monthly mean was taken, omitting the disturbed observation and giving fresh limiting values, by which the disturbances were marked afresh. The limits adopted, beyond which disturbances were omitted and within which observations were retained for the proposed investigation, were (at Toronto) four scale divisions (or $2'{\cdot}9$ in arc) above or below the monthly mean at the same hour. The observations retained were then marked in small figures on the face of the returns with the lunar hour to which each observation most nearly corresponded. For this purpose the time of the moon's passage of the meridian at Greenwich was taken from the Nautical Almanac, and corrected for the difference of longitude, so as to give the time of the moon's passage of the astronomical meridian at Toronto in the mean solar time of the station. The difference of time corresponding to the difference between the meridians of Toronto and Göttingen was then applied, so as to give the mean *Göttingen* time of the moon's passage of the astronomical meridian of Toronto. The observation at the Göttingen hour nearest to the time thus computed was then marked with 0^h, signifying that it was the nearest observation to the moon's upper culmination, and from which its distance could not exceed half an hour. The time of the moon's inferior passage was then computed in a similar manner, and the observation at the Göttingen hour nearest to it was marked 12^h. The intermediate hours received corresponding markings, except that on those occasions when thirteen solar hours, and consequently thirteen observations, were comprised within twelve lunar hours, that observation was omitted which fell most nearly equidistant between the epochs of two exact lunar hours. The observations were then considered to be prepared for arrangement in *lunar tables*, but instead of the observations themselves, the differences at each hour between the scale-reading observed and the mean scale-reading in the same month and at the same hour were entered in these tables, by which process the diurnal and other variations depending on the time of the solar year and the hour of the solar day were, in great part at least, eliminated. The differences were marked with a + or — sign according as the scale-reading at the time of observation was greater or less than the monthly mean at the same hour; the entries having a + sign implying a more westerly direction of the north end of the magnet than its mean direction in the same month and at the same hour; and those having a — sign implying the converse. The mean was then taken, in every month, of every lunar hour (taking the signs into account); the monthly means were collected into yearly means,—and finally, the means at each lunar hour in each of the six years of observation were collected in a single table.

The whole number of observations in the six years at Toronto which were thus treated amounted to 44,754, of which 6356 were put aside in consequence of the amount of disturbance (measured from the monthly mean at the same hour) equalling or exceeding $2'\cdot9$ in arc.

The following Table shows the amount of Easterly or Westerly deflection of the north end of the magnet at the different lunar hours derived from the observations of the six years by the process which has been described, and inferred to be due to the moon's action. The partial results, or those afforded by the separate years, will be printed in the introduction to the third volume of the Toronto Observations. They exhibit only such small partial differences from the mean of the six years as may reasonably be ascribed to the operation of other causes than the moon's influence; and present no notable trace of a progressive increase in the amount of the variation in the successive years from 1843 to 1847, such as that which has been found to characterize the variations depending upon the *solar* hours.

The deflections in the subjoined Table are in scale divisions, of which each $=0'\cdot721$. The readings to which the — signs are prefixed denote Easterly deflections, and those which have the + signs prefixed Westerly deflections.

TABLE I.

Lunar hours.	Deflections.	Lunar hours.	Deflections.	Lunar hours.	Deflections.	Lunar hours.	Deflections.
	Scale divisions.		Scale divisions.		Scale divisions.		Scale divisions.
21	−0·15	4	+0·14	9	−0·12	16	+0·03
22	−0·35	5	+0·175	10	−0·30	17	+0·17
23	−0·30	6	+0·17	11	−0·43	18	+0·31
0	−0·35	7	+0·11	12	−0·42	19	+0·11
1	−0·32	8	+0·01	13	−0·30	20	+0·06
2	−0·225			14	−0·19		
3	−0·14			15	−0·12		

We may represent these numbers by the general formula—

$$\begin{aligned}\Delta_x = -0{\cdot}10125 &+ {\cdot}0147 \sin(a+36^\circ\ 43') - {\cdot}2993 \sin(2a+276^\circ\ 51') \\ &- {\cdot}0045 \sin(3a+247^\circ\ 23') + {\cdot}0234 \sin(4a+68^\circ\ 13') \\ &+ {\cdot}0376 \sin(5a+49^\circ\ 19') - {\cdot}0195 \sin(6a+16^\circ\ 08') \\ &- {\cdot}0135 \sin(7a+345^\circ\ 25') - {\cdot}0109 \sin(8a+6^\circ\ 35') \\ &- {\cdot}0266 \sin(9a+307^\circ\ 22') + {\cdot}0244 \sin(10a+58^\circ\ 17') \\ &+ {\cdot}0043 \sin(11a+87^\circ\ 01') + {\cdot}00833 \cos 12a;\end{aligned}$$

a being the difference between x and 18 lunar hours expressed in hours and parts of an hour multiplied by 15°.

