Shift of the Earth's magnetic pole: how it will influence on technosphere and bioshere

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It is well known that magnetic storms negatively influenced on biosphere and technosphere. More exactly influence is caused by the polar magnetic storms (magnetospheric substorms), which intensity increased during global magnetic storms. Possible shift of the North magnetic pole toward Siberia will be accompanied by the shift of the auroral zone where substorm activity has maximum force. As a result negative consequences of the magnetic activity will be increasing in Russia and North Europe and decreased in North America. Modeling shows that a shift of the North pole to the location of the geographical pole will results in the shift of the auroral zone close to the latitudes of S-Petersburg and Oslo, whereas pole shift to the north coast of the Novaja Zemlia will bring auroral zone over the Moscow and Baikal Lake. Influence on biosphere and technosphere will be small during the years of solar minimum, but during years of solar maximum about 40% of a days will reach high activity level when negative influences will be essential.

Key words: magnetic storms and substorms, magnetic pole shift, technosphere and biosphere hazards.

1. Introduction. Technosphere and biosphere reaction to the magnetic activity.

Information about the shift of the North magnetic pole toward Siberia published by (F mmm) and catalyze numerous publications (especially in internet) ranged from speculations of possible reverse of the Earth's magnetic field polarity to the predictions of the catastrophic end of the Earth's life. Meanwhile there is possibility to predict possible consequences of the shift based not on the mystical speculations but on scientifically justified modeling. It is possible to predict how magnetic activity influence upon Earths technosphere and biosphere may be affected be the shift of the magnetic pole.

Study of the effects of magnetic activity on our life and environment was initiated by famous Russian scientist A. L. Chizhevsky (***Chizhevsky,*** 1973*)* and developed by his followers (***Breus, Rappoport,* 2004, *Vladimirsky, Temuriants,* 2000, *and publications of this proceeding)***. Influence of the global magnetic storms on animals and human beings is well established; especial attention is attracted to the effects on the heart diseases, increasing during magnetic storms. We will not go deep into the phenomena of the magnetic storms, the popular review can be find in (Lazutin, 2012). Mostly accepted opinions relates magnetic storm bio-medical influence with intensity of the magnetic pulsations and that on tekhnosphere with induced electric currents.

First registered effects on electric technical objects caused by very strong magnetic storm on September 1, 1859 are associated with a name of English astronomer R.C. Carrington who observed for the first time large solar flare which caused magnetic storm one day later.

Since Carrington times number of the technical objects on the Earth increased enormously and even much smaller magnetic storms caused technical disasters. Let us name the most important objects:

- High-voltage transmission systems , including underwater power cables,
- Long communication lines,
- High-voltage transformers damage
- Long pipe lines,
- Railroad lines.

Magnetic storms may destroy or interrupt operation of those objects and for many hours large

regions remain without electricity and communication service. The main source of these disasters is related with an induced electric fields and associated earths currents, which are create by the fast variation of the magnetic field during polar and global magnetic storms.
US National Energy Reliability Counsel placed magnetic storms at March 1989 and October 1991 in the same category as a hurricain Hugo and San-Francisco earthquake by the rate of disaster to national economy.

2. Magnetospheric substorms and auroral zone

Although popular opinion relate all disasters with magnetic storms, the real influence belong to the magnetospheric substorms. Strong magnetic storms bring substorm activity to the subauroral and middle latitudes and increase substorm magnitude. Indeed, induced electric field E ~ dB/dt proportional to the magnitude of the magnetic field and velocity of changes. Magnetic variations at the earths surface are created by the high altitude currents: ring current (Dst) of the magnetic storms and ionosphere westward currents of the substorm.

