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IMPACT OF COSMIC FACTORS ON THE BAIKAL RIFT ZONE SEISMIC REGIME

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Introduction

Problem of possible relationship between the Earth global seismicity and different cosmic cycles connected with gravitational interaction in the Earth-Moon-Sun system and irregularity of the Earth rotary mode is intensively studied in recent years [3, 7, 11 et al.]. Periodicity of seismic regime is reported by many researchers and great number of harmonics is recognized including 0,5; 1,0; 5-6; 10-11; 40-44 years [3, 5 et al.]. Previously [4, 10], in the study of seismic activity the repetition periods of migration clusters with periodicity of 6, 11 and 18 years were distinguished and it was suggested that migration of seismic activity and periodicity in seismic regime are the two aspects of the same processes. It is assumed that they may be caused by periodical passages of deformation fronts capable to initiate seismic activation in lithosphere [2, 4]. Based on variety of possible energetic sources of wave elevations in the Earth's lithosphere one can suggest the initiation of interference interaction of the waves which complicate identification of their parameters and nature. In the work the presence of static relationship between several cosmic cycles and increase in seismic activity is shown by the Baikal rift zone (BRZ) example.

Method and data

Accumulation mode is used: in order to ascertainment of static relationship of two processes the appropriate series are initially smoothed by the same time window. Then, it is calculated to which phases or amplitudes of one process the maximum values of the other process parameters summed according to long time interval fall on. Using this method a 27- diurnal cycle the Earth revolution around the Earth-Moon system barycenter, annual cycle of the Earth revolution around the Sun, 11-years cycle of solar activity and 18-years cycle of nodes of lunar orbit revolution were considered. Catalogue of the BRZ earthquakes given by the Baikal branch of Geophysical center of SBRAS was used for calculations [9]. Ephemerids of barycenter of the Earth-Moon system and the Sun are calculated using the program EPOS (Ephemeric Program for Objects of the Solar system), accessible for free downloading of the Pulkovo observatory site [8].

Results

27-diurnal cycle of the Earth revolution around the Earth-Moon system barycenter.

It was necessary to ascertain is there some dependence between δ declination of barycenter and maxima of seismic activity. Both series were smoothed by the time window with 1day step. Then, values of earthquakes quantity and released seismic energy over a period of 2010 – 2016s in the BRZ were summed for δ values with step of 1°. The results are presented in Fig.1.

