

## THE POSSIBLE TECHNOSPHERE IMPACT ON THE EARTHQUAKE FOCAL MECHANISMS IN JAPAN

O.D. Zotov<sup>1</sup>, I. P. Lavrov<sup>1</sup>

<sup>1</sup>Geophysical Observatory Borok, IPE, RAS, Borok, Russia, e-mail: [ozotov@inbox.ru](mailto:ozotov@inbox.ru)

This paper is devoted to the problem of technosphere-lithosphere interaction. The so-called weekend effect in the global seismic activity has been discovered earlier. The essence of the effect is that the seismicity (number of earthquakes) is experiencing a strict seven-day modulation, with the maximum of activity in weekends. This definitely indicates the effects of industrial activity on the lithospheric processes. The question arises whether it is possible to detect the weekend effect in variations of the earthquake focal mechanisms? To answer the question we examined the earthquake catalogue of Kanto-Tokai observation network ([http://www.bosai.go.jp/kotai/kanto/kanto-tokai/index\\_e.html](http://www.bosai.go.jp/kotai/kanto/kanto-tokai/index_e.html)) of National Research Institute for Earth Science and Disaster Prevention (NIED, Japan). The weekend effect in variation of the earthquake focal mechanisms has been detected for the relatively shallow (less than 10 km) earthquakes and was not found for the more deep earthquakes.

### Introduction

This research addresses to the effects of synchronism in geospheres under the influences of technosphere. Earlier, this effect which manifests itself in the form of so-called *Big Ben* and *Weekend* effects was observed by statistical analysis of the electromagnetic and seismic events [Guglielmi, Zotov, 2012].

Weekend effect, or, more generally, a specific weekly cycle (septan variation) were found 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 (left) and number of earthquakes (right).

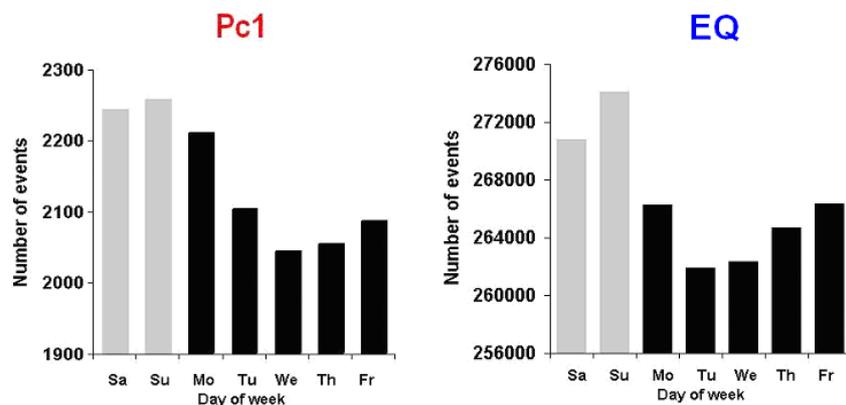


Fig.1. Weekend effect in the magnetospheric Pc1 wave (obs. Borok 1958-1992, [http://www.wdcb.ru/stp/data/catal\\_pc](http://www.wdcb.ru/stp/data/catal_pc)) and seismic activity (EQ, catalog ISC, 1964-2003, <http://www.isc.ac.uk>,  $M \leq 5.5$ ). Days of week are plotted on the horizontal axis. The signs **Sa** and **Su** denote Saturday and Sunday and the vertical gray columns indicate the weekend. Number of one week intervals (number of epochs) is ~1800 for Pc1 and ~2000 for EQ.

It is supposed that weekend effect has anthropogenic origin because natural variations with a period of strictly equal to 7 days are not known. The phenomenon indicates that the technosphere has a nontrivial impact on the magnetosphere and lithosphere.

Fig. 2 shows weekend effect in the chemical (a, left) and nuclear (b, left) explosions (catalog ISC) [Zotov, 2007], in the power consumption (bottom right, catalog NYISO,

[http://www.nyiso.com/public/market\\_data/load\\_data/rt\\_actual\\_load.jsp](http://www.nyiso.com/public/market_data/load_data/rt_actual_load.jsp)) [Guglielmi, Zotov, 2012] and in the launch of spacecraft (top right, catalog LSC, <http://www.zabor.com/launch>).

