

Diurnal Magnetic variation in Equatorial Regions

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The large diurnal variation in H at Kodaikanal had remained unnoticed and it was the still larger diurnal variation at Huancayo which when examined by McNish¹ led to the discovery that the magnetic diurnal variations there were markedly different from those expected for such a region. McNish's explanation implied that this large diurnal variation at Huancayo was due to its position between the geomagnetic and magnetic equators, and he pointed out that at places where the magnetic equator was situated far from the geographic equator an increase of the diurnal variation would occur. Chakravarty² suggested geomagnetic control of the diurnal variation in low latitudes. Egedal³ plotted the range of H (September) for Alibag, Antipolo, Madras, Kodaikanal, Batavia and Huancayo against the magnetic inclination, as an indication of the distances of the observatory from the magnetic equator, and found that the values were symmetrical about the magnetic inclination 0° . Chapman⁴ compared some observations of diurnal variation of H at Uganda and Mombasa with those at Huancayo. He pointed out that Uganda, Mombasa and Huancayo where the diurnal variation is large "lie not very far from the longitude at which the magnetic equator crosses the geographical equator at a fairly steep angle, whereas Singapore and Batavia (where the variation is much smaller) lie in a region where the latitude of the magnetic equator changes very slowly." Whether this was significant or not, he suggested, should be tested by further observations at a number of places near the interequatorial region. Martyn⁵ found that the data of diurnal variation examined by Egedal and Chapman showed that the distribution was not symmetrical about the geomagnetic

equator, but about an equator midway between the magnetic and geomagnetic equators. Price and Wilkins⁶ as a result of the analysis of the sq -field for the polar year 1932-33 found that the maximum diurnal variation of H was between the magnetic and dipole equators in South America and Africa, but occurred to the south of both these equators in the Far East, and further the line of maximum variation appeared to move in the opposite direction to that of the sun.

2. Gulatee⁷ arranged for the measurement of the diurnal variation of H at 5 places in Southern India and Ceylon. Observations were taken with 3 QHMs, Nos. 17, 18 and 32 at three specified times, at 1200 IST, roughly corresponding to the expected maximum epoch, and at 0300 and 1800 IST, roughly corresponding to the expected minimum epoch. Two QHMs were used on each day and the difference between the largest and smallest of the six values were taken as the range. The observations were taken at 5 places for about 3 days at each place during June and August 1950. The places and the diurnal range of H obtained are given (as ratio of the values at the places to those at Kodaikanal) below—

TABLE 1

Date	June 18-20	June 5-8	June 1-3	July 9-12	July 31-Aug 2
Station	Galle ($80^\circ.2$ E $6^\circ.0$ N)	Tinne- velly ($77^\circ.6$ E $8^\circ.7$ N)	Manda- pam ($79^\circ.1$ E $9^\circ.3$ N)	Banga- lore ($77^\circ.6$ E $13^\circ.0$ N)	Gun- takal ($77^\circ.4$ E $15^\circ.2$ N)
Mean ratio	0.86	1.12	1.21	0.82	0.74
Mean range (%)	69	90	97	87	78

Ranges at Kodaikanal for the quiet days in June and July were 80 γ and 106 γ respectively.

It may, however, be mentioned that the maximum occurred at Kodaikanal on the days of experiment at Guntakal, Bangalore, Tinnevely and Galle between 0940 and 1340 IST and the minimum between 0038 and 0740 and between 1600 and 2300 IST. The ranges obtained from the observations at these places are, therefore, generally less than the diurnal ranges, for the minima and maxima occurred probably at these places on most of the days at times other than those of observations. Besides, it is seen from the experiments arranged by us at Cape Comorin, Palamcottah and Sankaranainarkoil in 1951 that although the maximum occurred at these places and at Kodaikanal generally within an hour, the times of minimum epoch differed often by 3 to 5 hours. The ratio of the ranges (Table 1) given by Gulatee at these places with respect to the corresponding range at Kodaikanal based on the values at the times of observation are, therefore, likely to differ from the ratio of the actual diurnal ranges at these places to those at Kodaikanal, but the differences are, however, unlikely to be large.

