during auroral displays, *i. e.* decrease of geomagnetic holizontal intensity, increase in fEs due to anomalous ionization in the lower ionosphere and auroral intensity, are examined and proved to be consistent with each other. As an example, relation of number density of electrons with auroral luminosity λ5577 is shown in Fig. 2, together with the same kind of relation with luminosity of Nitrogen negative groups obtained by OMHOLT[1].

5) From the observed facts mentioned above, it may be concluded that the polar magnetic disturbances are due to the motion of electrical charge along the lower border of aurorae caused by anomalous ionization in the lower ionosphere, which results in either ionospheric blackout or increase in fEs.

Reference

1) Omholt A.: Journ. Atmos. Terr. Phys. 7, 73 (1955).

MAGNETIC VARIATION ON THE ANTARCTIC OCEAN NEAR SYOWA BASE*

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昭和基地周辺における海上の磁気偏差*

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Introduction

In the case of using the magnetic compass for sailing, we must know the compass error between the compass north and the meridian. This compass error consists of the variation, the deviation and the mechanical errors of the compass itself. We report about the result of the magnetic variation observed in the Antarctic ocean near Syowa Base.

Measurement

The magnetic variation is the difference between the true meridian and the magnetic meridian, but we must think of the including deviation in it. The true meridian can be easily get by the gyro-compass.

T the true bearing of the ship's head

C the compass bearing of the ship's magnetic compass

δ the deviation by the ship's head

V the variation

i shows N, NE, E, SE, S, SW, W, NW (8 cardinal points of the compasses)

$$Ti-Ci=\delta i+V \quad \ldots.(1)$$

$$1/8\sum(Ti-Ci)=1/8\sum\delta i+V \quad \ldots.(2)$$

$$V=1/8\sum(Ti-Ci)-1/8\sum\delta i \quad \ldots.(3)$$

We calculate the variation V by this formula.

$1/8\sum\delta i$....practical coefficient of the deviation.

$$V=1/8\sum(Ti-Ci)-A \quad \ldots.(4)$$

Coefficient A has no connection in the element of the terrestrial magnetism and we can adapt

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the value at a place, because it is caused by the induced magnetism of the soft iron in the ship. In case of measurement in the A, we use the formula (4) given above.

Of course we must know the variation, on that occasion we can get a good measurement of the variation, if observed on the sea near the land with a known variation.

T is measured by the gyro-compass and it's error was not over 0.3° by the celestial observation measured every day. Nineteen observations for the variation were done at every midnight from Lat. 67°S. to Lat. 69°S., from Long. 20°E. to Long. 50°E., when the sea was very smooth. Ship's clock is mean solar time at Long. 45°E.

Instrument

1) Magnetic compass
   JES (JIS) S165 standard compass.
   Magnetic moment 1650 c.g.s. units.
   Period (H=0.30, 15°C) 24 sec.
2) Gyro-compass
   Sperry gyro-compass MK14
   Compass error ±0.1°
3) Photographic apparatus

When the ship's head steered on eight cardinal points of the magnetic compass on the compass bridge, we must read immediately the index of the master gyro-compass. For this purpose we adapted the photographic method.

Conclusion

Table 1 shows the result of the residual deviation of standard compass of which deviations were corrected on Tateyama Bay in Japan, where the magnetic variation was 6.0° westerly. And as we get the zero value coefficient A there, the compass should be best available for measureing the magnetic variation. Then on the position (Lat. 1°48′N., Long. 122°57′E.) near the

Table 1. The Result of deviation adjustment at Tateyama Bay.
(Lat. 35°05.′0N., Long. 139°46.′6E.)

Ship's compass co.	Residual deviations	Coefficients of deviation	Location of adjustor
N	0°	A= 0°	Red fore starb'd 78 cm port 56 cm
N E	0°	B= 0°	
E	0°	C=−0.°2	Red starb'd 58, 60, 62, 64, 66, 68cm
S E	+0.°5	D= 0°	
S	0°	E= 0°	
S W	0°		Flinders' bar fore short 1
W	0°		
NW	−0.°5		Perm alloy both 3 27.5 cm

Table 2. The Result of deviation adjustment near the magnetic equator.
(Lat. 1°48′N., Long. 122°57′E.)