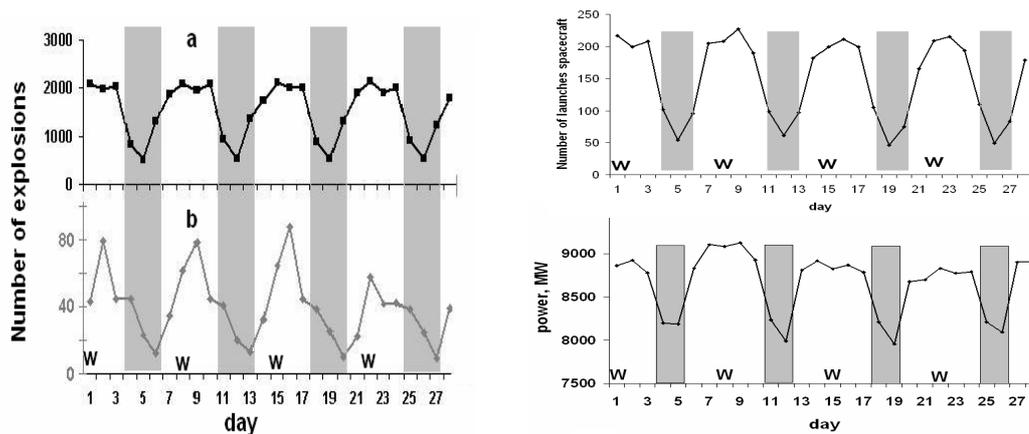


Fig.2. Weekend effect in anthropogenic seismic events (left), namely, chemical explosion (a, the black line, 40 000 events, catalog ISC) and the nuclear explosions (b, the gray line, 1100 events, catalog ISC), the number of events is plotted on the vertical axis; weekend effect in power consumption (bottom right, catalog NYISO); weekend effect in the launch of spacecraft (top right, catalog LSC). The synchronous detection interval (epochs duration) of 28 days plotted on the horizontal axis (W denotes the first day Wednesday). The gray vertical columns indicate the weekends.

The seven-day modulation of anthropogenic activity is clearly seen for all groups of events.

A large number of studies are devoted to the presentation of experimental results related to the influence of different sources of natural and artificial origin on seismic and magnetospheric activities. The different so-called active experiments (MGD-generator, mechanical vibration, explosion etc) demonstrate the influence on seismic activity of the physical fields of different nature. But a distinctive feature of active experimentation is their episodic. It is logical to assume that the response of the geosphere to external influence depends on its physical condition. Active experiments are short and pre-planned. In these cases it is difficult to take into account the conditions in the geosphere during the experiment. Unfocused but regular impact may be more effective. Continuous impact covers the entire spectrum of conditions of the geosphere including the most favorable conditions for the occurrence of the effect of influence. The source of such a continuous influence on the geosphere is the technosphere.

The industrial activity characterized by a variety of types of generated physical fields which have the same periodicities which we find in the lithosphere and magnetosphere.

So, there is an experimental foundation for the phenomenon of synchronism of the electromagnetic and seismic events which manifests itself in the form of weekend effects.

Thus we have many reasons for the search of similar effects in other characteristics of the geosphere. We will study the earthquakes (EQ) in Japan.

Is it possible to detect the weekend effect in variations of the earthquakes mechanisms?

### Method and data

The synchronous detection method (in the form of the superposed epoch analysis) has been used. This method is an effective way to detect a weak periodic signal on a background of noise.

In this work we have attempted to observe the effect by using the regional seismicity data. For the present statistical study we have used data from the earthquake catalogue of the Kanto-Tokai observation network ([http://www.bosai.go.jp/kotai/kanto/kanto-tokai/index\\_e.html](http://www.bosai.go.jp/kotai/kanto/kanto-tokai/index_e.html)) of the National Research Institute for Earth Science and Disaster Prevention (NIED, Japan). The catalogue contains 55,000 earthquakes with fault plane solution data from 1980 to 2002.

General characteristics of earthquakes are given in Fig. 3a, b.