It is well shown in the upper plot that total earthquakes quantity has three maxima: with δ values close to maximum, minimum and about 0° and all three maxima are well pronounced at that. On the ordinate the $lg(E)$ is laid off in the lower plot, where E is a total quantity of released seismic energy. It is shown that in the case of the energy the situation is significantly more complicated and statistical regularities of its distribution across the values of the barycenter declination are weakly too much pronounced. Obtained regularity in distribution of the earthquakes quantity throughout the declination ranges of the Earth-Moon system barycenter is evidently the reflection of cyclic
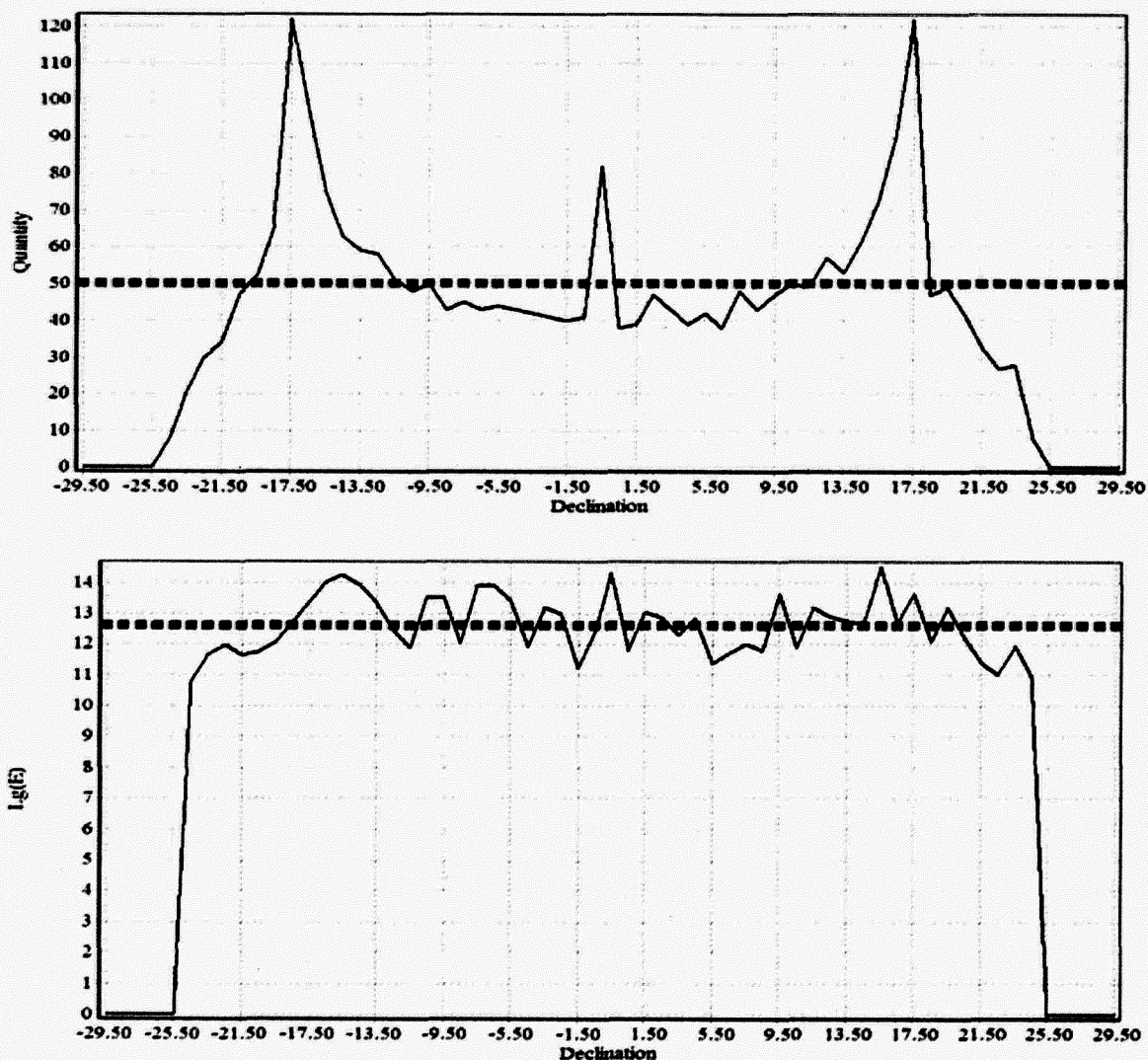
Figure 1: Relationship of the earthquakes quantity (the upper plot) and released seismic energy (the lower plot) in the BRZ summed over period of 2010-2016s with 1 day step and the barycenter declination of the Earth-Moon system.

variations of the tidal forces changes. The tidal forces change the Earth ellipticity. The moment of inertia of the elliptical Earth increases. Since, the Earth angular momentum must remain constant, rotational velocity of elliptical Earth decreases. Considering that the Moon declination as well as lunar distance permanently change, the tide-generating force varies with time resulted in changes of the Earth ellipticity and its rotational velocity. Therefore, lunar month includes four periods: the Earth rotational velocity increases during two of them (barycenter declination varies from 0° to maximum or minimum values) and in the course of two other periods the Earth rotational velocity decreases (barycenter declination varies to 0°) [11].

In the upper plot of Fig.1 is shown that there is a sharp increase in the earthquakes number when change of the Earth rotational velocity reverses sign. In this case three periods are distinguished: monthly, fortnightly and less pronounced period ≈ seven-day one.