With this formula we obtain the times of greatest easterly deflection $0^h\ 22^m$ and $11^h\ 23^m$, and the amounts $15''{\cdot}7$ and $19''{\cdot}1$: and of greatest westerly deflection $5^h\ 0^m$ and $18^h\ 0^m$, and the amounts $7''{\cdot}6$ and $13''{\cdot}4$. If we suppose the differences between the times and amounts of the two extreme easterly deflections to be due, wholly or in part, to accidental irregularities in the amount of the deflections at the different hours, the exact values of which would probably require a longer period of observation to determine,—and if the same remark be also applicable to the times and amounts of the two extreme westerly deflections,—we find, as the mean of the times of extreme easterly deflection, $11^h\ 53^m{\cdot}5$, and $23^h\ 53^m{\cdot}5$, and the amount $17''{\cdot}4$; and of the extreme westerly deflections $5^h\ 30^m$, and $17^h\ 30^m$, and the amount $10''{\cdot}5$; making the total amount of the variation due to lunar influence $(17''{\cdot}4+10''{\cdot}5=)27''{\cdot}9$.

The progression being a double one in the 24 lunar hours the variation passes four times through zero when the lunar variation disappears or equals 0. These times as given by the formula are $3^h\ 29^m$; $8^h\ 08^m$; $15^h\ 45^m$; and $20^h\ 27^m$; or $3^h\ 33^m$ before, and $3^h\ 29^m$ after the moon's upper culmination; and $3^h\ 52^m$ before, and $3^h\ 45^m$ after the moon's lower culmination.

It is quite possible that when the facts shall have been more precisely determined, it may prove that neither the times nor the amounts of the two easterly deflections are strictly symmetrical; and so also in regard to the two extreme westerly deflections. With a full consideration of what may be due to accidental irregularities, and particularly to the influence on the precise time of the extreme elongation of even a very small error occurring near the turning hours, there still seems an indication of systematic difference, which is the more deserving of attention, because M. KREIL has inferred the existence of an inequality of the same kind, especially in the amounts of the similar deflections at opposite points of the hour-circle, in the Prague observations.

The disparity in the amounts of the deflections in *opposite* directions, viz. 17''·4 easterly, and 10''·5 westerly, is one which, from its magnitude, cannot be imagined to be occasioned by accidental irregularities, and must be regarded as a real feature of the phenomena under discussion.

M. KREIL has inferred from the Prague observations, that the variation due to the moon's influence is not equally cognisable in all parts of the year, being greatest in summer, and disappearing wholly in the three winter months. To examine this question, I have caused in the following table the results of the Toronto observations to be arranged in two divisions, one comprising the results of thirty-six months composed of the six summer months in each of the six years under examination, and the other also of thirty-six months composed of the six winter months in each of the same years.

TABLE II.

Lunar hours.	Summer.	Winter.	Table I.	Lunar hours.	Summer.	Winter.	Table I.
	Scale divisions.	Scale divisions.	Scale divisions.		Scale divisions.	Scale divisions.	Scale divisions.
0	−0·51	−0·18	−0·35	12	−0·43	−0·42	−0·42
1	−0·54	−0·10	−0·32	13	−0·40	−0·21	−0·30
2	−0·49	+0·05	−0·225	14	−0·32	−0·08	−0·19
3	−0·35	+0·07	−0·14	15	−0·37	+0·12	−0·12
4	−0·08	+0·36	+0·14	16	−0·09	+0·15	+0·03
5	+0·07	+0·29	+0·175	17	−0·01	+0·31	+0·17
6	+0·13	+0·21	+0·17	18	+0·27	+0·34	+0·31
7	+0·14	+0·09	+0·11	19	+0·15	+0·07	+0·11
8	+0·11	−0·09	+0·01	20	+0·07	+0·04	+0·06
9	+0·01	−0·25	−0·12	21	−0·15	−0·15	−0·15
10	−0·26	−0·33	−0·30	22	−0·45	−0·24	−0·35
11	−0·42	−0·42	−0·43	23	−0·43	−0·18	−0·30