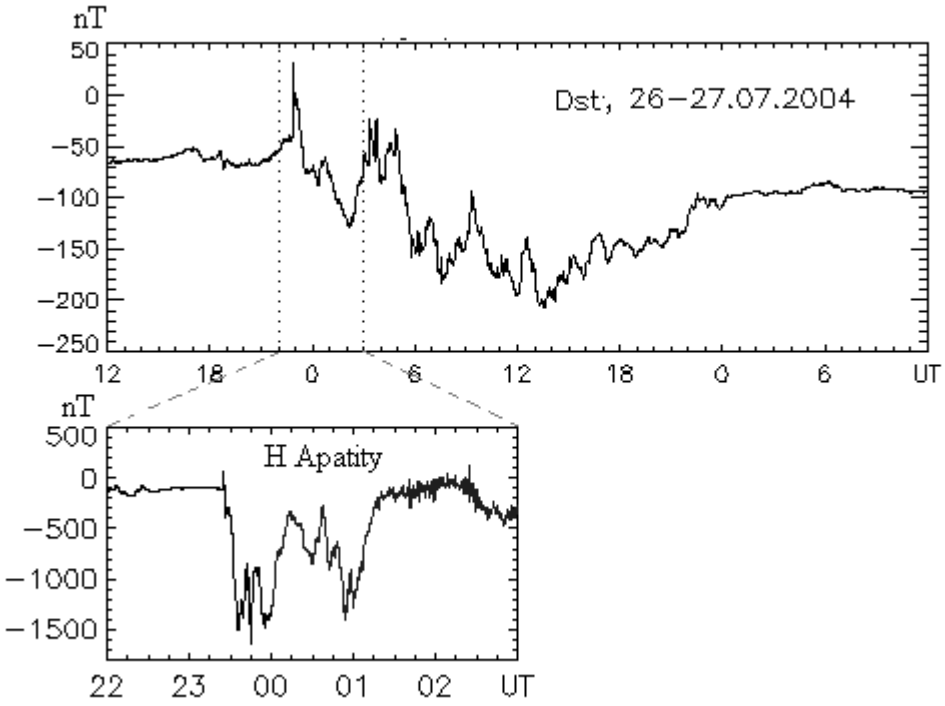

Figure 1 Dst index of the global magnetic storm and one of the substorm magnetic bays in the auroral zone.

From Figure 1 where those current effects are presented, one can see that the magnitude of the very strong magnetic storm restricted by 400 nT and duration of the decrease may vary from 2-3 to 20-30 hours. As for substorm magnetic bays, decrease for 1000-2000 nT may be occurs for 1-10 minutes. That means that substorm induced electric field is two order higher than induced by Dst magnetic storms.
As it was said before, the role of magnetic storms is important because they bring substorm activity to middle latitudes. But at the same time substorm activity remains higher in the auroral zone. Figure 2 presents a global position of the auroral zone, the latitudes where active aurora or substorm magnetic bays are registered more often. With the increase of the magnetic activity latitudinal width of the zone is increasing and equatorial boundary is shifting toward the lower latitudes. By broken lines possible latitudes where active aurora may be observed during very strong magnetic storms are shown (***adopted from Starkov,* 2000**). It is due to such equatorial shift of the active aurora

which allows peoples of the middle latitudes to observe beautiful auroral display. Because of the magnetic pole asymmetric location both aurora and technical problems caused by magnetic disturbances are more often in Canada and USA than in Europe and Russia. But still technical disasters are rare because of the position of the belt of the most active and most often magnetic disturbances is helpfully come through the Arctic Ocean and the lands with low population and industrial activity.
Situation may be changed with the shift of the North magnetic pole.

3. Magnetic pole shift effects

Measurements of the North magnetic pole position show regular shift toward Siberia and velocity of the shift is increasing from 10 km/year in 1970 to more than 70 km/year today. We cannot say whether this shift will continue, it is not a goal of this paper, but if it will proceed, we can calculate associated shift of the auroral zone and consequences of the magnetic disturbances effects on the noasphere.
For the modeling we take that auroral zone is located around the magnetic pole at the magnetic latitude 63° and that it conserve this relative position with the magnetic pole motion. Because the Earths magnetic field is not exactly a magnetic dipole, real auroral zone position usually is described in corrected magnetic coordinate and slightly deviates from that shown by Fig 2. But, first, it is impossible to predict how high order components of the Earths magnetic field will be changing during magnetic pole shift, and, second, the simplified position of the auroral zone will not differs significantly from the real one. For our purpose deviation by several degrees is not important.

