THE ANTHROPOGENIC FACTOR IN THE VARIATIONS OF MAGNETIC FIELD

O.D. Zotov

Geophysical Observatory Borok, IPE, RAS, Borok, Russia, e-mail: ozotov@inbox.ru

Abstract. This research addresses to the problem of synchronism in geospheres under the influences of technosphere. The report deals with the problem of human impact on the magnetospheric processes. The attention is focused on the statistical analysis of the long-term observations to study the so-called Big Ben effects (clock pulse effect), which are the 60- and 30-minutes modulation of the Ipdp electromagnetic waves activity (frequency band is 0.1 – 5 Hz) and the slow magnetic field variations (quasi-periods are tens minutes). It is supposed that such effects are evidently of the human origin. The ample data on the magnetospheric Ipdp waves and Earth's magnetic field accumulated in the catalogs are examined. The synchronous detection method in the form of the superposition epoch analysis has been used. The main conclusion is that the Big Ben effects is the real geophysical phenomena, and evidently human in origin. These effects indicate that there is some nontrivial impact caused by industrial activity on the natural processes in the magnetosphere.

DATA. For the study were used long series of data (long-term observations) in catalogs:

Catalog of earthquakes by International Seismological Centre (ISC), 1964-2003 http://www.isc.ac.uk
Catalog of earthquakes by National Earthquake Information Centre (the U.S. Geological Survey, USGS/NEIC), 1973–2007, http://neic.usgs.gov/neis/epic/epic_global.html.
Catalog of Pc1 ‘‘pearls’’ geomagnetic pulsations observed at Borok geophysical observatory, 1958–1992 (by Matveyeva, E.T.). http://www.wdcb.ru/stp/data/catal_pc/
Catalog of Ipdp geomagnetic pulsations observed at Borok geophysical observatory, 1957–1992 (by Matveyeva, E.T.). http://www.wdcb.ru/stp/data/catal_ipdp/
Catalog of electric power consumption for different regions of USA, 2006-2009, http://www.nyiso.com
Catalog of lightnings, registered by LDAR-system (Kennedy Space Center, Canaveral), 2007, http://ghrc.nsstc.nasa.gov
Catalogs minute values of the components of the geomagnetic field at observatories in Borok (58.03N, 38.97E), Irkutsk (52.20N, 104.14E) and Moscow (55.48N, 37.31E), http://www.wdcb.ru/stp/data/geo_min.val
Catalog minute values of the indices SYM-H, ASY-H, Kyoto (35.02N, 135.75E), WDC C2, http://swdcwww.kugi.kyoto-u.ac.jp/index.html

METHOD. The synchronous detection method analysis has been used. Method is effective way to detect a weak periodic signal on a background of noise.

This research addresses to the effects of synchronism in geospheres under the influences of technosphere, in particular - to the anthropogenic influence on the magnetospheric phenomena. First of all show a short introduction about results and effects which were found previously.

ANTHROPOGENIC PERIODICITIES IN DIFFERENT GEOSPHERES. As a result of the analysis were found the so-called weekend effect, or, more generally, a specific weekly cycle (septan variation) in the magnetosphere [Guglielmi and Zotov, 2007] (Pc1 wave activity) and lithosphere [Zotov, 2007] (global seismic activity). Fig. 1 shows these periodicities. The period of synchronous detection (epoch duration) is 7 days. The number of events means the number of Pc1 series onsets (left) and number of earthquakes (right). It is supposed that such effects are evident of human origin.