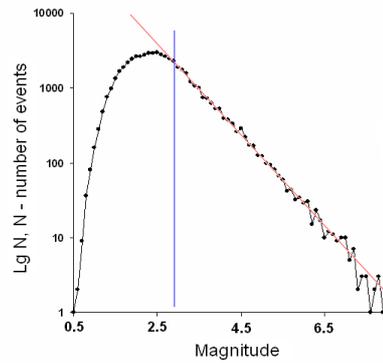


Fig.3a. The distribution of magnitude.

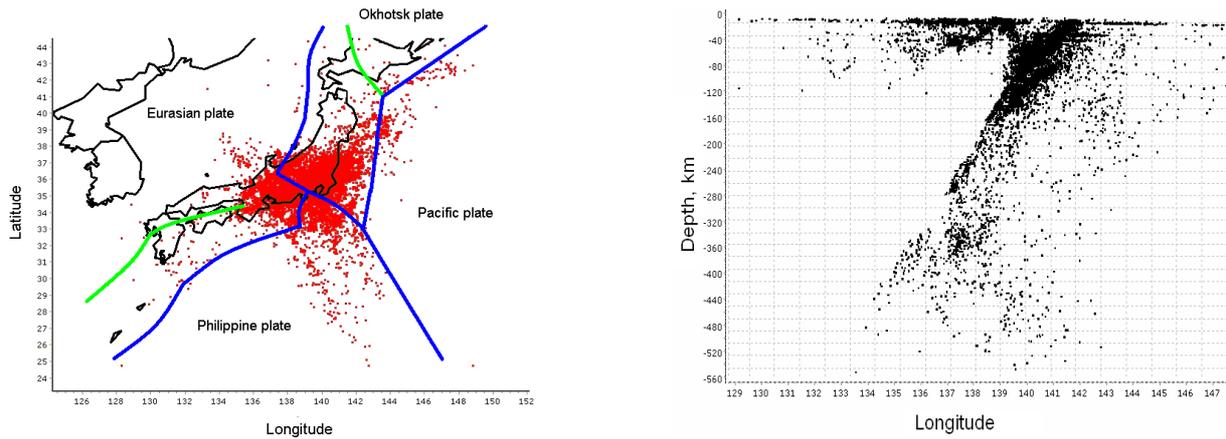


Fig.3b. The distribution of epicenters (on the left, red dots) and the distribution of hypocenters (on the right, black dots, shown one of projection) earthquakes. Dark blue line marks the boundaries of tectonic plates.

Catalogue contains focal mechanism solution for each earthquake, in particularly, angles STRIKE, DIP and SLIP. Fig. 4 schematically shows these angles and the three main types of focal mechanisms earthquakes.

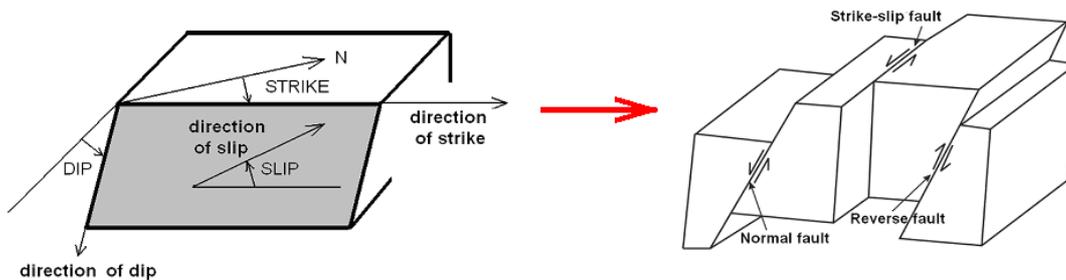


Fig.4. Type of focal mechanism = function (STRIKE, DIP, SLIP).

Consider the weekend effect. Null hypothesis: the ratio of types of focal mechanisms does not depend on the day of the week (weekday - weekend) and alternative hypothesis - there is dependence (exist the real impact of industrial activities on the seismic activity).

For each day of the week was calculated ratio of types of mechanisms in percentage. The ratio calculated in order to avoid dependence on the number of earthquakes.