Ship's compass course	Measured deviation	Residual deviation	Coefficient of deviation	Location of adjustor
N	+1.°0	+0.°1	A=0°	Red fore starb'd 47.5 cm port 86.5 cm
N E		−0.°1	B=0°	
E	+1.°5	0.°0	C=0.°1	Red starb'd 59, 61, 63, 65, 67, 69 cm
S E		+0.°1	D=0°	
S	+3.°5	−0.°1	E=0°	
S W	+4.°0	+0.°1		Flinders' bar fore short 1
W		+0.°1		
NW		+0.°1		Perm alloy both 3 27.5 cm

Table 3. The Comparison of variation obtained from the measurement on 16 points & 8 points of ship's compass course.

Ship's compass course	$T_i - C_i$	Ship's compass course	$T_i - C_i$
N	−47.4	NNE	−45.5
NE	−48.6	ENE	−48.9
E	−49.1	ESE	−47.1
SE	−45.6	SSE	−43.4
S	−42.1	SSW	−40.2
SW	−37.7	WSW	−36.0
W	−37.5	WNW	−39.1
NW	−41.9	NNW	−44.1
Variation obtained from 8 measured values was 43.°7W		Variation from 16 measured values was 43.°4W	

magnetic equator, the deviation was obtained as the values of second column, and the residual deviations were as the values of Table 2 after adjusting the the observed deviations at that place.

Measuring the magnetic variation by the formula (4) is better to be made on the many compass courses which equally devided the card by 8 or 16. In Table 3 we can compare the measured variations which were obtained at 8 and 16 points of ship's compass course.

The measurement on 16 ship's compass courses might to more accurate than on eight ship's compass, we measured only on eight courses, since the difference of variation between measured on eight courses and on 16 courses was only 0.3 degrees in Table 3, and it was smaller than the accuracy 0.5 degrees of navigational use.

Table 4 shows the compass errors ($T-C$) on each ship's compass course, and the sea, weather and ship's condition. For reference, the coefficients of deviation of the magnetic compass are presented in Table 5. Measured variations at each observed position are indicated on Fig. 1. Equal magnetic variation curves by British Admiralty chart and U.S.H.O. chart are added on Fig. 1.

Table 5. Coefficients of standard magnetic compass.

Station No. s \ Coefficient	A	B	C	D	E
A 1	−48.4	− 7.5	− 3.1	0.0	0.1
A 2	−41.5	− 7.3	− 1.1	0.0	− 0.1
A 3	−39.1	− 6.5	− 2.4	0.3	0.5
A 4	−36.3	− 5.7	− 1.5	0.3	0.0
A 5	−39.4	− 5.9	− 0.5	1.5	0.3
A 6	−36.0	− 6.1	− 1.0	0.1	− 0.6
A 7	−36.7	− 6.3	− 3.2	0.9	− 0.1
A 8	−35.3	− 5.9	− 2.1	0.5	0.2
A 9	−35.4	− 5.1	− 2.7	− 0.2	− 0.1
A10	−35.3	− 5.8	− 0.5	0.6	0.1
A11	−34.5	− 6.9	− 0.4	1.0	0.9
A12	−42.7	− 5.2	− 1.2	0.0	− 0.1
A13	−43.9	− 5.6	− 1.2	1.0	− 0.1
A14	−43.7	− 5.5	− 2.6	0.3	− 0.7
A15	−45.9	− 5.6	− 2.8	− 0.6	0.3
A16	−39.9	− 5.7	− 2.8	− 0.2	0.1

Table 4. Table of measured variation.