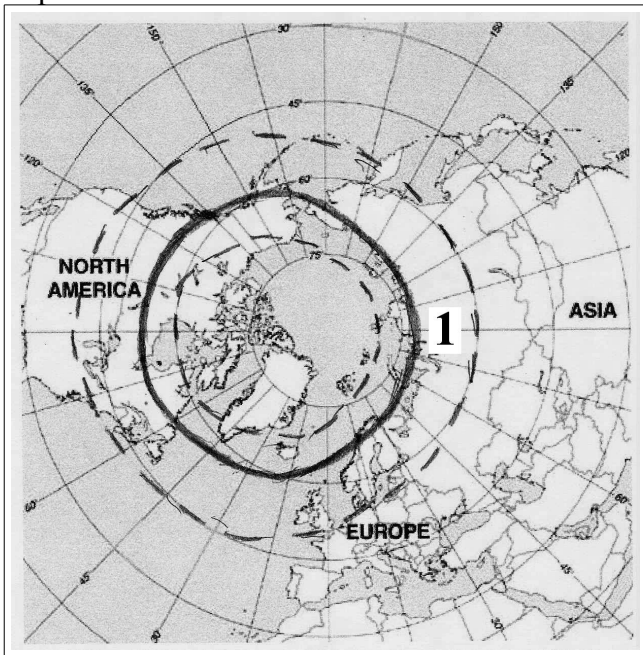

Figure 2 Auroral zone today and boundaries of auroral activity during strong magnetic storms (broken lines).

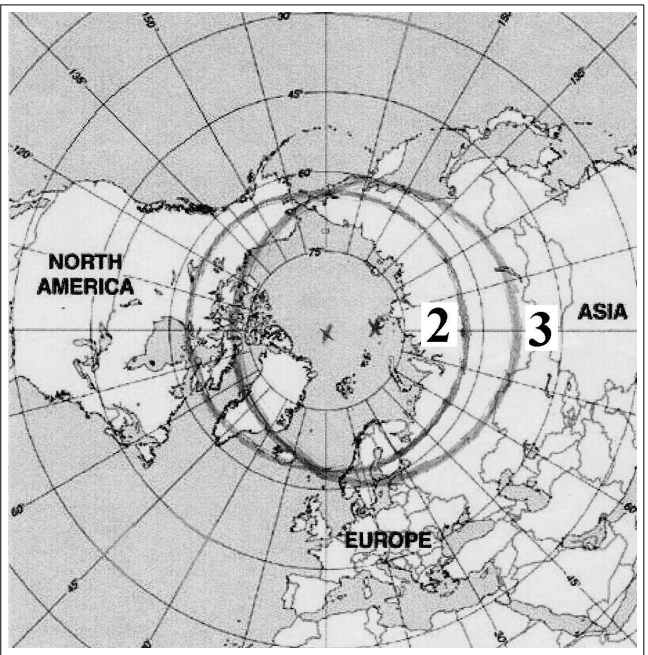

Figure 3 Two positions of the auroral zone in a case of the magnetic pole shift toward Siberia.

Figure 3 shows auroral zone positions calculated for two shift points of the magnetic pole — number 2 coinciding with geographic pole, and the number 3 located at the Severnaya Zemlia. As a consequence of the shift for inhabitants of Canada and USA possibility to observe aurora borealis became much smaller, but at the same time a number of the serious consequence of the magnetic storms on the human health and industry will decrease significantly. But for the Europe and Russia, especially for the Siberia, situation will be totally different. Polar aurora will be shine over Baikal

lake nearly every week, as often as now is shining over Murmansk. At the same tine that will bring high probability of the hearth attacks and technogenic catastrophes to Europe and Russia. And then auroral zone will be located not in deserted Arctic regions, but in the lands with dense population and overwhelmed by electric lines and oil tubes.

How often high level activity may be observed in auroral zone? To found that we used 3-hour Kp index of the magnetic activity during three years of solar cycle maximum, three years of solar minimum and three years transition from maximum to minimum. We considered that day was active if at least one of eight Kp values was equal 6 or higher, moderate, if Kp was between 3 and 6 with low activity if all Kp were less than 3. The results of the analysis are shown by Table. Years of the solar activity minimum are not dangerous – less than 2% of days have high activity level. But in the activity maximum nearly half of days have high activity hours and only 15% of days were relatively quite. There are no reasons to suppose that distribution of activity level will change after shift of the auroral zone, because magnetic activity is directed by solar wind velocity pressure and magnetic field, independent of the Earth magnetic dipole orientation.

Table. Number of days with different Kp depending ot the 11-year so;a cycle phase.