The principal differences which show themselves in this comparison of opposite seasons are, that the easterly deflection at the upper culmination is less, and the westerly deflection on both sides of the meridian is greater, in the winter than in the summer half-period; at the inferior culmination the amount of extreme easterly deflection is nearly identical in the two seasons. For the purpose of examining how far similar partial differences would be shown when periods of similar duration are taken without reference to season, I arranged as in the following table, a comparison of the results in two half-periods, each comprising three complete years (including both summer and winter months), and each, therefore, containing the same number of months, viz. thirty-six, as in Table II.

TABLE III.

Lunar hours.	October 1842 to September 1845.	October 1845 to September 1848.	Table I.	Lunar hours.	October 1842 to September 1845.	October 1845 to September 1848.	Table I.
	Scale divisions.	Scale divisions.	Scale divisions.		Scale divisions.	Scale divisions.	Scale divisions.
0	−0·32	−0·39	−0·35	12	−0·49	−0·35	−0·42
1	−0·26	−0·38	−0·32	13	−0·34	−0·26	−0·30
2	−0·18	−0·27	−0·225	14	−0·27	−0·12	−0·19
3	−0·05	−0·23	−0·14	15	−0·11	−0·13	−0·12
4	+0·15	+0·14	+0·14	16	+0·07	−0·01	+0·03
5	+0·21	+0·14	+0·175	17	+0·20	+0·10	+0·17
6	+0·20	+0·13	+0·17	18	+0·31	+0·31	+0·31
7	+0·15	+0·08	+0·11	19	+0·13	+0·09	+0·11
8	−0·04	+0·05	+0·01	20	+0·07	+0·04	+0·06
9	−0·10	−0·14	−0·12	21	−0·17	−0·13	−0·15
10	−0·34	−0·26	−0·30	22	−0·31	−0·39	−0·35
11	−0·47	−0·37	−0·43	23	−0·39	−0·22	−0·30

The inference from these two comparisons, Tables II. and III., appears to be simply, that in consequence of the small amount of the moon's influence, which has to be brought out from amongst many disturbing causes of much greater influence, the mean result of six years is considerably more satisfactory than the mean results of three years of observation, whether the latter consist of three complete years, or of three years composed either of thirty-six summer or of thirty-six winter months; but that the variation due to the moon's influence is distinctly cognisable in all cases. The results may be more irregular in the winter months, in consequence possibly of the greater prevalence of the other disturbing causes at that season; and these, in a less complete system of observation, may in the extreme winter months, as appears to be the case at Prague, even wholly mask the effect of the moon's influence. In the present case, if we take a mean of opposite points of the hour-circle at Toronto in the summer and winter half-period, we find the amount of the whole deflection, between 0^h and 12^h on the one hand, and 6^h and 18^h on the other hand, to be $29''$ in the three years consisting of thirty-six summer months, and $24''\cdot9$ in the three years consisting of thirty-six winter months. If we do the same by the half-periods, each of three complete years or of eighteen summer and eighteen winter months, we find the whole deflection between 0^h and 12^h on the one hand, and 6^h and 18^h on the other, $28''\cdot5$ in the years 1842–45, and $24''\cdot4$ in the years 1845–48. The differences from the results of the six years combined are nearly equal in both cases.

In order to examine whether any difference is to be traced in the lunar diurnal variation which it might be possible to attribute to the moon's change of declination, I caused two tables to be formed, consisting respectively of the lunar diurnal variation on the three days of highest northern, and on the three days of highest southern declination throughout the six years of observation; the three days in the first table consisted in every case of the day when the moon was at her extreme distance north of the equator, and of one day before and one day after; and in the second table of the day when she was at the extreme distance south of the equator, and of one day on either side of that day. The first table comprised 230 days and the second 226 days; the reason of the number of days falling short of the full complement being the intervention of Sundays, when no observations were recorded. Table IV. exhibits in one view the results of these two tables. It does not appear to present any satisfactory evidence of the existence of a difference either in the character or the amount of the lunar diurnal variation at the periods of the moon's extreme divergence on either side of the equator; at the same time the number of days (230 and 226) is too few to furnish *positive* evidence as to the existence of a *small* difference; the general character of the variation appears to be the same in both cases, when allowance is made for irregularities which must be expected to present themselves in such short periods of comparison.

