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# Analytical comparison of geomagnetic total field between Sino-US stations*

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**Abstract**

Using observational data of geomagnetic total intensity from 13 stations in the Beijing—Tianjin region, 3 stations in the western Yunnan region of China, and 6 stations in California of U. S. A., the daily variations and their spectra of geomagnetic total intensity were analyzed and compared. The results show that the morphology, the range and spectrum of daily variations in geomagnetic total intensity are basically the same within the local extent of 100—200 km and are different in the large extent of 500 km. The latitude factor of the daily variation range of geomagnetic total intensity is about 1—2 nT/degree within the latitude extent of 25°—40°.

**Key words**: geomagnetic total intensity, geomagnetic daily variation and its spectrum, Beijing—Tianjin area and western Yunnan area in China, California in U. S. A.

## Introduction

The proton precession magnetometer has characters of high accuracy, good stability, convenient operation and so on, and is a good instrument for geomagnetic and seismomagnetic observations (Zhou, 1986). At present, the networks installed up mainly with proton precession magnetometers for observing geomagnetic total intensity are set up in earthquake prediction experimental sites both at home and abroad, and an amount of significant seismomagnetic results have been obtained (Zhan, 1989; Mueller *et al.*, 1981; Johnston, 1987; Shapiro and Abdullabekov, 1982; Rikitake *et al.*, 1980).

Geomagnetic daily variation is one of the important subjects in geomagnetism (Matsushita and Campbell, 1967; Fu *et al.*, 1985). Most of the research on geomagnetic daily variations in the past was to analyse geomagnetic component data recorded at the observatories. Using the data of geomagnetic total intensity in the networks of seismomagnetic observation in the Beijing—Tianjin area and western Yunnan area of China, and in California of U. S. A., this paper analyzes and compares the morphology, daily range and spectrum of daily variations of the geomagnetic total intensity from these regions.

## Observation data

According to the Scientific and Technological Agreement for Sino-U. S. Cooperation of Earthquake Research, geomagnetic observation networks have been set up in the Beijing—Tianjin area and western Yunnan area of China to do cooperative investigation using proton precession magnetometers provided by U. S. Geological Survey in order to research tectonomagnetic effect and earthquake pre-

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diction by geomagnetic approach (Zhan and Lin, 1985).

Figure 1 shows the locations of 6 magnetometer stations in California, U. S. A. The 6 stations are part of geomagnetic network set up by the U. S. Geological Survey along the San Andreas Fault. The network has played an important role in investigation of tectonomagnetic effects (Johnston, 1989). The 5 stations in the northwest part of Figure 1 are located in the earthquake prediction experimental site at Parkfield, California; the distance between adjacent stations is 5—10 km. The OC station given in Figure 1 is about 450 km from the Parkfield area. All these stations use the proton precession magnetometers improved by U. S. Geological Survey. Geomagnetic total intensity is synchronously observed every 10 min. The accuracy of the synchronous time is within 0. 1 second, and the measurement accuracy is 0. 2 nT.

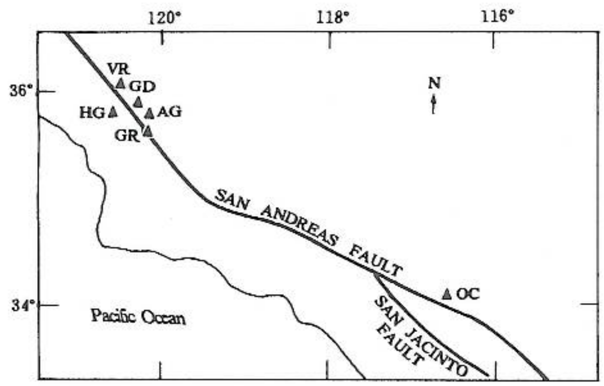


Figure 1 Locations of 6 magnetometer stations in California, U. S. A. used in this paper.