Years , activity	Kp 0-2	Kp 3-5	Kp 6-9
1999-2001 (maximum)	182 (16.6%)	467 (42.6%)	447 (40.8%)
2002-2004 (decrease)	226 (20.6%)	754 (68.8%)	116 (10.6%)
2006-2008 (minimum)	545 (49.7%)	532 (48.6%)	19 (1.7%)

Conclusions

- Shift of the North magnetic pole toward Siberia will cause associated shift of the auroral zone and the polar storms (substorms).
- Main technical and biological problrms are created by polar magnetic storms (substorms) which magnitude increase and latitudinal distribution widened during magnetic storms.
- Probability of the technogenic catastroph will be essentially increasing in Europe and Russia, especially in Siberia and decreasing in Canada and USA.
- It is difficult to predict whether the shift of the North magnetic pole toward Syberia will continue, but it is important to know beforehand about sich possibility and be prepared to use all possible measures to decrease consequences.

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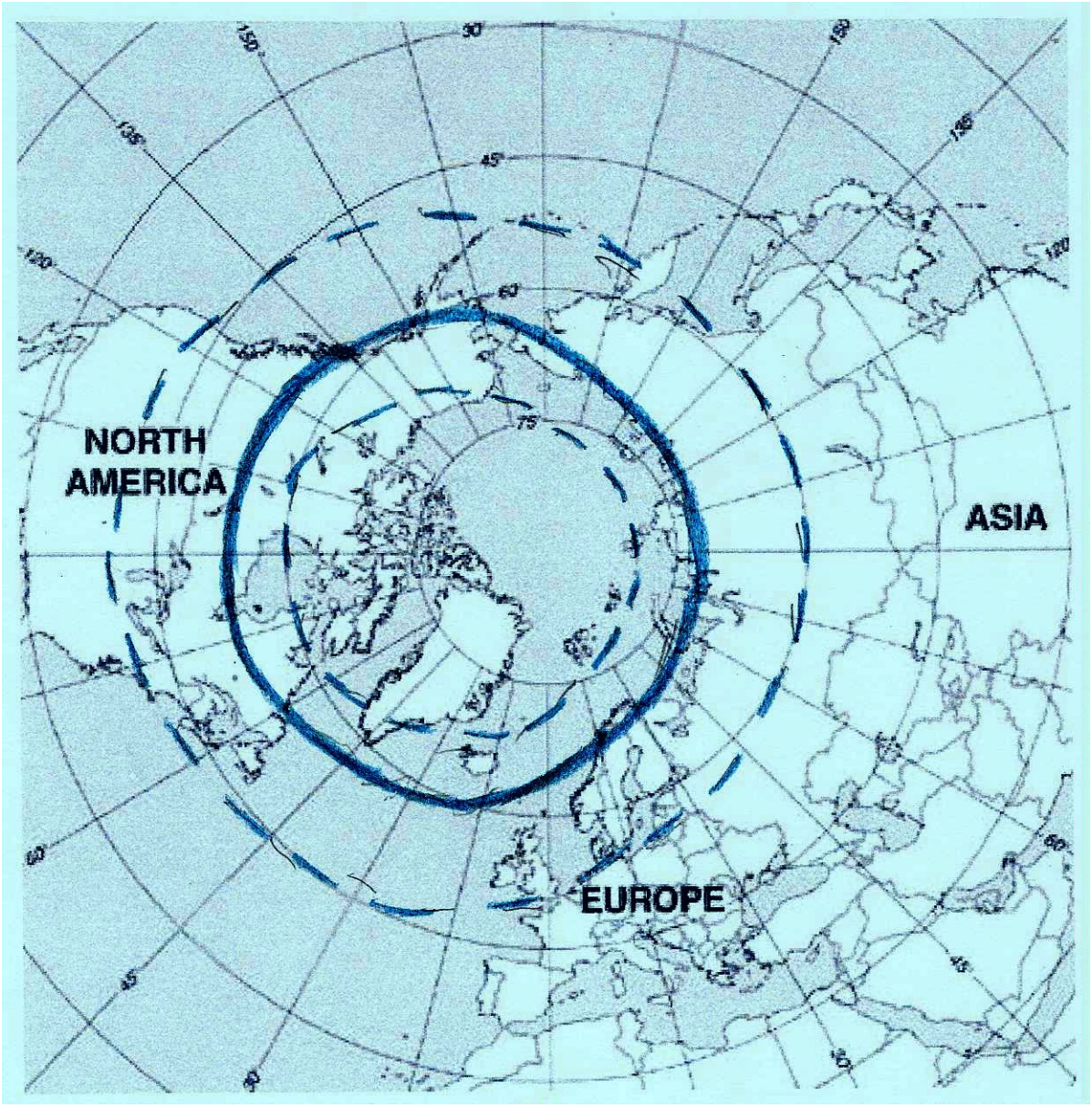