## Results

Japanese islands region is an interesting seismic region, since there are four tectonic plates - two continental (Eurasian Plate and Okhotsk Plate) and two oceanic (Philippine and Pacific plate). The oceanic plate subducts below the edge of the continental plate when continental and oceanic plates converge (see Fig.3a, b).

We hypothesized that the impact of the technosphere will be more effective firstly on shallow earthquakes and secondly, on the earthquakes which belong to the continental plates. And it was so (see Fig. 5, 6).

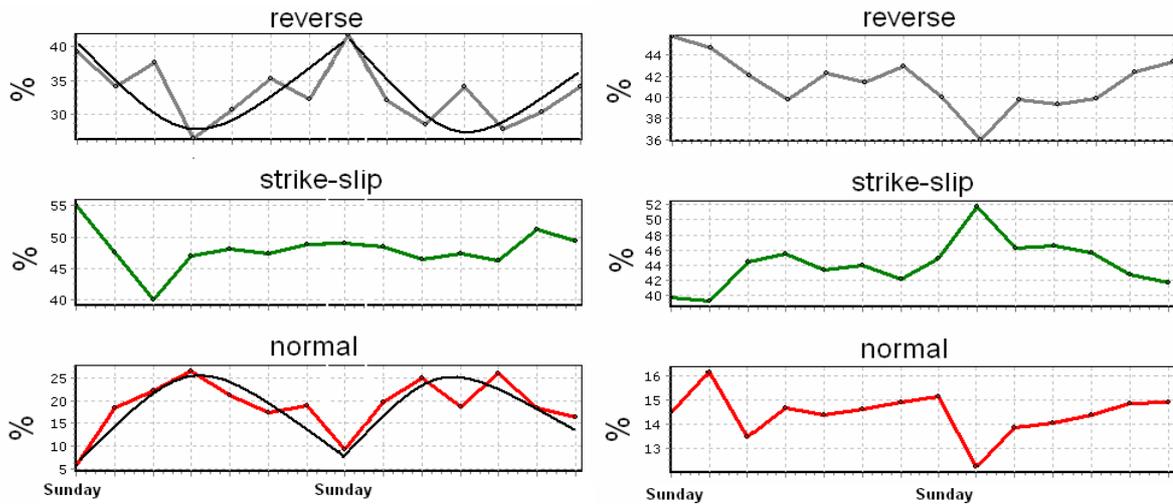


Fig.5. The dependence of ratio of types of focal mechanisms from the day of the week. On the left - continental plates, on the right - oceanic plates. Black line - approximation of initial curves.

For continental plates were selected earthquakes with longitude from 125 to 142, latitude from 35.5 to 44, magnitude from 0 to 10 and depth from 0 to 7 km, total 3158 events. For oceanic plates were selected 46600 earthquakes (Long 130.5 - 148, Lat 24.7 - 43.5, M 0-10, depth 7-500 km).