Annual cycle of the Earth revolution about the Sun.

All above-mentioned arguments concerning the Earth motion around the Earth-Moon system barycenter also concerns the Earth revolution about the Sun. The number of earthquakes and released seismic energy in the BRZ during period of 2006-2016 s were smoothed with step of 7 day and summed for the δ declination values of the Sun with step of 1°.
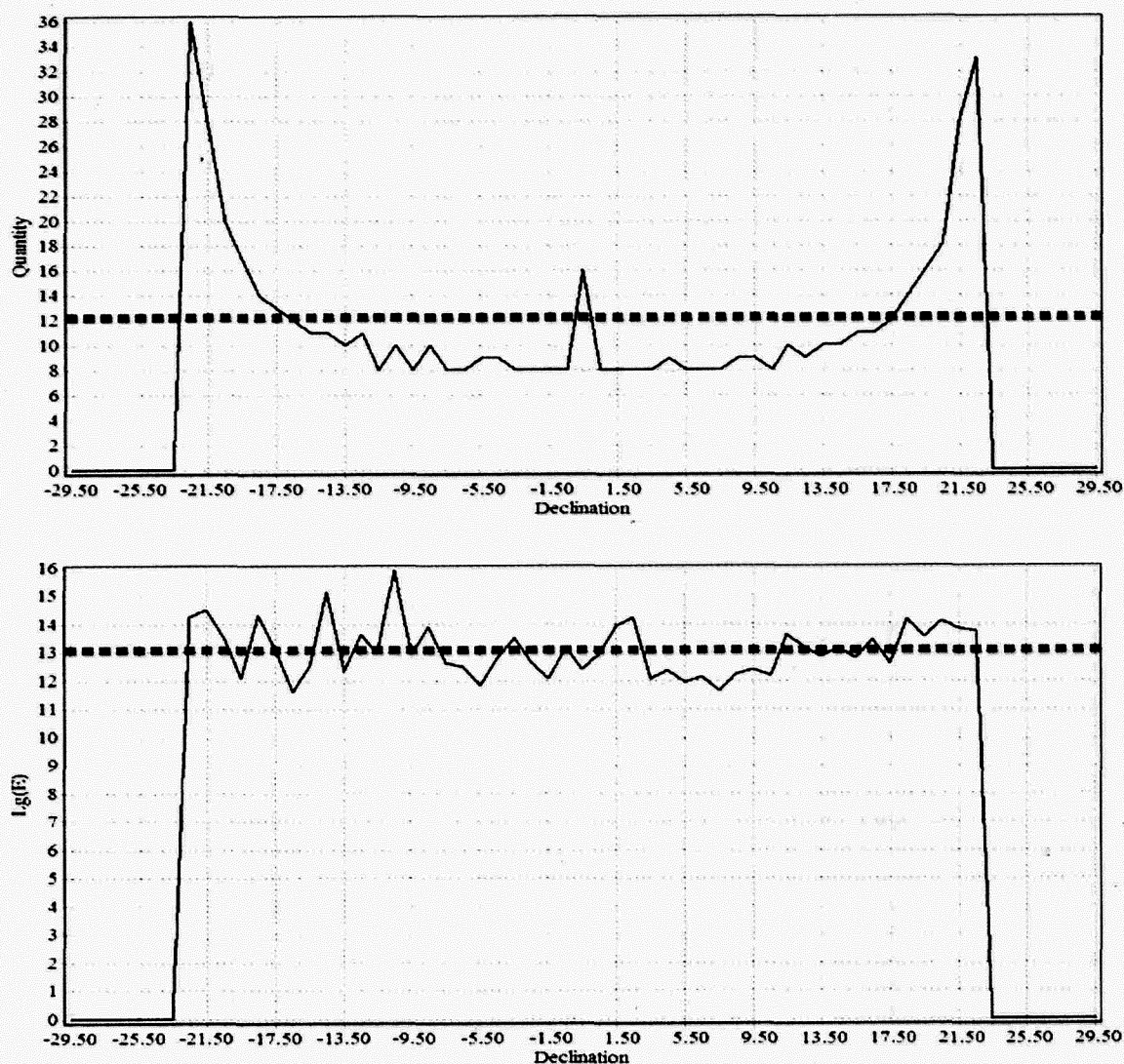
Figure 2: Relationship of the earthquakes quantity (upper plot) and released seismic energy (lower plot) in BRZ summed over the period of 2006-2016s with steps of 7 day and the Sun declination.