Station No. s		A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A 9	A 10	A 11	A 12	A 13	A 14	A 15	A 16
Date		Jan. 9, '57	Jan. 12	Jan. 13	Jan. 16	Jan. 17	Jan. 21	Jan. 26	Jan. 27	Jan. 28	Jan. 29	Feb. 1	Feb. 4	Feb. 4	Feb. 5	Feb. 5	Feb. 7
Time		1406–1420	0035–0100	0020–0035	0055–0105	0043–0055	0042–0053	1416–1430	0050–0104	0148–0225	0035–0055	0057–0112	0140–0155	1435–1450	0250–0312	1631–1647	0340–0400
Latitude		65°53.′0 S	67°17.′9 S	67°22.′9 S	68°02.′5 S	67°32.′0 S	68°16.′5 S	66°31.′3 S	66°51.′0 S	67°32.′5 S	67°46.′6 S	68°11.′5 S	67°34.′5 S	67°18.′8 S	67°19.′0 S	67°12.′0 S	67°49.′0 S
Longitude		45°29.′0 E	35°41.′1 E	33°05.′9 E	27°28.′0 E	32°18.′0 E	25°32.′5 E	30°34.′2 E	28°00.′0 E	28°06.′5 E	25°31.′0 E	23°23.′8 E	35°57.′5 E	38°10.′0 E	40°12.′0 E	41°31.′0 E	34°00.′0 E
Ship's compass course	N	−51.5	−44.3	−41.5	−37.6	−39.8	−37.2	−39.9	−37.2	−38.3	−35.6	−33.3	−44.2	−45.4	−47.4	−48.0	−42.0
	N E	−55.8	−49.0	−45.0	−41.6	−42.2	−41.4	−43.0	−40.7	−41.2	−39.8	−40.8	−47.0	−48.1	−48.6	−52.9	−46.6
	E	−56.1	−47.5	−45.8	−41.5	−45.5	−41.4	−42.6	−41.2	−40.8	−40.6	−41.4	−48.0	−48.6	−49.1	−51.2	−45.5
	S E	−50.2	−45.4	−42.6	−40.1	−45.2	−40.0	−39.2	−38.6	−36.1	−39.6	−39.5	−45.8	−47.5	−45.6	−47.8	−41.6
	S	−47.2	−40.4	−36.2	−34.5	−37.9	−35.5	−34.2	−33.0	−34.0	−35.4	−33.6	−41.0	−44.3	−42.1	−42.4	−37.5
	S W	−39.7	−33.9	−32.0	−31.1	−34.0	−30.7	−28.1	−28.8	−28.8	−29.3	−31.0	−38.9	−38.2	−37.7	−41.0	−33.6
	W	−40.8	−34.5	−33.8	−30.7	−33.5	−29.4	−31.1	−29.8	−31.3	−30.2	−28.6	−36.9	−36.6	−37.5	−40.2	−34.2
	N W	−45.5	−37.3	−35.5	−33.6	−37.1	−32.4	−34.9	−33.0	−33.1	−31.8	−28.4	−40.6	−42.7	−41.9	−43.7	−38.0
Measured variation		48.4W	41.5W	39.1W	36.3W	39.4W	36.0W	36.7W	35.3W	35.4W	35.3W	34.5W	42.7W	43.9W	43.7W	45.9W	39.9W
Weather		o	o	o	o	o	c	bc	bc	o	c	o	o	bc	b	bc	o
Wind direction		S	E/S	S E/E	S E	S E	E/N	S W/W	S W	S W/W	WNW	N/E	N	E	E	E	E/S
Wind force		2	2	1	1	2	3	2	2	3	3	4	1	3	3	2	4
Sea condition		2	2	1	Calm	1	3	3	2	2	2	4	1	2	2	3	2
Rolling angle	Starboard	0°	0°	1°	0°	1°	1°	2°	2°	1°	1°	4°	0°	0°	1°	0°	0°
	Port	2°	1°	1°	0°	1°	1°	2°	2°	1°	1°	4°	0°	1°	1°	0°	0°

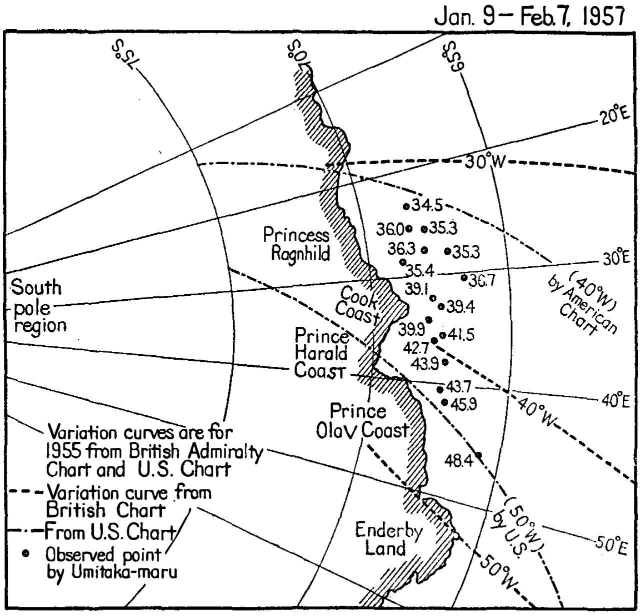

Fig. 1. Magnetic variation chart.

Comparing these variations, the difference and values of the measured variations for the variable position were likely the ones of the Admiralty chart. Consequently, the measured variations shall be sufficiently practical for navigational use.

Though the magnetic variation had never been measured on steel ship for the reason of ship's deviation, we observed the variation on 16 positions in the Antarctic Ocean, by making use of swinging the ship. Though the results are not always extremely accurate, it seems to provide sufficiently practical accuracy for navigational purpose.