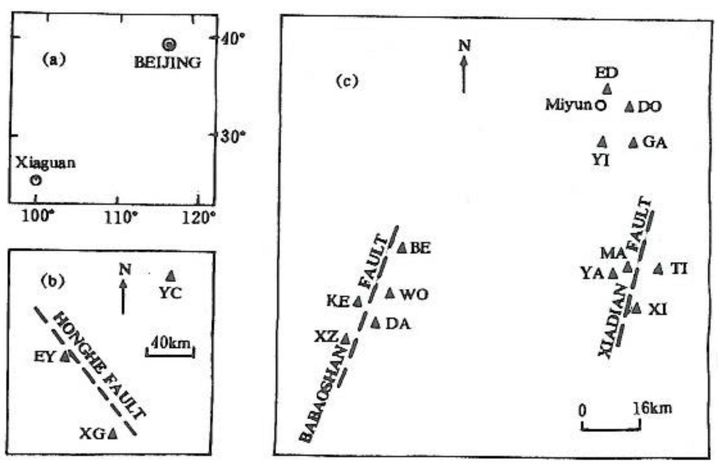


Figure 2 Locations of magnetometer stations in western Yunnan and Beijing—Tianjin areas. (a) Geographical locations of Beijing and Xiaguan. (b) Locations of 3 stations in western Yunnan area. (c) Locations of 13 stations in Beijing—Tianjin area.

Figure 2 shows the locations of 3 magnetometer stations in western Yunnan area (Xiaguan and its adjacent area) and 13 ones in Beijing — Tianjin area (Beijing neighbouring area) of China. The recording magnetometers provided by the U. S. Geological Survey are used to observe geomagnetic total intensity at these locations. The sensitivity of the magnetometers is 0. 25 nT and the accuracy is 1.0 nT. They have the automatic recording printers. At the 3 stations in western Yunnan area geomagnetic total intensity was sampled synchronously every 5 min. The 13 stations in Beijing—Tianjin area are in the center station and three small local networks near the Babaoshan fault, Xiadian fault and in the Miyun area; the geomagnetic total intensity is observed once every season; geomagnetic total intensity at the 4 magnetometer stations in various small local networks and the center station BE is recorded synchronously once every 2 min for period of 3—5 days during each observation.

For convenience of comparative analysis, universal time ( UT ) is used in this paper. All data of the geomagnetic total intensity used in this paper are synchronous observation values with every 10 min sample at various stations.

## Comparison of daily variations in geomagnetic total intensity

Figure 3 shows the variations in geomagnetic total intensity at various stations during March 1—10, 1988. The geographical locations of these stations are given in Figure 1 and Figure 2. From the view point of the variation morphology, the variations of geomagnetic total intensity at 6 stations in California, U. S. A. (Figure 3a) are quite consistent. The daily variations have the same regularities, showing V-shape variations. The variations of geomagnetic total intensity at 3 stations in western Yunnan area of China are also consistent. By comparing the variation shape of geomagnetic total intensity in these 2 areas shown in Figure 3, it can be seen that the difference is quite obvious. During this period, the regularity of daily variation shape in geomagnetic total intensity in California, U. S. A. is more obvious, but the daily variation shape is characterized by random in western Yunnan area of China. The western Yunnan area in China is at a low latitude area, about 26°N. The randomness in daily variations of geomagnetic total intensity in western Yunnan area may be related to the influence of the equatorial electrojet current.

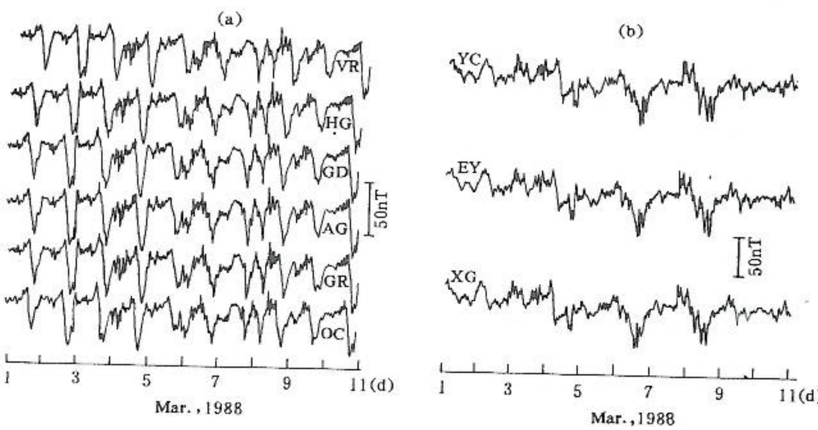


Figure 3 Variations of geomagnetic total intensity at various stations in California, U. S. A. (a), and in western Yunnan area, China during March 1—10, 1988 (b).