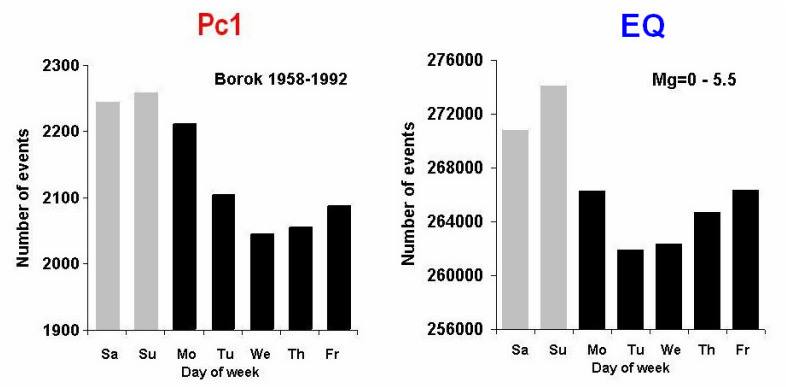

Fig. 1. Weekend effect in the Pc1 wave (obs. Borok 1958-1992) and seismic activity EQ (catalog ISC, 1964-2003). Number of one week intervals is ~1800 for Pc1 and ~2000 for EQ. The sign **Sa** and **Su** denotes Saturday and Sunday and the vertical gray columns indicate the weekend.

Also were found Big Ben Effect (or clock pulse effect) in geoelectromagnetic waves activity. Which attributes the Big Ben effect in natural dynamics of different parameters of geospheres? When we find a periodicity synchronized with the hour marks and its period is equal to or a multiple of the duration of one hour, then we assume that such effects are evident of human origin and that is the Big Ben effect. Fig. 2 shows the 15-minutes modulation of the Pc1 geoelectromagnetic waves activity (see the paper [Guglielmi and Zotov, 2010] for the more detail).

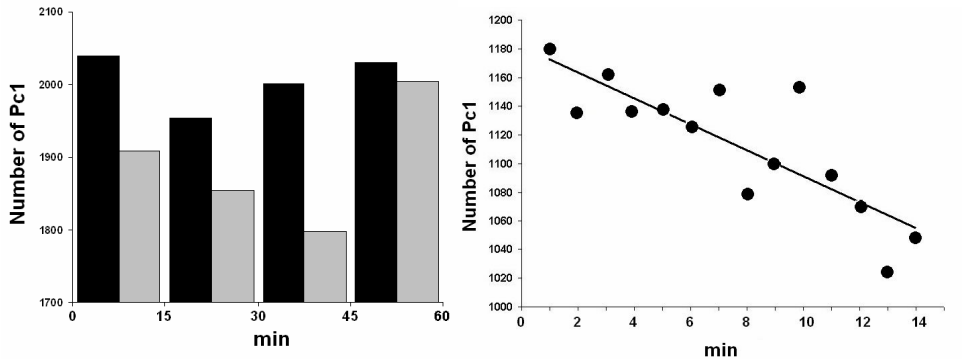

Fig. 2. 15-minutes modulation of the Pc1 geoelectromagnetic waves activity. The period of synchronous detection (epoch duration) is 60 minutes (left) and 15 minutes (right)

Big Ben Effect was found in seismic activity. The Fig. 3 (left) gives the idea of these effects - 15-minutes modulation of the seismic activity [Zotov and Guglielmi, 2009]. The period of synchronous detection (epoch duration) is 60 minutes.

