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CHARACTERISTICS OF Sq VARIATION OF GEOMAGNETIC FIELD AT THE GREAT WALL STATION, ANTARCTICA IN WINTER

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Abstract In this paper the characteristics of Sq variation of geomagnetic field in the region of the Chinese Great Wall Station (CGWS), Antarctica, in winter are analyzed from geomagnetic data obtained at the Geomagnetic Observatory of CGWS. The result enables us to reveal the following aspects: (1) The pattern of Sq variation at CGWS in early (Apr.) and Late winter (Sep.) is similar to that at Beijing Geomagnetic Observatory (BJO) at the middle latitude in the Northern Hemisphere. It may be controlled by the midlatitudinal ionospheric dynamo current. Amplitude of Sq variation is very small, and the harmonics in 8 hours or shorter periods in midwinter (June and July) is predominant because of the decreased effect of solar ultraviolet radiation and the dominant geomagnetic disturbance at high latitudes. (2) The vectors of Sq-equivalent current in the daytime are about five times more than that in the night. The direction of the vectors is clockwise in the daytime (08—15^h) and counterclockwise in the night in early and late winter. Both of the vectors are very small because of the effect of the current density in the ionosphere is relatively weak in midwinter. The direction of vectors of Sq-equivalent current at CGWS in early and late winter is different from that in midwinter. It may be affected by the ionospheric current and field-aligned current in the polar region.

Key words Sq variation, harmonics, geomagnetic disturbance, vector of equivalent current, midwinter.

1. Introduction

The geomagnetic quiet daily S_q, strictly speaking, is not absolutly quiet. At the beginning of 19th century Moos showed a considerable change in average level of S_q from day to day, even in the quiet days. Chapman and Stagg (1929, 1931) confirmed this variation, and found that the amplitude of deviation from average level reaches 20—30% in individual quiet days (Brown and williams, 1969). According to the analyses of the diurnal S_q variation at high latitudes, Nagata and Kokubun (1962a) showed that the S_q variation on the polar cap connot be expressed to be the same as diurnal S_q^0 variation at middle latitudes in solar quiet day, but may be an independent geophysical event, which is expressed as an S_q^p Maeda (1973) indicated that S_q variation is a superposition of extrapolated S_q in middle latitudes on the so-called S_q^p or DP_2 filed.

The Chinese Great Wall Station (CGWS) is located on the Fildes Peninsula of King George Island (geographical coordinates: $\varphi=62.2°$ S, $\lambda=59.0°$W, and geomagnetic coordinates: $\Phi=-50.6°$, $\Lambda=7.4°$, calculated from IGRF coefficients in 1980s), West Antarctica. From a viewpoint of geomagnetic disturbance, The position belongs to the auroral zone or local disturbance zone ($\Phi=45°-70°$), i.e, it is located in a mid-high latitude region.

In order to study the characteristics of diurnal S_q variation of geomagnetic field at CGWS, we adopted a method, which Akasofu and Kiseabeth (1980) have applied to study on the characteristics of geomagnetic field at the Alaska meridian chain of geomagnetic observatories. In this paper the geomagnetic data obtained in five international geomagnetic quiet days every month from April to September of 1987 in local winter in Antarctica are analysed. The result shows that the diurnal S_q variation is dominated by Fourier third or higher harmonics in short periods at CGWS in midwinter.

2. Data Analysis

2.1. We assumed that the diurnal S_q variation of geomagnetic field at CGWS consists of two parts and can be writen as

$$S_q = S_q^o + S_q^D \tag{1}$$

where S_q^o denotes a sum of first and second harmonics (Akasofu and Kiseabeth, 1980), and it is similar to S_q variation at middle latitudes in the quiet days. S_q^D denotes the sum of third or higher harmonics in shorter periods. It contains substorm and other weaker disturbance, such as DP_2 etc.

2.2. An approaximate formula for expressing the equivalent overhead current density, as suggested by Kamida and Bekke (1965), is given in following:

$$I = \frac{H}{0.943} \approx H$$

i.e. the equivalent overhead current density I (A / km) is equal to the magnitude of the horizontal geomagnetic disturbance H (nT). Akasofu and Kiseabeth (1980) examined the S_q variation from the distribution of vectors of the corresponding equivalent current, which is caused by clockwise rotation of the magnetic vector by 90°.