The result is shown in Fig.2. One can see that effect of the seismic activity relationship with certain values of the Sun declination is also better pronounced for the earthquakes quantities (upper plot) than for released seismic energy (lower plot). Monthly, fortnightly periods and less pronounced period of three months are similarly distinguished. Maxima of the earthquakes quantities fall on periods when the Sun declination has the maximum absolute value of 23.5° (solstice) and its declination reaches 1° (equinox).

11-year cycle of solar activity.

Many researchers associate the 11-year period in seismic regime with a cycle of solar activity [6 et al.]. In order to characterize the solar activity since 1964 to 2008 years were used. So long as the amplitude is considerably changed from cycle to cycle it was necessary to elucidate the dependence of the earthquake quantities and total released energy in the BRZ on the 11-year period phase. In this case the time when the Wolf numbers values were in minimum was taken as the cycle beginning. The plots in Fig. 1 show that two main maxima lie on descending branch of 11-year cycle both according to earthquakes numbers (upper plot) and released seismic energy (lower plot). One of them is located near to time of the maximum value of the Wolf numbers (the plot middle) and the second – the 1.5 year before the minimum value of series.
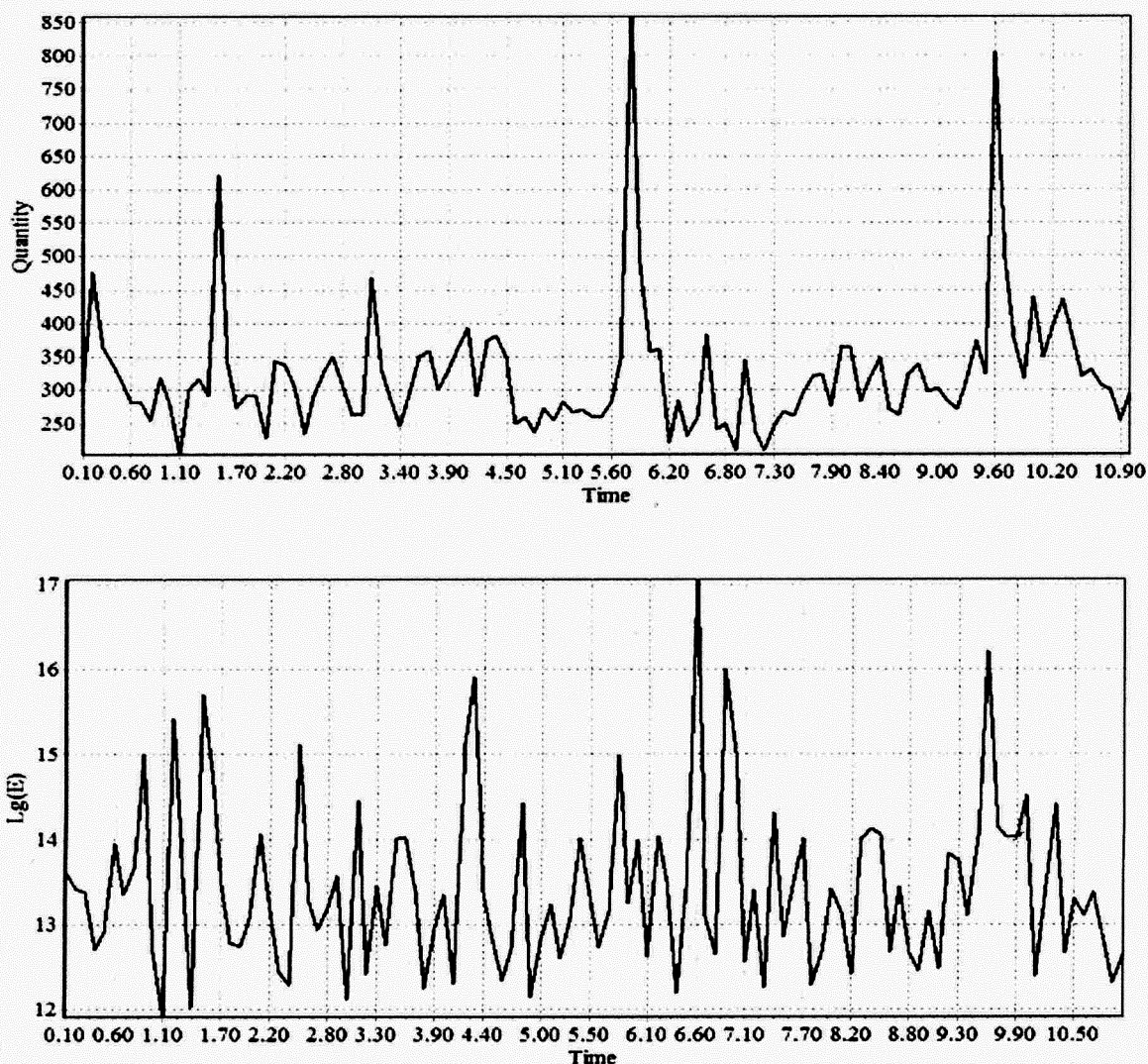
Figure 3: Relationship of the earthquake numbers (upper plot) and released seismic energy (lower plot) in the BRZ summed over the 1964-2008s period with step of 0.1 year and phases of 11-year cycle of solar activity.