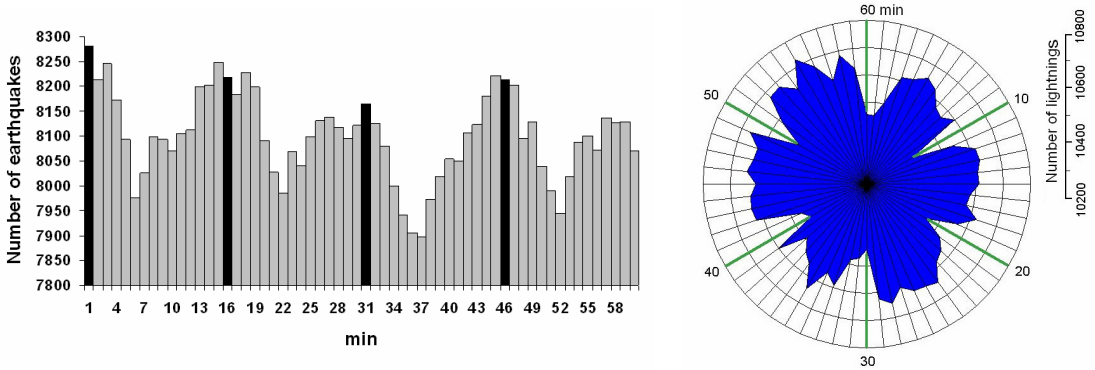

Fig. 3. 15-minutes modulation of the seismic activity (500 000 earthquakes, catalog USGS, left) and 10-minutes modulation of lightnings (6500000 lightnings with height H < 1000 m, analyzed only days of weak thunderstorm activity, catalog of lightnings registered by LDAR-system)

Big Ben Effect was found in thunderstorm activity. Fig. 3 (right) shows the modulation of the lightning activity with a period of 10 minutes. We clearly see a variation with six deep minima, which coincide with the 10-minute marks [Zotov and Guglielmi, 2009].

PERIODICITIES IN TECHNOSPHERE. Fig. 4 shows weekend effect in the chemical (a, left) and nuclear (b, left) explosions (catalog ISC) [Zotov, 2007] and in the power consumption (right, catalog NYISO) [Zotov and Guglielmi, 2009].

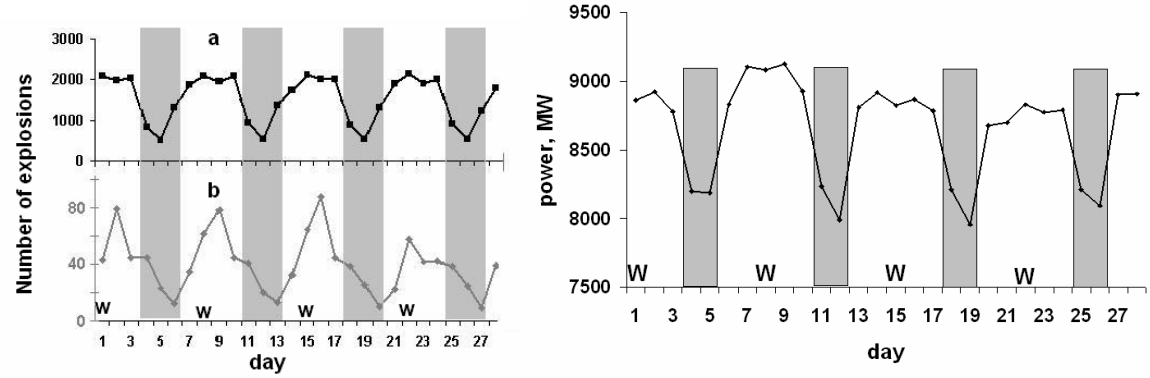

Fig. 4. Weekend effect in anthropogenic seismic events (left), namely, chemical explosion (a, the black line, 40 000 events, catalog ISC) and the nuclear explosions (b, the gray line, 1100 events, catalog ISC), the number of four-week intervals is 500, the number of events is plotted on the vertical axis; weekend effect in power consumption (right, catalog NYISO). The synchronous detection interval of 28 days plotted on the horizontal axis (the first day is Wednesday).The gray vertical columns indicate the weekends.

The seven-day modulation of anthropogenic seismic activity and power consumption is clearly seen for both groups of events.

Fig. 5 shows Big Ben Effect in the chemical explosions (left, catalog ISC) and Big Ben Effect in the power consumption (catalog NYISO) [Zotov and Guglielmi, 2009].