2.3. The average values of S_q variation in five international geomagnetic quiet days every month from April to September in winter of 1987 at CGWS, Antarctica, are separated into three data groups: group I of average values in April and September, group II of average values in May and August, and group III of average values in June and July or in midwinter months. The values in the quiet days in January-March and in October—December of 1987 at Beijing Geomagnetic Observatory (BJO) at middle latitudes in the Northern Hemisphere (geographical coordinates: $\varphi = 40.0°$N, $\lambda = 116.8°$E; geomagnetic coordinates: $\Phi = 28.9°$ $\Lambda = 186.1°$) are also separated into three data groups: group I of average values in March and October, group II of values in February and November, and group III of values in January and December or in midwinter. The observation data were analyzed simultaneously. The obtained result on $S_q(H)$ and $S_q(D)$ variations in the geomagnetic quiet days is present in the following.

2.3.1. The curves of average diurnal variation of S_q(H) and declination $S_q(D)$ of geomagnetic field from these three data groups are shown in Fig. 1. It can be seen in Fig. 1 that the forms of S_q(H) curves are similar for data groups I and II at CGWS and BJO, but different for data group III. The forms of $S_q(D)$ curves are opposite in direction for data groups I, II, and Ⅲ at CGWS and BJO.

Fig. 2 shows curves of S_q^o variation obtained from a conbination of Fourier first and second harmonics. It is clearly seen that these curves of diurnal S_q variation are smooth for both observatories. But curves S_q(H) for data group III seem not to change in the daytime at CGWS because of short day time and decreased effect of the solar ultraviolet radiation in midwinter.

The horizontal vectors of diurnal S_q^o variation of geomagnetic field at CGWS and BJO

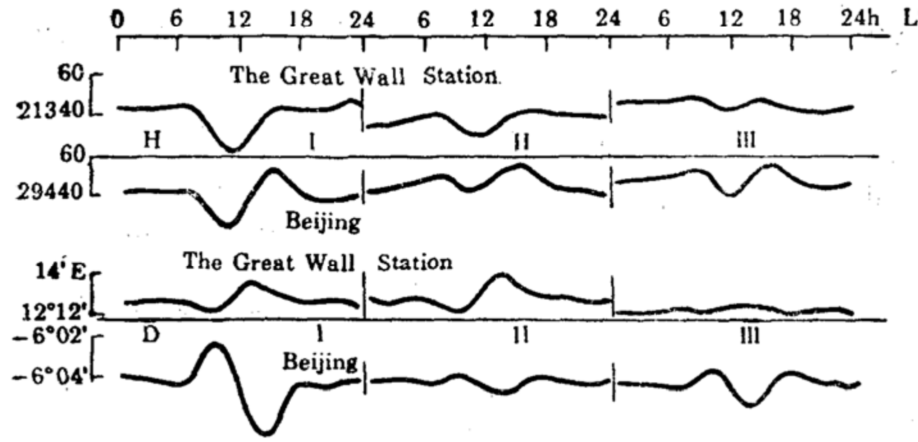

Fig. 1. Curves of Sq variation of geomagnetic field in the geomagnetic quiet days.

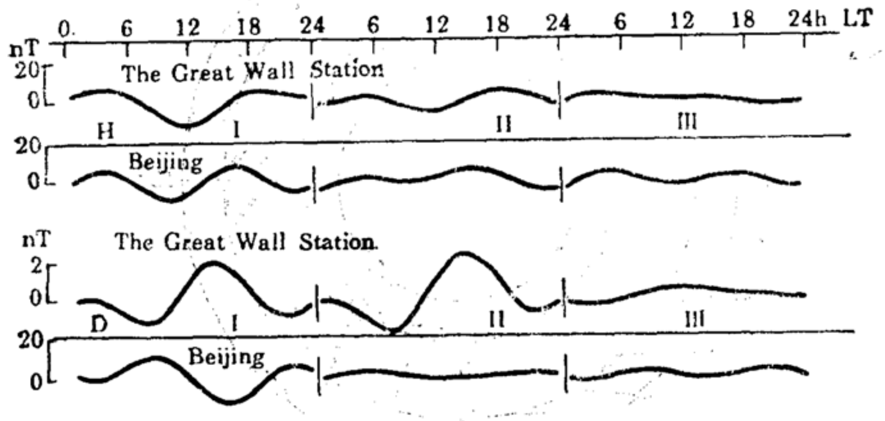

Fig. 2. Curves of diurnal S_q^D variation from the combined first and second harmonics.

in geomagnetic quiet days are shown in Fig. 3. These vectors are composed of deviation values △H and △*D* (*nT*). It can be seen in the Figure that the horizontal vecctors point to a minimum position at BJO at noon and away the minimum position at CGWS at noon. The distribution of vectors for data groups I and II are similar at both observatories, but very small for data group III at CGWS either in the daytime or in the night.