I.e. we observe two periods – 4-5 –years and 10-11-years. The work [1] shows that variations of complete tidal force affecting the Sun (in the Sun-Jupiter-Saturn system) corresponds to variations of solar activity over the period from 1800 to 1980 year. Here, the complete tidal force implies the perturbation accounting in motion of the Sun produced by its revolution about the solar system barycenter. It is believed that the same forces are able to initiate the similar in duration short-period variations of seismic and seismomigratory regimes within different the Earth's regions.

18-year cycle of the lunar orbit nodes revolution.

Figure 4 presents the earthquakes number (upper plot) and total released seismic energy (lower plot) phase-distributed over the 18-year cycle of the lunar orbit nodes revolution. The main maxima which are well pronounced according to the earthquake numbers and are less pronounced accordingly to the released seismic energy lie at the beginning, at the end and in the middle of the 18-year cycle. Here, we obtain ≈ 9- and 18-year periods. In this case, the time when·the dragon's tail is in the vernal equinoctial point is taken as the cycle beginning.

Therefore, at the middle of cycle the ascending node will find oneself at the vernal equinoctial point. Thus, the maxima of earthquakes quantity fall on periods when the line of lunar orbit nodes coincides with the line of intersection of equatorial plane and ecliptic.
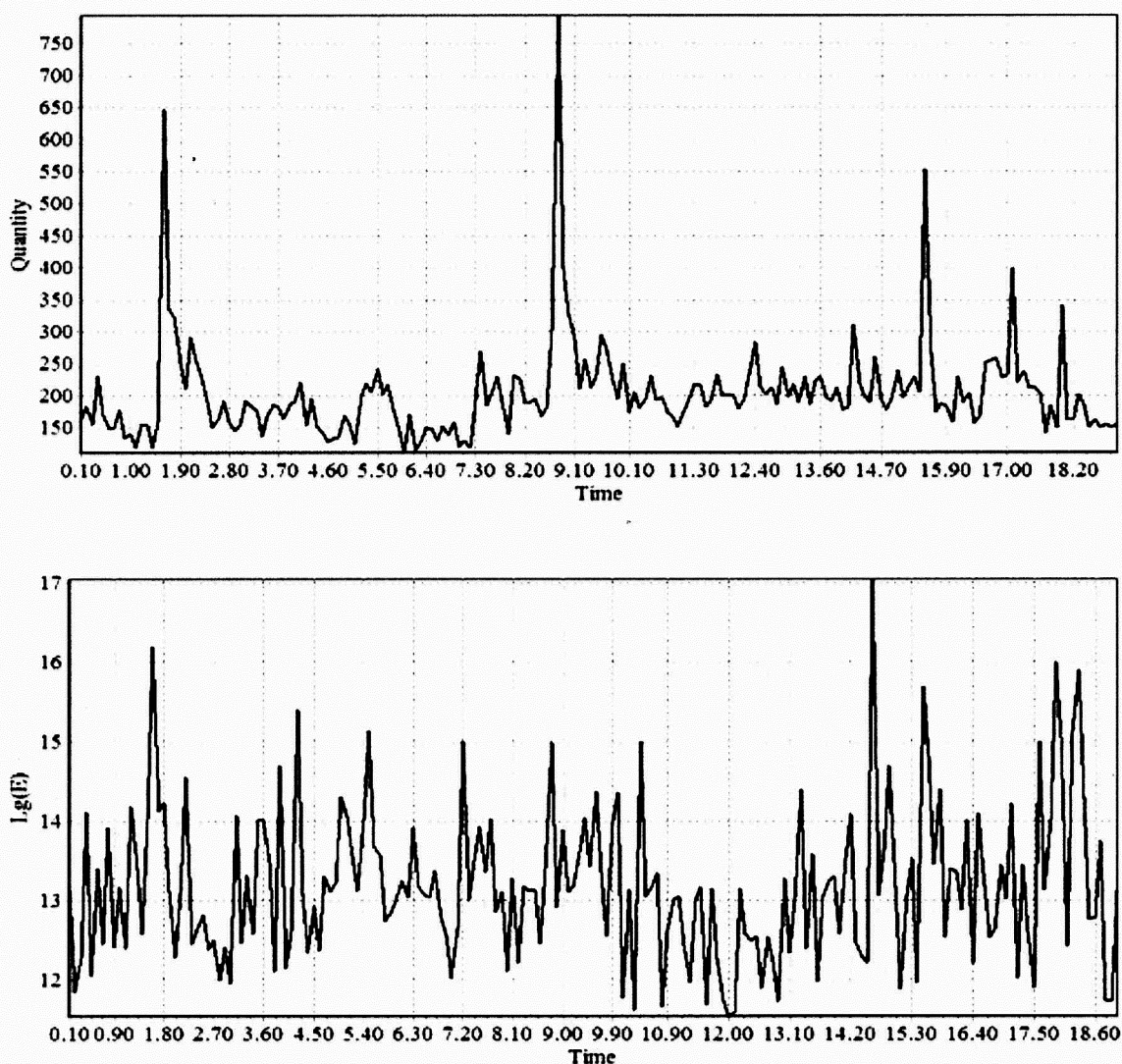
Figure 4: Relationship of the earthquake numbers (upper plot) and released seismic energy (lower plot) in the BRZ summed over the 1959-2016s period with step of 0.1 year and phases of 18-year cycle of the lunar orbit node revolution.

Conclusions

The presence in the BRZ seismic regime of 7-day, 0.5-, 1- and 3-month, 0.5-, 1-, 4-5-, 9-11- and 18-year periodicities is confirmed by the accumulation mode. The findings allow us to draw the following conclusion. Despite the fact that the seismotectonic phenomena within the Earth lithosphere are resulted from the processes occurring into its interiors the above-mentioned standing cosmic factors can modulate the seismic energy dissipation. These regularities are practically used for the medium-term earthquake prediction in the BRZ.

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