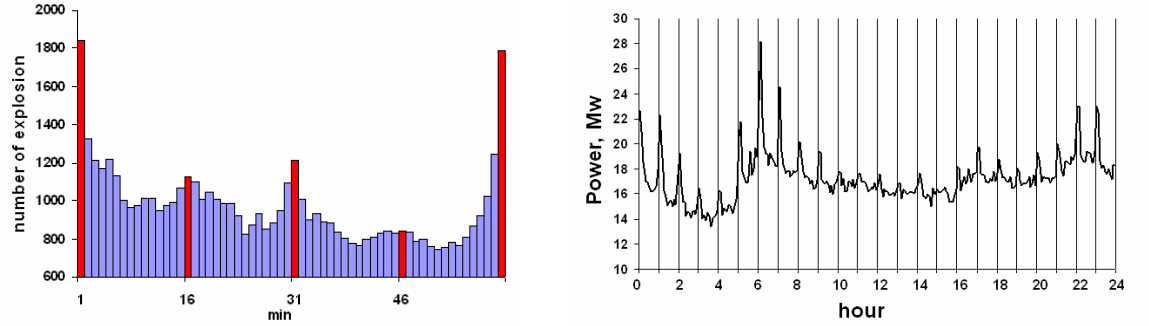

Fig. 5. 15-minutes modulation of the chemical explosion (left, catalog ISC) and hour modulation of the power consumption (right, catalog NYISO).

ANTHROPOGENIC PERIODICITIES IN MAGNETOSPHERE. So, in the magnetosphere and lithosphere we find the variations with periods of technosphere and we assume that there are effects of synchronism in geospheres under the influence of technosphere. Thus we have many reasons for the search of similar effects in other characteristics of the geospheres. Results of this study are the new effects of the human impact on the magnetosphere.

Big Ben effect in Ipdp electromagnetic waves activity (frequency band is 0.1 – 5 Hz). Figure 6 (left) shows the example of Ipdp geomagnetic pulsations (obs. Borok). Figure 6 (right) shows the distribution of the beginning Ipdp pulsations in the four 15-minute intervals on the period accumulation of 60 minutes (catalog Ipdp, obs. Borok, 1957- 1992). We clearly see the hour and half-hour variations in activity of Ipdp.

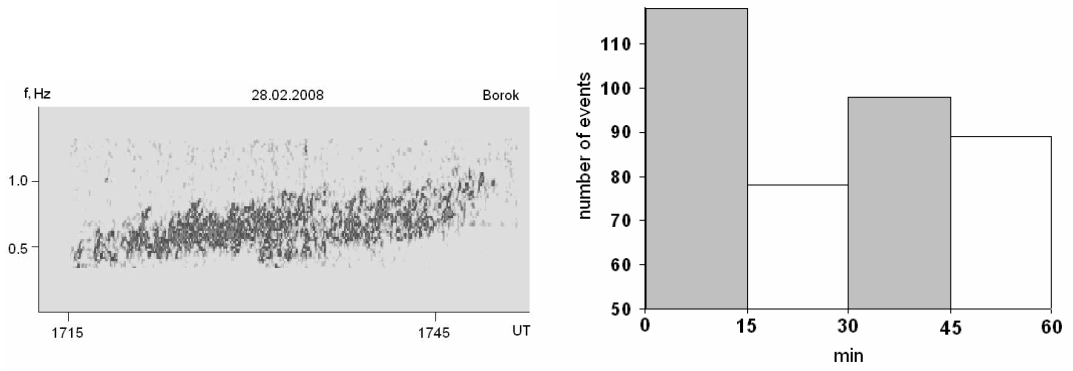

Fig. 6. The example of Ipdp geomagnetic pulsation (left) and the half-hour variation in activity of Ipdp (right) obtained by using the data of Ipdp catalog (obs. Borok).