Fig. 4 shows the distribution of vectors of S_q°-equivalent current, corresponding to the horizontal vectors of S_q° in different magnetic latitude cycles. The inner cycle corresponds to an area at magnetic latitudes from -50° to -60° on Antarctica, and outer cycle at magnetic latitudes from 20° to 30° on Arctica. It can be seen in Fig. 4 that the vectors of S_q°-equivalent current are larger in Fig. 4–I than in Fig. 4–III at both observatories. The vectors rotate counter-clockwise before dawn and afternoon, and clockwise in the morning and night. The equivalent current intensity reaches a maximum at 16^h, I≈14A/km. and a minimum at 0^h, I≈1A / km for data group I. It is maximum at 16^h, 1≈4A / Km, and minimum at 8^h, I≈2 A / km for data group III at BJO in midwinter.

The vector orientation of S_q°-equivalent current rotates clockwise at 8–15^h and counter-clockwise at all other hours in the months for data group I. It rotates counter-clockwise at 0–15^h and clockwise at all other hours in the months for data group III, i.e. in midwinter. The equivalent current intensity reaches a maximum at h,11 I≈11A / km, and a minimum at

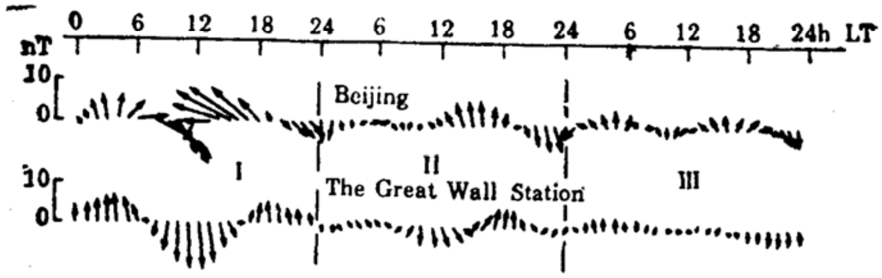

Fig. 3. Horizontal vectors of diurnal S_q^D variation of geomagnetic field.

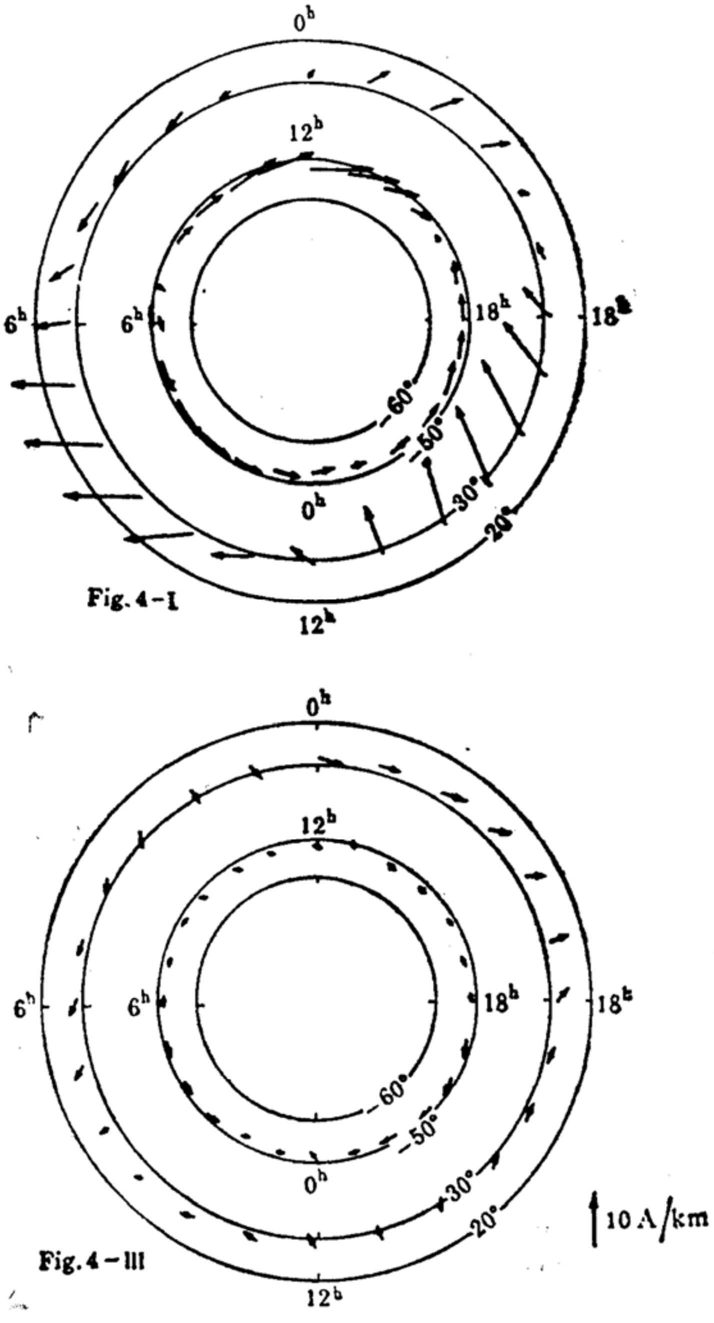

Fig. 4. Distribution of vectors of S_q^D-equivalent current at magnetic latitudes (I and III).