TABLE IV.

Lunar hours.	Days of the moon's extreme north declination.	Days of the moon's extreme south declination.	Mean of six years, Table I.	Lunar hours.	Days of the moon's extreme north declination.	Days of the moon's extreme south declination.	Mean of six years, Table I.
	Scale divisions.	Scale divisions.	Scale divisions.		Scale divisions.	Scale divisions.	Scale divisions.
0	—·35	—·35	—·35	12	—·47	—·31	—·42
1	—·33	—·17	—·32	13	—·14	—·28	—·30
2	—·48	—·10	—·225	14	—·16	—·28	—·19
3	—·13	+·13	—·14	15	—·16	—·10	—·12
4	+·05	+·11	+·14	16	+·07	—·04	+·03
5	+·18	—·04	+·175	17	+·01	+·36	+·17
6	+·15	+·01	+·17	18	+·15	+·18	+·31
7	+·16	—·03	+·11	19	—·12	+·19	+·11
8	—·01	+·10	+·01	20	+·14	+·08	+·06
9	·00	+·07	—·12	21	+·02	+·04	—·15
10	—·19	—·16	—·30	22	—·04	—·35	—·35
11	—·43	—·25	—·43	23	—·22	—·38	—·30

St. Helena.—The hourly observations at St. Helena, which have been employed in this investigation, extended from September 1842 to August 1847, comprehending five years. They have been treated in the manner already described in the discussion of the Toronto observations, with this difference only, that as the magnetic disturbances are less in amount at St. Helena, the limits of exclusion on account of disturbance were taken at 2·5 scale divisions, or 1′·78 in arc.

The whole number of observations at St. Helena, which have been thus treated, amounts to 36,449, of which 2678 have been put aside in consequence of the amount of disturbance (measured from the monthly mean at the same hour) equalling or exceeding 1′·78 in arc. The following Table exhibits the mean variation in the five years at the several lunar hours, due to the moon's influence. The deflections are those of the north end of the magnet, and are easterly when the — sign is used, and westerly when the + sign is used. The value of a scale division at St. Helena was 0′·711.

TABLE V.

Lunar hours.	Deflections.	Lunar hours.	Deflections.	Opposite points on the hour-circle combined.	
				Lunar hours.	Deflections.
	Scale divisions.		Scale divisions.		Scale divisions.
2	·00	14	·00	2 and 14	·00
3	−·10	15	−·09	3 and 15	−·095
4	−·08	16	−·11	4 and 16	−·095
5	−·10	17	−·08	5 and 17	−·09
6	−·07	18	−·06	6 and 18	−·065
7	+·01	19	+·01	7 and 19	+·01
8	+·09	20	+·06	8 and 20	+·075
9	+·11	21	+·11	9 and 21	+·11
10	+·14	22	+·16	10 and 22	+·15
11	+·16	23	+·10	11 and 23	+·13
12	+·14	0	+·08	12 and 0	+·11
13	+·09	1	+·06	13 and 1	+·075

The differences between the deflections at opposite points of the hour-circle at this station have so much the character of mere accidental irregularities that we may venture for greater simplicity to combine them, as is done in the two last columns of Table V., and to represent the deflections thus combined by a formula of fewer terms, in which a, the hour-angle (reckoned from eighteen hours), is multiplied by 30° instead of 15°. The formula is as follows:—

$$\Delta_x = +\cdot 02625 + \cdot 1259 \sin(a + 317^\circ\ 51') + \cdot 01047 \sin(2a + 25^\circ\ 57')$$
$$- \cdot 0083 \sin(3a + 5^\circ\ 43') + \cdot 0118 \sin(4a + 287^\circ\ 48')$$
$$+ \cdot 00235 \sin(5a + 291^\circ\ 26') + \cdot 0029 \cos 6a.$$