Big Ben Effect in the slow magnetic field variations by data obs. Moscow. In Fig. 7 (left) present the results of synchronous accumulation of minute values of the Z-components of the geomagnetic field. We see the average half-hour variation of the vertical component of the magnetic field. The period of synchronous detection (epoch duration) is 180 minutes (six periods of 30 minutes). Analyzed the absolute value of the derivative of original data (period from 2001 to 2005). In Fig. 7 (right) present the dynamics of the accumulated amplitude of variation at different periods of synchronous detection. We see when the period of synchronous detection is 180 minutes the accumulated amplitude of variation is proportional to the number of superpositions. But when the period of synchronous detection is 174 minutes (six periods of 29 minutes) or 186 minutes (six periods of 31 minutes) the accumulated amplitude of variation is proportional to the square root of the number of superpositions. It is a proof that 30 min periodicity is real effect.

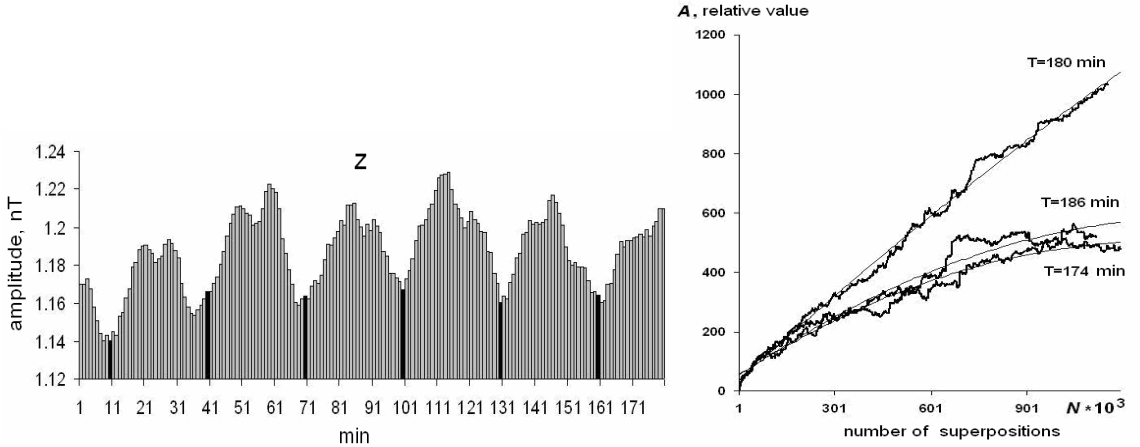

Fig. 7. Big Ben Effect (half-hour variation) in the slow magnetic field variations at obs. Moscow.

Big-Ben effect in the slow magnetic field variations by data obs. Irkutsk. Fig. 8 shows the average hourly variation of the D, H, and Z-components of the geomagnetic field variations (1996-1997). The period of synchronous detection (epoch duration) is 60 minutes. Analyzed the absolute values of the derivative of original data (period from 1996 to 1997).

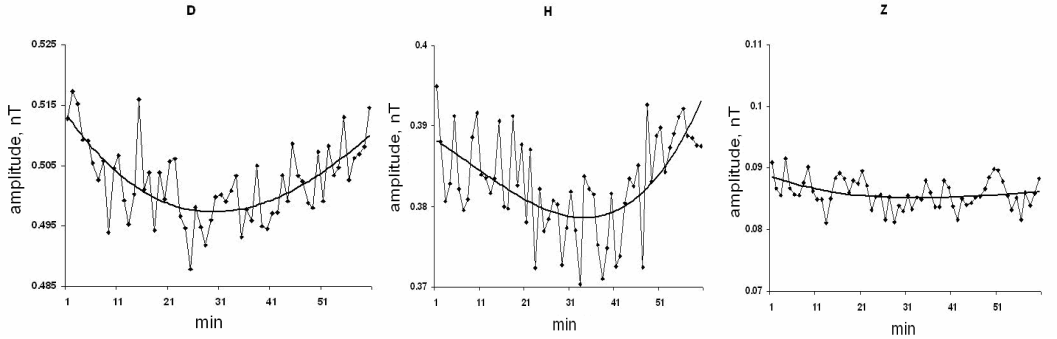

Fig. 8. Big-Ben effect (hour variation) in the slow magnetic field variations at obs. Irkutsk