16h, I≈2A/km in the months for data group I, It is minimum at 11h, I≈0.4A/km, and maximum at 3h or 21h, I=3A/km in the months for data group III, i.e. in midwinter at CGWS.

Therefore, the equivalent current intensity is very weak in the daytime and night due to short time of sunlight and decreased effect of solar ultarviolet radiation and relatively weak effect of the ionospheric current at CGWS.

2.3.2. Curves of S_q^D variation of disturbed geomagnetic field in geomagnetic quiet days are shown in Fig. 5. These curves were established by a combination of third to sixth Fourier harmonics, sometime containing substorm, DP_2 and other weak disturbance. It is seen in Fig. 5 that the curves of S_q^D (H) change similarly, and the curves of S_q^D(D) change in opposite direction, Predominated by a harmonics in eight hour period at both observatories.

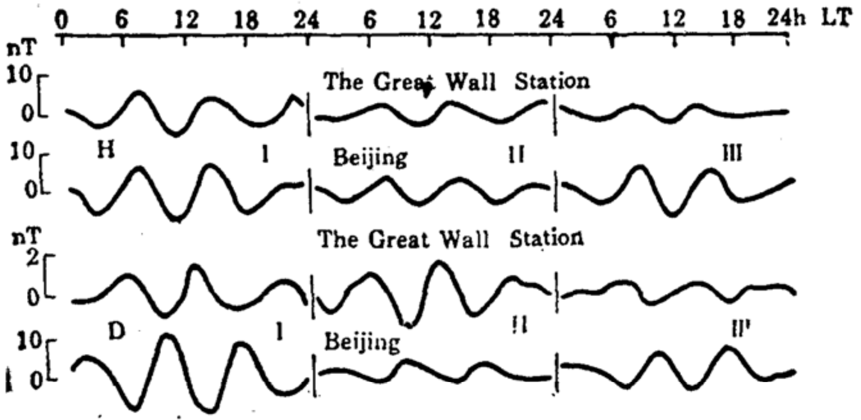

Fig. 5. Curves of S_q^D variation of disturbed geomagnetic field in geomagnetic quiet days.

The vectors of S_q^D variation of horizontally disturbed geomagnetic field in the geomagnetic quiet days are shown in Fig. 6. It can be seen in the Fig. 6 that the vectors of horizontal disturbance of geomagnetic field for data groups I, II and III are approximately the same at both CGWS and BJO observatories. But they are larger at BJO than those at CGWS.

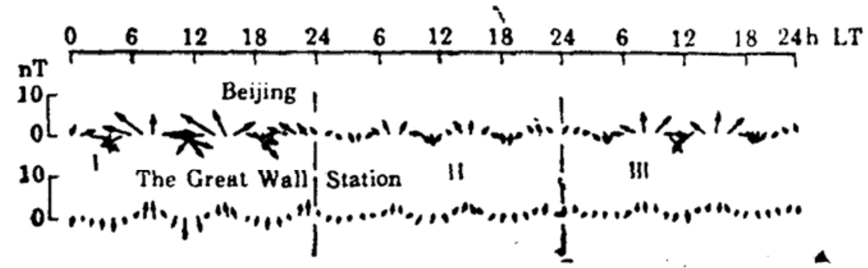

Fig. 6. Vectors of horizontally disturbed geomagnetic field (S_q^D in geomagnetic quiet days.