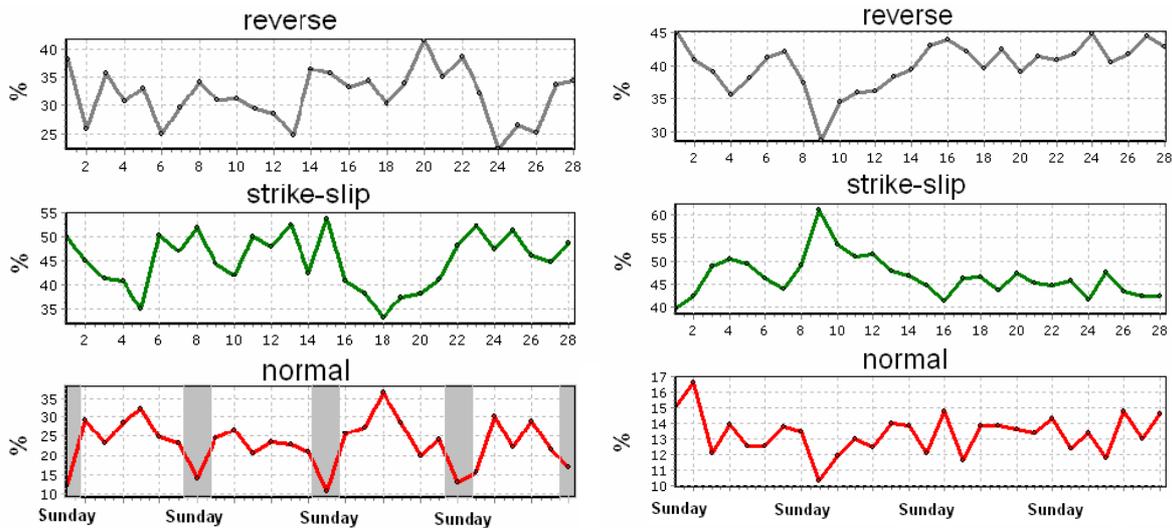


Fig.6. The dependence of ratio of types of focal mechanisms from the day of the week. Left panel - shallow earthquakes, and right panel - deep earthquakes. The gray vertical columns indicate the weekends.

For shallow earthquakes were selected events regardless of latitude and longitude with M 0-3 and depth 0-6 km, total 3569 events. For deep earthquakes were selected 33740 events regardless of latitude and longitude with M 0-3 and depth 7-500 km.

Fig. 5 shows that for continental earthquakes reverse and normal types of focal mechanisms have a weekly cycle with minimum in Sunday. For oceanic plates no mechanisms has septan variation.

Fig. 6 shows that for shallow earthquakes normal types of focal mechanisms have a weekly cycle with minimum in Sunday. For deep earthquakes no mechanisms has septan variation.

So, probably shallow earthquakes with small magnitudes that have occurred in continental plates have a best weekly cycle with minimum in Sunday. These earthquakes, more exactly their mechanisms are the most sensitive to the effects of the technosphere.

Fig. 7 shows one more preliminary result. Catalogue contains for each earthquake the angles AZP (azimuth of P-axes) and AZT (azimuth of T-axes). P - the axis of maximum compression (P - pressure) and T - the axis of minimum compression (T - tension) in earthquake source. For each day of the week, we calculated the average value of these angles.

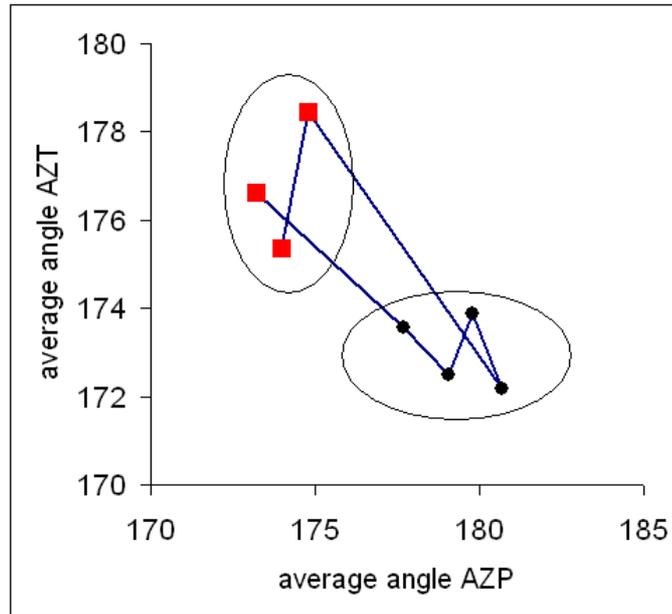


Fig.7. Dependence average value AZT from AZP (rad square – day of week Friday, Saturday, Sunday; **black dots** – Monday, Tuesday, Wednesday, Thursday).

Ellipses mark the two groups of points (days), one group - the weekend, the second group – weekdays. Such clustering also indicates the seven-day cycle in the dynamics of types of focal mechanisms.

### Summary

The main conclusion is that the weekend effect is the real geophysical phenomena, and evidently human in origin. This effect indicates that there is some nontrivial impact caused by industrial activity on the natural processes in the lithosphere.

Weekly cycle in the earthquake focal mechanisms is an interesting and strange and unusual result. Why only the normal and reverse mechanism has weekly variation? What physical mechanism of the influence of the technosphere on earthquake focal mechanisms? To these questions yet to be answered.

### Acknowledgements

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### References

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