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UNITED STATES
COAST AND GEODETIC SURVEY

F. M. THORN
SUPERINTENDENT

METHODS AND RESULTS

TERRESTRIAL MAGNETISM

THE MAGNETIC WORK OF THE GREELY ARCTIC EXPEDITION

1881—1884

APPENDIX No. 10—REPORT FOR 1887

WASHINGTON
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National Oceanic and Atmospheric Administration

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APPENDIX No. 10.—1887.

THE MAGNETIC WORK OF THE GREELY ARCTIC EXPEDITION.

Abstract of a Report by CHARLES A. SCHOTT, Assistant.

It is well known that the Expedition sent out by the Government to Lady Franklin Bay in command of Lieut. A. W. Greely, U. S. Army, was one of two expeditions to co-operate with and form part of the physical explorations proposed by the International Polar Commission. By invitation of its president, the late General Hazen, Chief Signal Officer, accepted the organization and fitting out of two parties, one under Lieutenant Greely to be sent to the shores of Lady Franklin Bay, Grinnell Land, the other, under Lieut. P. H. Ray, to go to Uglaamie, Point Barrow, Alaska. While the general responsibility, the supervision, the accounts, the selection of men and their transportation to and from the stations, remained in his own hands, General Hazen requested and received the aid of the Coast and Geodetic Survey in the special departments of terrestrial magnetism, of tides and gravitation. The assistance of the Survey by its then Superintendent, Capt. C. P. Patterson, consisted in furnishing such instruments as could be spared from its limited supply, in training the observers for their work and in providing them with the necessary instructions and forms of record for the proper performance of their duty. It so happened that Congress had already (in 1880) authorized a scientific expedition to Lady Franklin Bay, but the funds were appropriated so late in the spring of 1881 that it was found impossible to procure the needed special instruments and to give that thorough training to the corps of observers which could only be obtained by ample time for preparation. Indeed the Commission itself found it expedient to start other expeditions a year later in order to obtain a better organization of the scientific labor, and especially for the construction of suitable magnetic differential instruments.

There is no need of referring here to the general history of the two American expeditions, as we already have the official publication of the one under Lieutenant Ray, and the narrative of the Lady Franklin Bay party, in two handsome volumes, by its leader, Lieutenant Greely. By his permission we were enabled to lay at an early date before the readers of "Science" the general results of his labors during 1881–'84 in the domain of Terrestrial Magnetism. They are extracted from the manuscript, now ready for the printer, but it is not our intention to enter minutely into any details which would be here out of place, nor to forestall the judgment of scientists on the merits of the work—this must be reserved for a time after the official publication, and when the results by the several international expeditions can be compared and collated. A brief statement of facts, so far as they relate to that part of the work which was intrusted to the special direction of the U. S. Coast and Geodetic Survey, is all we propose to give at present.

The astronomical and magnetic work of the Expedition was placed in special charge of Sergeant Edward Israel, who unfortunately was one of those not permitted to return, but whose records abundantly testify to his faithfulness and painstaking industry. Copies of these records in a highly condensed form were safely brought home and were placed in the hands of C. A. Schott, Assistant

U. S. Coast and Geodetic Survey, for discussion, and for preparation for the press. This task was rendered somewhat difficult from want of sufficient explanation on the part of the observer. Fortunately Lieutenant Greely took the precaution when retreating in 1883 from his station to bring with him the magnets and pendulums, thus permitting certain supplementary observations to be made at home. This can not be too highly commended when we consider that every pound of dead weight carried necessitated leaving behind so much food to sustain the life of the party on its perilous retreat. In judging of the merits of the labors of the Expedition it should be borne in mind that all efforts had failed to succor this party, which occupied the northernmost station assigned to any of the Expeditions, and that at the time of its sailing certain magnetic instruments, needed for fully carrying out the programme adopted by the International Commission could not be obtained.