Table 1 shows the comparison of the range $\Delta F$, high-point time $HT$ and low-point time $LT$ in daily variations of geomagnetic total intensity at the various stations on March 1, 4 and 8 of 1988. It can be seen in Table 1 that on the same day the $\Delta F$, $HT$ and $LT$ are nearly the same at the 13 stations located in the Beijing—Tianjin area; that at the 3 stations in the western Yunnan area are roughly same, but some of them exists difference. Among the 6 stations in California, U. S. A., the $\Delta F$, $HT$ and $LT$

at the 5 stations in the Parkfield area are identical, but differ from the OC station, where $HT$ and $LT$ have some leading time and $\Delta F$ is smaller. The difference of $\Delta F$, $HT$ and $LT$ in the 3 areas is obvious.

**Table 1 Comparison of the range $\Delta F$ (nT), high-point time $HT$ and low-point time $LT$ (UT) in daily variations of geomagnetic total intensity at various stations on March 1, 4 and 8, 1988**

| Area | | Beijing—Tianjin, China | | | | | Western Yunnan, China | | | California, U. S. A. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Station | DO | ED | GA | YI | BE | YC | EY | XG | VR | HG | GD | AG | GR | OC |
| 1 | $\Delta F$ | 29.5 | 28.5 | 29.3 | 30.3 | 32.5 | 25.5 | 25.3 | 25.0 | 45.3 | 43.8 | 44.6 | 44.4 | 43.5 | 37.8 |
| | $HT$ | 0000 | 0010 | 0000 | 0010 | 0010 | 1940 | 1940 | 1940 | 1550 | 1510 | 1510 | 1510 | 1530 | 1430 |
| | $LT$ | 0500 | 0510 | 0500 | 0500 | 0500 | 1110 | 0930 | 1200 | 1920 | 1910 | 1910 | 1910 | 1900 | 1820 |
| | Station | KE | WO | DA | XZ | | | | | | | | | | |
| 4 | $\Delta F$ | 43.8 | 44.3 | 44.3 | 44.3 | 46.5 | 37.0 | 35.0 | 35.0 | 55.3 | 54.8 | 54.4 | 54.3 | 54.8 | 48.5 |
| | $HT$ | 0010 | 0010 | 0010 | 0010 | 0000 | 2300 | 2300 | 2300 | 1540 | 1540 | 1540 | 1540 | 1540 | 1430 |
| | $LT$ | 0710 | 0710 | 0710 | 0710 | 0710 | 0410 | 0340 | 0510 | 2010 | 2010 | 2010 | 1950 | 1950 | 1910 |
| | Station | TI | MA | YA | XI | | | | | | | | | | |
| 8 | $\Delta F$ | 53.0 | 53.3 | 52.8 | 52.8 | 55.5 | 33.0 | 35.0 | 38.5 | 56.3 | 54.3 | 54.1 | 53.9 | 54.5 | 49.8 |
| | $HT$ | 0040 | 0040 | 0040 | 0040 | 0040 | 0210 | 0350 | 0350 | 1020 | 1030 | 1020 | 1020 | 1020 | 1030 |
| | $LT$ | 0540 | 0540 | 0540 | 0540 | 0540 | 0940 | 0930 | 0930 | 2000 | 1950 | 1950 | 1950 | 1950 | 1950 |

Table 2 is comparison of the mean values of the range $\Delta F$, high-point time $HT$ and and low-point time $LT$ in daily variations of geomagnetic total intensity at various stations for all days, quiet days and disturbed days during January—March, 1988. It can be seen in Table 2 that $\Delta F$ and its standard deviation on disturbed days at the same station are the largest, $\Delta F$ and its standard deviation on quiet days are the smallest. The $\Delta F$, $HT$ and $LT$ of five stations in Parkfield area, USA are quite identical; but $\Delta F$ at OC station is smaller, $LT$ has a leading time. The $\Delta F$ at the three stations in west Yunnan area in China is comparatively identical, there exist some differences in $HT$ and $LT$. Comparing the data in Table 2, $\Delta F$ at stations in California, USA is larger than that in west Yunnan area, China for all days and quiet days, but $\Delta F$ is smaller than that in west Yunnan area, China for disturbed days.