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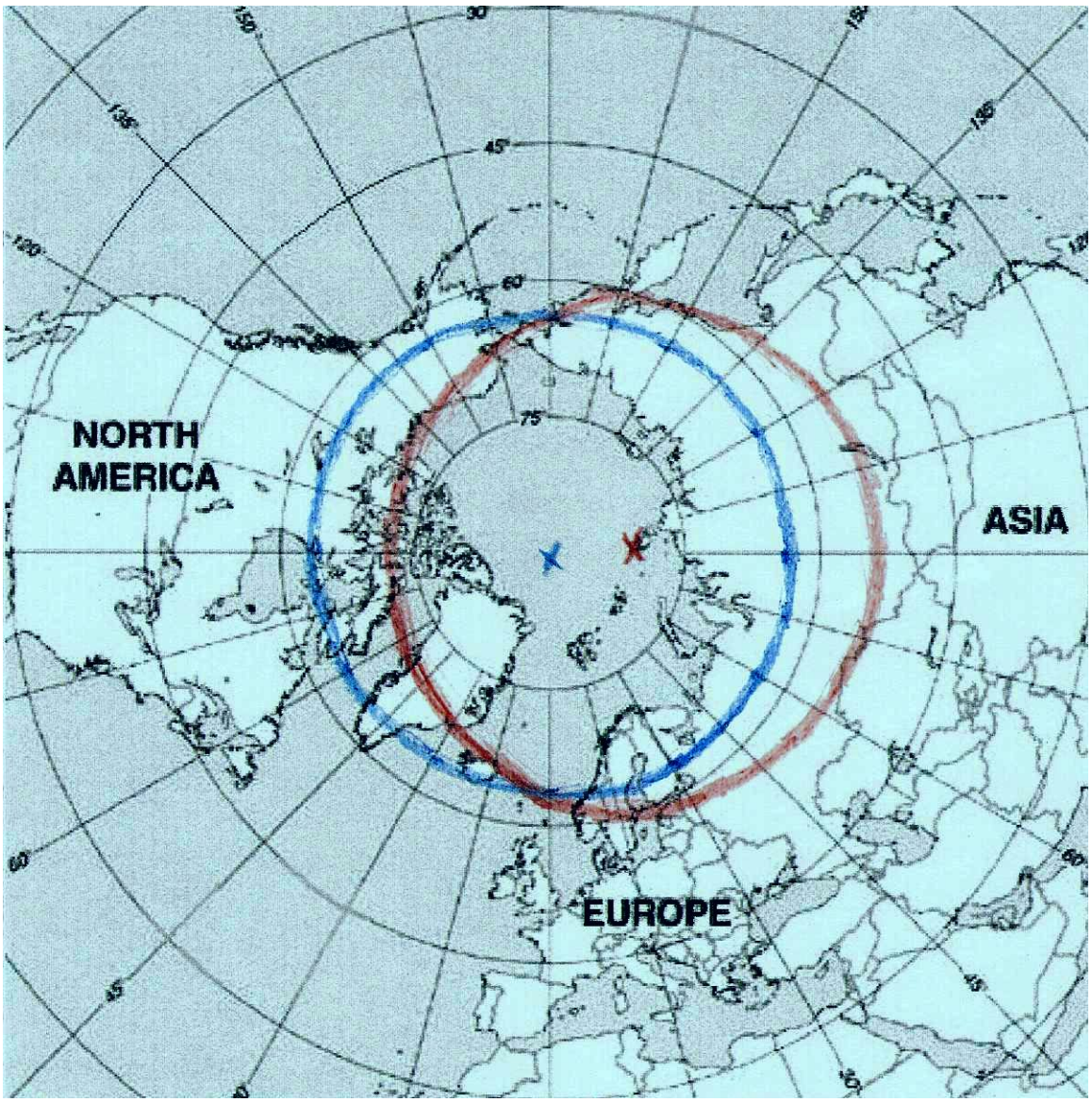

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