The lunar diurnal variation at St. Helena is, as at Toronto, a double progression, having two westerly extremes at nearly opposite points of the hour-circle, and two easterly extremes also at nearly opposite points. The amounts of extreme deflection, both easterly and westerly, are considerably less than at Toronto, but exhibit the same peculiarity of the extreme elongations in the one direction being about one-third greater than the extreme elongations in the other direction; at Toronto, the easterly elongations are the greater, at St. Helena the westerly. But a still more remarkable distinction in the lunar variation at the two stations respects the lunar hours at which the elongations respectively occur. At Toronto, as we have seen, the two easterly extremes coincide nearly with the epochs of the moon's superior and inferior culminations, and the westerly extremes nearly with the quadrantal hours of 6 and 18. At St. Helena, on the other hand, neither the times of the easterly nor of the westerly elongation coincide either with the culminations or with the hours of 6 and 18; and are so far and so systematically distant from those hours as to leave no doubt of the reality of their differences from them. The above formula gives for the times of extreme easterly deflection at St. Helena $3^h\ 24^m$ and $15^h\ 24^m$; and for the times of extreme westerly deflection $10^h\ 6^m$ and $22^h\ 6^m$; and the four hours at which the lunar variation disappears, or becomes 0, are $2^h\ 0^m$, $6^h\ 53^m$, $14^h\ 0^m$ and

$18^h\ 53^m$. The mean amount of extreme easterly elongation is $4''\cdot48$, and of extreme westerly elongation $6''\cdot43$, making the whole range of variation in a lunar day due to the moon's influence $10''\cdot91$.

The question of any possible difference existing in the lunar diurnal variation at St. Helena when the moon is at her extreme distance on either side of the equator, has been examined in the same manner as has been already described in pages 554 and 555 in the case of the Toronto observations, and with the same general result. The lunar diurnal variation appears to be the same whether the moon is N. or S. of the equator (or in this case N. or S. of the station). The amount of the lunar diurnal variation being altogether less at St. Helena than at Toronto, small irregularities naturally appear larger in proportion. The number of days included in the comparison is also less, extending through five years only instead of six.

Hobarton.—The hourly observations at Hobarton which have been employed for this investigation are from January 1843 to December 1847 inclusive, comprehending five years; their number is 36,820, of which 3242 have been omitted as disturbed, being found to differ from the monthly mean at the same hour to an amount equalling or exceeding 3·4 scale divisions, or $2'\cdot41$ in arc.

The deflections are those of the north end of the magnet, and the signs imply, as at each of the other two stations, an easterly deflection when the — sign is used, and a westerly deflection when the + sign is used. The value of a scale division at Hobarton was $0'\cdot71$. The deflections are exhibited in the following Table, which may be advantageously compared with the similar table at Toronto, page 552.

TABLE VI.

Lunar hours.	Deflections.	Lunar hours.	Deflections.	Lunar hours.	Deflections.	Lunar hours.	Deflections.
	Scale divisions.		Scale divisions.		Scale divisions.		Scale divisions.
23	+·08	6	—·05	10	+·05	18	—·08
0	+·15	7	—·06	11	+·14	19	—·15
1	+·19	8	—·10	12	+·25	20	—·15
2	+·24	9	—·01	13	+·33	21	—·12
3	+·30			14	+·31	22	—·02
4	+·21			15	+·24		
5	+·07			16	+·15		
				17	+·01		

This table exhibits, as at Toronto and St. Helena, a double progression, having two westerly and two easterly extremes at nearly opposite points of the hour-circle; and still showing, as at the other two stations, the phænomenon of the elongations in one direction being considerably greater than in the other direction. At Hobarton, as at St. Helena, the westerly elongations are the greatest, whilst at Toronto the easterly are greatest. The hours of extreme elongation differ both from those at Toronto and those at St. Helena. The values in Table VI. may be represented by the following formula, in which a, the hour-angle reckoned as before from eighteen hours, is multiplied by 15°.

$$\Delta_x = +\cdot0825 - \cdot0487 \sin(a+39°\ 15') - \cdot2056 \sin(2a+38°\ 00')$$
$$+\cdot0173 \sin(3a+339°\ 41') - \cdot0161 \sin(4a+68°\ 56')$$
$$-\cdot0187 \sin(5a+274°\ 54') + \cdot0083 \sin(6a+323°\ 08')$$
$$-\cdot0098 \sin(7a+52°\ 26') + \cdot0076 \sin(8a+19°\ 06')$$
$$-\cdot0023 \sin(9a+334°\ 32') + \cdot0015 \sin(10a+323°\ 08')$$
$$-\cdot0100 \sin(11a+274°\ 44') - \cdot0025 \cos 12a.$$

This formula gives for the times of extreme westerly deflection $2^h\ 52^m$ and $13^h\ 21^m$, the amounts being $12''\cdot8$ and $14''\cdot9$; and for the times of extreme easterly deflection $8^h\ 0^m$ and $19^h\ 30^m$, the amounts being $4''\cdot3$ and $6''\cdot7$. The means of the two times of westerly elongation are $2^h\ 06^m\cdot5$ and $14^h\ 06^m\cdot5$, and of the amounts, $13''\cdot85$. The means of the two times of easterly elongation are $7^h\ 45^m$ and $19^h\ 45^m$, and of the amounts, $5''\cdot5$. The total range of the lunar variation is $(13''\cdot85+5''\cdot5=)19''\cdot35$.