**Table 2 Comparison of mean values of the range $\Delta F$ and standard deviation $\sigma$ (nT), high-point time $HT$ and low-point time $LT$ (UT) in daily variations of geomagnetic total intensity at various stations on all days(AD), quiet days(QD) and disturbed days(DD) during January—March, 1988**

| Area | California, U. S. A. | | | | | | Western Yunnan area | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | VR | HG | GD | AG | GR | OC | YC | EY | XG |
| AD $\Delta F$ | 46.9 | 47.5 | 45.4 | 46.3 | 46.8 | 43.1 | 42.7 | 43.4 | 45.0 |
| $\sigma$ | 19.1 | 20.0 | 18.7 | 18.6 | 19.1 | 17.8 | 27.2 | 27.9 | 28.7 |
| QD $\Delta F$ | 37.6 | 37.2 | 37.2 | 37.2 | 37.7 | 32.8 | 20.3 | 21.3 | 21.9 |
| $\sigma$ | 7.7 | 7.6 | 7.8 | 7.7 | 8.7 | 7.2 | 4.0 | 4.4 | 5.1 |
| DD $\Delta F$ | 75.2 | 78.3 | 73.6 | 73.5 | 74.9 | 69.9 | 85.8 | 87.1 | 89.8 |
| $\sigma$ | 26.6 | 27.5 | 26.3 | 26.0 | 26.7 | 24.0 | 33.8 | 35.1 | 36.4 |
| $HT$ | | | | | | | | | |
| AD | 1900 | 1859 | 1905 | 1907 | 1853 | 1840 | 1106 | 1147 | 1139 |
| QD | 1859 | 1857 | 1858 | 1859 | 1856 | 1844 | 1150 | 1152 | 1150 |
| DD | 1347 | 1341 | 1335 | 1335 | 1334 | 1252 | 1231 | 1352 | 1407 |
| $LT$ | | | | | | | | | |
| AD | 1248 | 1247 | 1247 | 1302 | 1259 | 1323 | 0939 | 0934 | 0939 |
| QD | 1216 | 1255 | 1213 | 1424 | 1324 | 1513 | 1125 | 0936 | 1125 |
| DD | 0940 | 0941 | 0938 | 0941 | 0941 | 0941 | 0622 | 0446 | 0622 |

Comparing the results in Table 2 and the geographical locations of various stations, it can be seen that the daily variation range $\Delta F$ of geomagnetic total intensity for quiet days is related to the latitude of the station. By analysing the data in this paper, the change factor of daily variation range $\Delta F$ of geomagnetic total intensity with latitude can be approximately obtained and listed in Table 3. It can be seen in Table 3 that the change factor of the range in daily variation of geomagnetic total intensity with latitude is about 1—2 nT/degree within the latitude extent of 25—40° studied in this paper.

**Table 3 Change factor $\alpha$ of quiet day variation range of geomagnetic total intensity with latitude**

| Comparing stations | California | California—West Yunnan | BE—XG |
|---|---|---|---|
| $\alpha$(nT/degree) | 2.3 | 1.6 | 0.9 |

Figure 4 shows the frequency distribution of high-point time *HT*(a) and low-point time *LT*(b) in daily variation of geomagnetic total intensity at VR, OC, XG stations during January—March, 1988 with universal time (UT). The frequency distribution of *HT* and *LT* at other 4 stations in California, U. S. A. is fairly the same as that at VR station; that at other 2 stations in western Yunnan area of China is basically the same as that at XG station. It can be seen that *HT* and *LT* frequency distributions with UT time at VR and OC stations in California, U. S. A. relatively concentrate; the *HT* peak value is at 15—17h UT, the *LT* one is at 19—21h UT. The *HT* and *LT* frequency distributions with UT time at XG station in western Yunnan area relatively scatter; the *HT* peak value is at 01—03h UT, the *LT* one is at 09—11h UT. Comparing the above frequency distribution at the stations in California, U. S. A. and in western Yunnan area, the difference of the *HT* peak values is about 14 h, and the difference of the *LT* peak values is about 10 h. In statistical sense, the difference of high-point time and low-point time in daily variation of geomagnetic total intensity is mainly caused by the longitude distribution of stations.