The distribution of vectors of disturbed S_q^D-equivalent current at different magnetic latitudes in geomagnetic quiet days is shown in Fig. 7. It is clearly seen in Fig. 7-I and Fig. 7-III that the vectors of disturbed S_q^D at BJO point to the polar region or equatorrial region, but the vectors at CGWS are clockwise or counter-clockwise along the magnetic latitude. The disturbed S_q^D-equivalent current intensity at BJO reaches a maximum at 15^h, I≈7A/km, and a minimum at O^h, I≈2A / km, for data group I. It is maximum at 11^h, I≈5A / km, and minimum

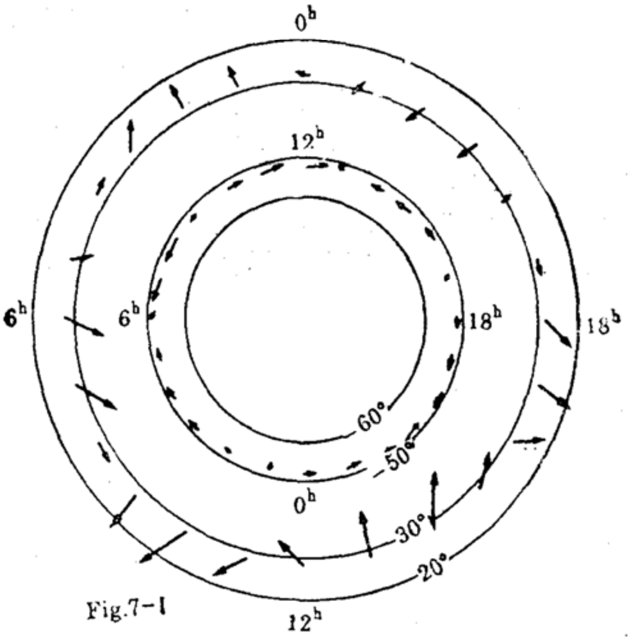

Fig.7-I

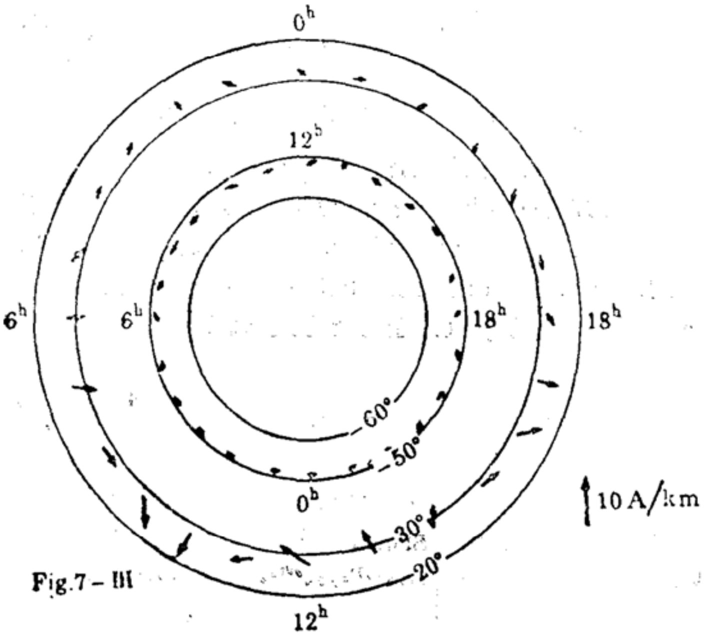

Fig.7-III

Fig. 7 Distribution of vectors of horizontally disturbed geomagnetic field (S_q^D) in geomagnetic quiet days.

at 2^h, $I \approx 2A/km$, for data group III, i.e. in midwinter at BJO. The S_q^D-equivalent current intensity at CGWS reaches a maximum at 11^h, $I \approx 5.5A/km$, and a minimum at 1^h, $I \approx 0.5 A/km$ for data group I and a maximum at 11^h, $I \approx 2.5A/km$, and a minimum at 2^h, $I \approx 0.1 A/km$, for data group III, i.e. in midwinter at CGWS.

It follows that the patterns of S_q^D variation are similar at both observatories. The disturbed S_q^D-equivalent current intensity at CGWS is similar to that at BJO, and it is weak either in the daytime or in the night.

3. Results

3.1. Comparing the curves for data groups I and II in Fig. 1 and Fig. 5, we can find that the pattern of S_q variation in geomagnetic quiet days at CGWS is similar to that at BJO. The S_q variation at both observatories may be controlled by the midlatitudinal dynamo currents. The diurnal S_q variation is present in the form of third or higher harmonics due to the decreased effect of solar ultraviolet radiation.

3.2. As it is shown in Fig. 4 and 7 that the S_q^o- and S_q^D-equivalent current intensity is Larger in the daytime than in the night for data group I at both observatories, but it is very weak at CGWS in the daytime and night in midwinter due to the relative weak effect of the ionospheric current and dominant geomagnetic disturbance at high latitudes.

Therefore, the diurnal S_q variation is mainly present in the harmonics in eight hour or shorter periods. The orientation of vectors of S_q-equivalent current is different in early, maddle and late winter. which may be caused by the ionospheric current and field-aligned current in polar region. The available data for this consideration are limited, so it is necessary to make further obverservation and research.

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