Big-ben effect in the slow magnetic field variations by data obs. Kioto and obs. Borok. Fig. 9 shows the effect of time marks in the average variations of the indices H-SYM and H-ASY (the indices were created by WDC C2 for Geomagnetism, Kioto, used data 1984-1990 y.) and the components of the magnetic field (Borok, 2004-2005). The period of synchronous detection (epoch duration) is 180 minutes. Analyzed the absolute values of the derivative of original data.

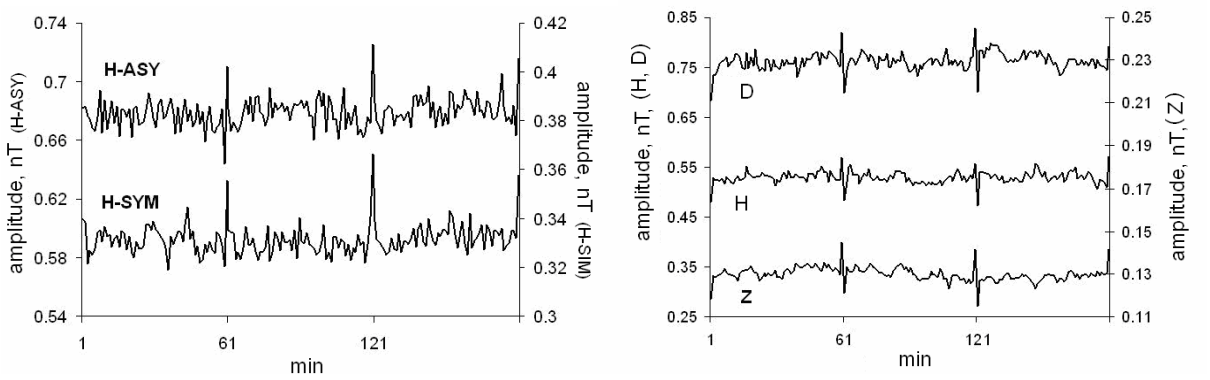

Fig. 9. Big-Ben Effect (hour variation) in the slow magnetic field variations at obs. Kioto (left) and obs. Borok (right).

CONCLUSION

- The main conclusion is that the Big Ben effects is the real geophysical phenomena, and evidently human in origin. These effects indicate that there is some nontrivial impact caused by industrial activity on the natural processes in the magnetosphere.
- We are still far from understanding the physical mechanisms of this interesting phenomenon.
- Particularly we can not answer the question about nature of these effects in slow magnetic field variations. What is it - direct or an indirect influence the industrial activity on the variation of magnetic field?

Acknowledgments. I will like to thank A.V. Guglielmi, B.I. Klain and A.S. Potapov for the valuable discussions. The work was supported by RFBR grants 09-05-00048, 10-05-00661 and Presidium of the Russian Academy of Sciences (Program 16).

REFERENCES

Guglielmi A., Zotov O. The human impact on the Pc1 wave activity // *Journal of Atmospheric and Solar-Terrestrial Physics.* 2007. V. 69. P. 1753–1758.

Zotov O.D. Weekend Effect in Seismic Activity // *Izvestiya, Physics of the Solid Earth*, 2007, Vol. 43, No. 12, P. 1005–1011.

Guglielmi A.V., Zotov O.D. 15-minutes modulation of the Pc1 geoelectromagnetic waves // *Geophysical Research,* 2010, Vol. 10, No.1, P. 64-71 (in Russian).

Zotov O.D., Guglielmi A.V. The problems of synchronism of electromagnetic and seismic events in the magnetosphere–technosphere–lithosphere dynamic system // *Solar and Terrestrial Physics*, v. 16, 2009, c 3-9 (in Russian).