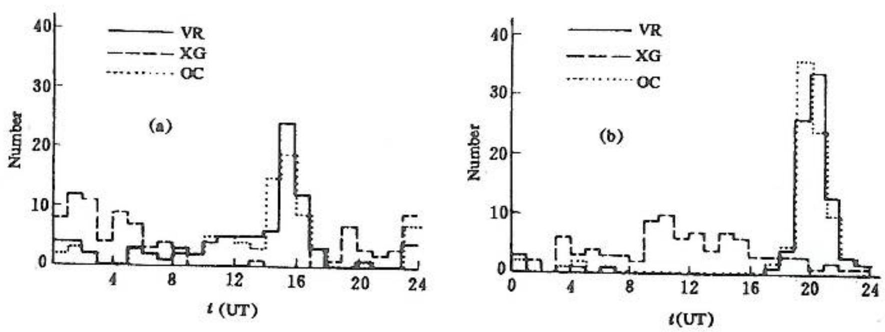


Figure 4 Frequency distribution of high-point time *HT*(a) and low-point time *LT*(b) in daily variation of geomagnetic total intensity at VR, OC and XG stations during January—March, 1988 with universal time(UT).

## Spectral comparison of daily variations in geomagnetic total intensity

In order to compare the spectra of daily variations of geomagnetic total intensity at various stations, the harmonic analysis was done for the daily observation data of geomagnetic total intensity at various stations during January—March, 1988 in the present paper, and the results are shown in Table 4 and Figure 5. It can be seen from Table 4 and Figure 5 that the spectral amplitude of daily variations of geomagnetic total intensity at the same station has decrease tendency when the period decreases; the spectral amplitudes with the same period at various stations in the local region are fairly consistent. The spectral amplitudes at various stations in different areas exist greater difference.

**Table 4 Comparison in spectral amplitudes of daily variations of geomagnetic total intensity at various stations on March 1, 1988 (unit: nT)**

| Period (h) | Area | California, U. S. A. | | | | | | Western Yunnan | | | Beijing—Tianjin, China | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Station | VR | HG | GD | AG | GR | OC | YC | EY | XG | BE | DO | ED | GA | YI |
| 24 | | 8.7 | 8.5 | 8.7 | 8.8 | 8.6 | 7.0 | 8.7 | 8.5 | 9.8 | 5.6 | 5.8 | 5.6 | 5.8 | 5.9 |
| 12 | | 10.0 | 9.6 | 10.0 | 9.8 | 9.8 | 7.5 | 5.4 | 5.4 | 6.4 | 4.5 | 4.1 | 4.0 | 4.1 | 4.3 |
| 8 | | 6.0 | 5.8 | 6.0 | 6.0 | 5.9 | 5.2 | 2.9 | 2.3 | 2.3 | 5.0 | 5.0 | 4.9 | 5.0 | 5.1 |
| 3.0 | | 3.0 | 2.8 | 2.9 | 3.0 | 2.8 | 2.5 | 1.4 | 0.9 | 1.3 | 1.7 | 1.7 | 1.7 | 1.7 | 1.8 |
| 4 | | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.9 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 |
| 3 | | 0.7 | 0.6 | 0.6 | 0.6 | 0.6 | 0.3 | 0.9 | 0.7 | 0.9 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 |