The Magnetic Observatory at Fort Conger was erected a short distance from the main house and was supplied with a new magnetometer made by Fauth & Co., of Washington, and with a dip circle of the Kew pattern, but it had no differential instruments. The observations were made on Göttingen mean time, which differs $4^h\ 59^m$ from local time and $5^h\ 48^m$ from Washington time. A small transit, loaned by the Survey, served for the determinations of time and longitude. The observations for time and latitude were made by means of the sextant, and comparisons of chronometers were made throughout the stay of the party. From a series of observations of double altitudes of the sun near (lower transit), and of circum-meridian altitudes of the sun (upper transit), the latitude was found to be $81^\circ\ 44'\ 00''.4 \pm 5''.4$. The azimuth of the mark for absolute declination was determined on three days from observations of the sun with the theodolite, viz, $44^\circ\ 44'.3 \pm 0'.8$ east of south. The longitude of the station from Greenwich was determined by means of ships' chronometers on the outward trip, and at the station by observations of moon culminations, occultations, and lunar distances, with the result $4^h\ 18^m\ 55^s.3 \pm 1^s.2$ W. of Greenwich.

The accuracy of this result is mainly due to a fine series of seventeen moon-culminations. In arc the longitude is $64^\circ\ 43'\ 50''$ W., and the value preliminarily adopted by Lieutenant Greely for his party was $64^\circ\ 45'$ W., on the authority of Lieutenant Archer, R. N., as the result by the British Expedition to this place in 1875–'76.

During the first ten months of the occupation of the post a series of hourly observations of the declination were made on three days in each month. This comprises the period from August 1, 1882, to August 31, 1883, and includes 846 observations with a resulting declination $100^\circ\ 13'.6$ west of north. The results of the diurnal variation of the declination are stated as follows: On the yearly average the needle reached its extreme westerly deflection between 3^h and 4^h p. m. (local time), amount $45'$, and its extreme easterly deflection between 0^h and 2^h a. m. (local time), amount $40'$, hence the diurnal range $1^\circ\ 25'$. The diurnal variation is illustrated by a diagram.

The series of hourly observations of the declination at Fort Conger began with July 1, 1882, and ended with August 1, 1883; this is the period which was assigned by the International Commission to be that of close and simultaneous co-operative magnetic work obligatory on all parties. The differential measures of this series were converted into absolute values; the tabulation and discussion of this series constituted the greater part of the labor expended on the observations. The method of separating the so-called disturbances from the general record, and their treatment when separated, was left, apparently, by the Vienna Conference to the discretion of each individual party, though several methods were proposed. It is well known that there is no certain criterion of what constitutes a disturbance, and, moreover, processes that may answer in lower latitudes will be found difficult of application for stations in high magnetic latitudes. It would take too much space to explain here this rather technical subject; it may be sufficiently described, however, by stating that the mean deviation of an observed value from its respective hourly and monthly normal value was first made out. Then according to Dr. Lloyd's rule one and a half times this value, or in the case of Fort Conger $1^\circ\ 06'$, was considered the limiting value, and any observation differing by this or a greater amount from the normal value was designated "a disturbance." These hourly normals and (larger) disturbances were tabulated and the results were discussed. The average declination from this series is $100^\circ\ 34'.5$ west, and when compared with the earlier results of the British Expedition gives $9'.9$ as the most probable value for the annual diminution of west declination at this place. It is shown that the effect of the presence of these (larger) disturb-

ances was to diminish the declination by 2′.3, and that the diurnal range of the motion of the needle was increased by their influence.

The solar diurnal variation of the declination is presented in tabular and analytical form as well as by a diagram; its most characteristic feature is the occurrence of the westerly extreme soon after local noon with a deflection of 37′.9, reached earlier in summer and later in winter; the opposite extreme is reached an hour and a half after midnight with a deflection of 27′.9, also found variable with the season. Average diurnal range October to March 0° 56′, and April to September 1° 22′.

In the annual variation of this average range, December exhibits the minimum of 28′ and June the maximum of 1° 48′. The lowest reading on record was on November 16, 1882, at 8^h 35^m a. m. (Göttingen time), when the declination was 92° 51′.6 W., and the highest reading on the day following at 10^h 20^m p. m. (Greenwich time), viz, 113° 19′.8 W., showing a change of no less than 20° 28′.2 within thirty eight hours, and it is noted that a great magnetic storm was raging between November 13 and November 19, 1882, which culminated in intensity on the 17th.