3. The authors arranged for observations of H and Z by India Meteorological Department staff for a week at each of the places, Cape Comorin (8°05'N 77°30'E), Palamcottah (8°44'N 77°44'E) and Sankaranainarkoil (9°10'N 77°32'E) on the last day of February and during March 1951 with QHM and BMZ instruments. Observations were taken at hourly and two hourly intervals on alternate days, but even on days of two hourly observations, hourly observations were taken for two hours before and after the maximum and minimum epochs. Observations were taken with both the QHM's at any hour and the mean of the two values for H given by the QHM's was taken as the value for H for that hour. The difference between the highest and lowest values of H on any day was taken as the diurnal range of H for that day. As the values for Z were very small, 4 to 6

observations were taken at any hour by BMZ with supplementary magnets in different positions without the field magnet and the mean value was taken as the value for Z for that hour. The diurnal range of Z was the difference between the highest and lowest values of Z on that day.

All the three stations are approximately on the same meridian as Kodaikanal. The QHM's (Nos. 166 and 167) and the BMZ (No. 58) were manufactured by Messrs Anderson and Sorensen, Copenhagen and had been compared at Rudeskov. They were compared at Alibag and also at Kodaikanal before and after the experiments.

4. During the series of observations extending over three weeks there were only four days which were magnetically calm at Kodaikanal. On one day, the first during the present series, there was a severe magnetic storm, four days were moderately disturbed and the rest slightly disturbed.

5. The diurnal ranges of H at the three places and their ratios to the corresponding ranges at Kodaikanal are given in Table 2. The mean ratios for all days and for calm and slightly disturbed days have also been given in the table.

The mean diurnal range of H for the five magnetically quiet days in March 1951 at Kodaikanal was 128 γ . The diurnal range at Cape Comorin, Palamcottah and Sankaranainarkoil for magnetically quiet days in March could be taken as 155 γ , 130 γ and 125 γ . The range remains fairly large and practically the same from Kodaikanal to Palamcottah and increases further south to about 155 γ at Cape Comorin. From Gulatee's observations one would expect the range to decrease soon afterwards and be much less in south Ceylon. The mean values of H at Cape Comorin, Palamcottah and Sankaranainarkoil on calm and slightly disturbed days were 39838 γ , 39872 γ and 39931 γ .

6. The diurnal range of Z at the three places are also given in Table 2. The mean value of Z at Cape Comorin, Palamcottah and Sankaranainarkoil are --1305 γ ,

TABLE 2
Diurnal Range of H and Z

Date (March 1951)	Charac- ter of day	H			Z Range
		Range γ	Range γ (Kodai- kanal)	Ratio (3) : (4)	
(1)	(2)	(3)	(4)	(5)	(6)
CAPE COMORIN					
1	S	133*	198	0.6717	61
2	S	142*	94	1.5106	72
3	S	132	130	1.0154	91
4	S	186	146	1.2740	49
5	C	136	113	1.2035	71
6	S	158	117	1.3504	112
Mean C and S days		153	127	1.2108	76
Mean all days		153	127	1.2108	76
PALAMCOTTAH					
9	M	91	115	0.7913	69
10	M	112	137	0.8175	60
11	S	168	161	1.0435	58
12	S	115	109	1.0550	64
13	S	154	161	0.9565	51
14	S	116	116	1.0000	50
Mean C and S days		138	137	1.0137	56
Mean all days		126	133	0.9440	59
SANKARANAINARKOIL					
17	S	164	161	1.0186	48
18	S	109	123	0.8862	36
19	C	164	166	0.9879	46
20	C	170	172	0.9884	46
21	C	169	163	1.0368	39
22	S	179	192	0.9323	43
Mean C and S days		159	163	0.9750	43
Mean all days		159	163	0.9750	43

C—calm S—slightly disturbed M—moderately disturbed
*Rejected for averages as some observations on these two days were inaccurate

—77 γ and 601 γ . It will be seen that the value of Z is very small at Palamcottah and that its sign changes between Palamcottah and Sankaranainarkoil, the value at the latter place being much larger. The magnetic equator passes very close to Palamcottah and just to the north of it. The geomagnetic latitude of Palamcottah is about 1°S (eccentric dipole) and 2°S (centred dipole).

7. The mean hourly values of H and Z for all days and for calm and slightly disturbed days are given in Tables 3 and 4 and also shown in Fig. 1.

8. Conclusion

1. The diurnal range of H in south India near the inter-equatorial region is quite large and was of the order of 135 γ in March 1951 and 80 γ in June-July 1950.