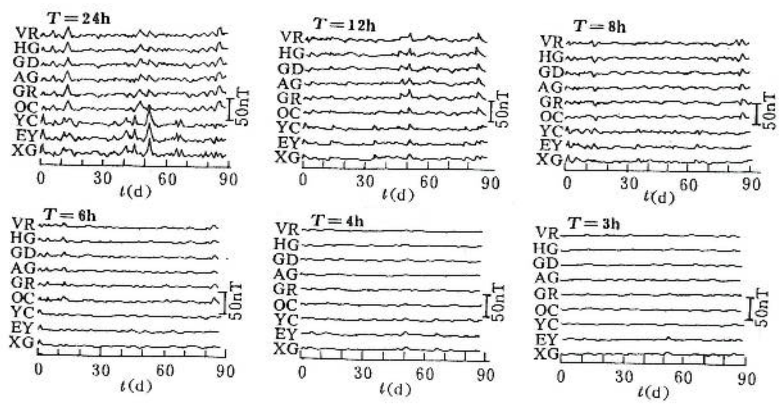


Figure 5 Daily changes in spectral amplitudes of daily variations of geomagnetic total intensity at various stations during January—March, 1988.

**Table 5 Comparison in spectral amplitude means of daily variations of geomagnetic total intensity at various stations for all days (AD), quiet days (QD) and disturbed days (DD) during January—March, 1988 (unit: nT)**

| Period(h) | | 24 | 12 | 8 | 6 | 4 | 3 |
|---|---|---|---|---|---|---|---|
| Days | Station | | | | | | |
| AD | VR | 10.1±5.1 | 8.7±3.4 | 5.6±2.3 | 2.7±1.6 | 1.3±0.9 | 1.1±0.8 |
| | OC | 9.5±4.9 | 7.8±3.4 | 5.0±2.2 | 2.5±1.8 | 1.3±0.9 | 1.0±0.8 |
| | XG | 9.5±6.7 | 5.0±3.6 | 3.9±2.8 | 2.7±1.9 | 1.8±1.4 | 1.3±1.1 |
| QD | VR | 8.7±3.0 | 8.4±2.1 | 5.3±1.3 | 2.1±1.0 | 0.9±0.6 | 0.6±0.3 |
| | OC | 7.7±2.7 | 7.2±2.0 | 4.6±1.3 | 1.9±0.8 | 0.7±0.5 | 0.5±0.3 |
| | XG | 6.3±2.1 | 2.5±1.6 | 2.2±0.9 | 1.6±0.8 | 0.7±0.4 | 0.6±0.3 |
| DD | VR | 15.4±7.3 | 9.9±5.5 | 6.4±3.5 | 4.1±2.5 | 2.6±0.9 | 2.0±1.2 |
| | OC | 14.9±7.4 | 9.2±5.8 | 6.2±3.4 | 4.2±3.1 | 2.3±0.8 | 1.9±1.0 |
| | XG | 15.3±11.4 | 9.5±5.0 | 6.8±4.2 | 4.6±3.2 | 3.4±1.8 | 2.3±1.5 |

Table 5 lists the mean values of spectral amplitudes for daily variations of geomagnetic total intensity at only 3 stations of VR, OC and XG ones during January—March, 1988, because the spectra of daily variations of geomagnetic total intensity at various stations are fairly consistent within a local region. It can be seen from Table 5 that the spectral amplitude decreases when the period decreases.

There is difference in the spectral amplitudes at various stations. For quiet days the spectral amplitude is smaller at the station with lower latitude at the same period ( except for $T=3$ h and 4 h). It agrees with the above result.

## Conclusion

1. It is clear from the above analytical comparison that the morphology, range, high-point time and low-point time in daily variations of geomagnetic total intensity at various stations are basically the same within the local extent of 100—200 km and are different in the large extent of >500 km. Roughly speaking, the range difference in the daily variations of geomagnetic total intensity at various stations correlates with the station latitude. The latitude change factor is about 1—2 nT/degree within the latitude extent of 25—40° N studied in this paper. The difference in high-point time and low-point times during quiet daily variations of geomagnetic total intensity at various stations correlates with the station longitude. It is mainly caused by the time-space change character of geomagnetic $S_q$ field.

2. The result of spectral analysis shows that the spectral amplitude has decrease tendency when the period decreases. The spectra of daily variations of geomagnetic total intensity at various stations are basically the same within the local extent and are different in the large extent.

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