The total number of hourly observations during the year was 8749, and the number of (larger) disturbances separated from them 1169; in other words, there was one (largely) disturbed observation in every eight. The distribution of the disturbances in the diurnal and annual periods, with separation into easterly and westerly disturbances, was then analyzed and the results were tabulated, both with respect to frequency and magnitude; but for want of space we can not follow out all the results presented. We may, however, mention the following: During the year (ending August 1, 1883) the easterly disturbances exceeded in number the westerly ones in the proportion of 661 to 508, or of 1.30 to 1; in the annual variation the disturbing force was most active during November, and least during September. In the diurnal variation the easterly and the westerly disturbances follow different laws as to frequency and amount. The disturbing force deflecting the north end of the needle towards the (magnetic) east is most active two hours after midnight and least active during hours 12 to 17 (or afternoon hours); on the other hand deflections to the west appear most frequent three hours after noon and least about the hours near midnight. Respecting intensity of action easterly disturbances slightly exceed westerly ones.

The term-day and term-hour observations extend over the interval from July 1, 1882, to August 1, 1883. They were made on the 1st and 15th of each month, when the declination magnet was observed every five minutes throughout the twenty-four hours, simultaneously, at all stations taking part in the research. Besides these, observations were made every twenty seconds during one selected hour on each of the term days. The labor bestowed on this part of the work was very great, but it is expected that correspondingly valuable results may be deduced by their intercomparison after all the expeditions shall have published their observations. Not content with these labors, the magnetic observers also recorded the motion of the needle during magnetic storms and in connection with appearances of auroras.

The usual observations of oscillations and deflections were made for the determination of the magnetic intensity; the record and computations are given in detail and the results are tabulated and expressed in British, Gaussian, and C. G. S. units or dynes. For the epoch (1882–'84) the horizontal component of the magnetic force was found to be 1.118 British units or 0.05155 dyne, and it would appear from comparison with the results found by the British Exploring Expedition, 1875–'76, that this intensity did not undergo any perceptible change during the interval. The tabular values show extreme variations of about $\frac{1}{50}$ part of the force.

Hourly observations of the dip were made between September 25, 1882, and June 1, 1883. These were in a measure differential, and resulted in an average dip of 85° 01′. Combining the dip with the horizontal component, the total intensity as observed at Fort Conger becomes 12.870 British units, or 0.5934 dyne, for the epoch 1882.2. By comparison it was found that the dip had been increasing since 1875–'76 at an annual rate of 1′.6.

The dates of auroral displays are next enumerated, and extracts are given of the character of the more imposing auroras. Then follows a table of magnetic results collected during explorations by different parties and extracted from Lieutenant Greely's narrative. The paper concludes with a general collection of magnetic results obtained from the expeditions of Kane, 1853–'55; of

Hayes, 1860–'61; of Hall, 1871–'73; of Nares, 1875–'76, and from Lieutenants Crosby and Sebree, of the *Bear* and *Thetis*, in 1884. From these observations it is concluded that for the last twenty-five years, at least, the magnetic west declination has been annually decreasing about 6′ in the region of the North Water, Smith Strait and Kane Basin, and that in the region to the north of it, and including the Hall Basin, this decrease was fully 10′ per year during the past decade.

In close connection with the scheme of physical researches undertaken by the International Arctic Committee, the desirability of a new determination of the American pole of dip does not appear to have been urged. It must be admitted that the region is difficult of approach, yet the gain to our knowledge of terrestrial magnetism and its secular changes would be equally certain if it could be successfully explored. More than half a century has elapsed since Ross made his memorable and bold dash to this point, but science nowadays will demand more, and the whole region in that vicinity would have to be surveyed in order to permit the tracing out of isoclinics or the application of a suitable analytical process to bring out the facts of the case, as, in consequence of local deflection, there may be many points of vertical dip covering or distributed over a considerable area.

From the time of Hansteen, early in this century, to the present time, efforts have been made to trace out the supposed motion of the intersection of the so-called magnetic axis with the surface. While some physicists hold it to be fixed in position, others believe it to have a slow secular motion of limited extent, and still others would give to it a rapid motion with a path which will carry it clear round the geographical pole.

The time has certainly arrived when in this matter facts shall take the place of speculation. The writer has the assurance of the willingness of three distinguished American arctic explorers to undertake this task; the one thing lacking is the necessary funds to sustain the explorer, say, for two years.

Here surely is a fine field open in which to gain well-merited distinction.