2. Batavia, Singapore and the stations in south India and Ceylon are all far away from the crossing of the geographic and magnetic equators and although the diurnal ranges of H at Batavia and Singapore are small, those at Indian and Ceylon stations are quite large.

3. The geographic and magnetic equators near Batavia and Singapore, and in south India and Ceylon regions are about equally far apart, but the diurnal range is considerably greater in this region.

4. The maximum range of H in south India and Ceylon is not as found by Martyn between the magnetic and geomagnetic equators for places examined by him, but to the south of both as expected by Price and Wilkins. It would appear that the diurnal range in south of Ceylon is much smaller and the line of maximum range is nearer to Cape Comorin than to south Ceylon.

5. The magnetic equator in this region crosses the longitude 77°30'E close to Palamcottah.

TABLE 3

Mean hourly values of H in γ (39000 +)

Hours (IST)	Cape Comorin		Palamcottah		Sankaranainar- koil	
	All days	C & S days	All days	C & S days	All days*	C & S days
00	791	789	850	842	895	895
01	809	812	861	859	903	903
02	805	797	860	851	899	899
03	805	804	855	846	906	906
04	802	800	857	851	904	904
05	817	819	863	858	905	905
06	798	796	858	855	900	900
07	819	819	873	877	914	914
08	845	858	884	889	937	937
09	873	877	926	932	971	971
10	904	912	944	945	009†	009†
11	920	924	947	949	023†	023†
12	896	902	937	932	010†	010†
13	864	874	914	910	978	978
14	839	850	891	887	964	964
15	826	833	863	863	925	925
16	824	830	854	841	901	901
17	821	830	859	853	900	900
18	803	805	855	847	894	894
19	797	798	845	834	893	893
20	794	795	840	826	898	898
21	789	789	841	823	897	897
22	802	799	838	833	891	891
23	805	806	849	833	900	900

*All days were calm or slightly disturbed days
† (40000 +)

TABLE 4

Mean hourly values of Z in γ

Hours (IST)	Cape Comorin		Palamcottah		Sankaranainar- koil	
	All days	C & S days	All days	C & S days	All days*	C & S days
00	-1302	-1297	-70	-61	605	605
01	-1302	-1302	-78	-98	609	609
02	-1305	-1303	-71	-61	609	609
03	-1304	-1302	-85	-83	609	609
04	-1303	-1298	-73	-62	609	609
05	-1311	-1309	-83	-81	605	605
06	-1308	-1307	-87	-75	605	605
07	-1297	-1296	-95	-88	613	613
08	-1278	-1271	-70	-61	612	612
09	-1256	-1264	-71	-71	615	615
10	-1265	-1268	-63	-63	608	608
11	-1300	-1312	-76	-77	600	600
12	-1304	-1302	-97	-85	591	591
13	-1312	-1314	-95	-74	584	584
14	-1329	-1323	-95	-64	585	585
15	-1320	-1327	-111	-102	586	586
16	-1325	-1328	-96	-70	594	594
17	-1321	-1321	-107	-91	594	594
18	-1319	-1321	-96	-78	597	597
19	-1315	-1319	-95	-81	600	600
20	-1314	-1317	-92	-79	601	601
21	-1312	-1312	-91	-70	605	605
22	-1308	-1308	-79	-71	602	602
23	-1306	-1306	-82	-70	608	608

*All days were calm or slightly disturbed days

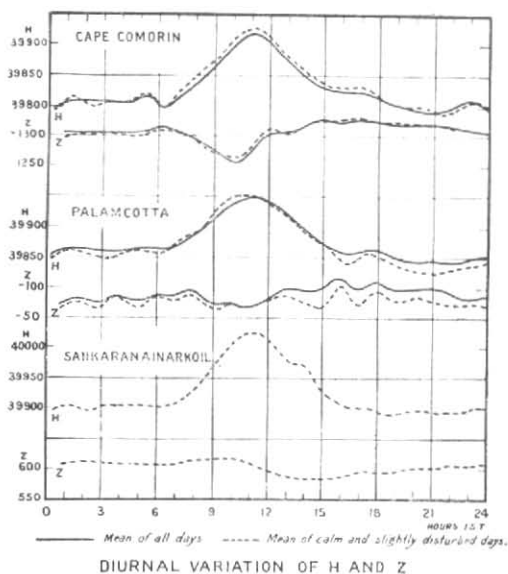


Fig. 1

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