The times at which the deflection due to the moon's action is 0 are $5^h\ 27^m$, $9^h\ 06^m$, $17^h\ 05^m$, and $22^h\ 09^m$. These times taken in pairs are equidistant from two points on the moon's hour-circle, of which one is $1^h\ 48^m$ after her upper culmination, and the other is $1^h\ 05^m\cdot5$ after her lower culmination.

General Remarks.—We learn from the results which have been thus stated, that the existence of a lunar diurnal variation in the magnetic declination is shown at each of the three stations, Toronto, St. Helena, and Hobarton, and that it has the same general character at each, viz. that of a double progression in the lunar day with two easterly maxima at nearly opposite points of the hour-circle, and two westerly maxima also at nearly opposite points of the hour-circle. The extreme elongations in the one direction are not at precisely opposite points of the hour-circle at any of the three stations, nor have the amounts of the two elongations, which take place in the same direction, always precisely the same value, but the slight inequalities in these respects are within the limits which might be occasioned by accidental irregularities. It is otherwise, however, with the difference in amount between the easterly and westerly deflections, which exhibit at each of the three stations a disparity too great to be ascribed to accident. At Hobarton and St. Helena the westerly elongations have the largest values, and at Toronto the easterly (speaking always of the north end of the magnet). At Toronto and St. Helena the lesser elongations are about two-thirds of the amount of the larger; at Hobarton the disparity is still greater; to obtain the exact proportions with a sufficient degree of assurance would require, no doubt, a longer period of observation.

The difference which presents itself at the different stations, in the times of the occurrence of the extreme easterly and westerly elongations of the variation, is a very important feature in its bearing on the questions which must arise in regard to the nature and character of the lunar magnetic influence. At Toronto the easterly elongations take place almost exactly at the hours of upper and lower culmination, and the westerly elongations at the intermediate hours of 6 and 18. At Hobarton the westerly elongations (which, as Hobarton and Toronto are in opposite hemispheres, may be regarded as corresponding to the easterly at Toronto) take place (speaking generally) about two hours after the upper and lower culminations, and the easterly elongations (corresponding to the westerly at Toronto) about two hours after the lunar hours of 6 and 18. At St. Helena, which is in the same hemisphere with Hobarton, the westerly elongations occur about two hours before the culminations, and the easterly extremes about two hours, or rather more, before the hours of 6 and 18. The differences in this respect at the different stations are a feature of such essential theoretical importance, that I should have delayed the presentation of this paper until it could have been accompanied by a similar investigation into the results obtainable from the five years of hourly observations printed in the first volume of the Magnetical Observations at the Cape of Good Hope, had I not the expectation that that portion of the task may be undertaken by Mr. Pierce Morton, who now conducts the magnetical observatory at that station.

The entire amount of the variation, reckoned from one extreme elongation to the other, is at Toronto about 27″; at Hobarton about 20″; and at St. Helena about 10″. The terrestrial force, retaining the magnet suspended horizontally in its mean position, may be taken approximately at Toronto at 3·54, at Hobarton at 4·51, and at St. Helena at 5·57. It may be desirable also to state that the amount of the magnetic Declination at the period under consideration was, at Toronto 1° 34′ West, at Hobarton 9° 55′ East, and at St. Helena 23° 25′ West.

The number of observations which have contributed to these results (exclusive of those omitted on account of disturbance) are, 38,398 at Toronto, 33,771 at St. Helena, and 33,578 at Hobarton; making, altogether, 105,747 observations.

With the exception of marking the observations for the lunar hours to which they most nearly correspond, and the calculation of the constants in the formulæ at Toronto and St. Helena, the processes to which the observations received from the stations have been submitted have been executed by Mr. John Magrath, principal Clerk in the Woolwich Office, assisted by Sergeant Charles Organ and Corporal Matthew M'Ilroy, of the Royal Artillery, employed in the office as military clerks.

Woolwich, November 16, 1853.