

THE RESULTS OF THE RESEARCH CONCERNING THE ORIGIN OF VARIATIONS IN THE MEAN GEOGRAPHIC LATITUDE OF BELGRADE

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(Received: December 20, 1991)

SUMMARY: The authors present the basic data concerning the study of the mean geographic latitude and seismic activity of Belgrade for the period 1964-1985, as well as the corresponding results.

1. INTRODUCTION

First determinations of the Belgrade geographic longitude at the Astronomical Observatory were begun in 1938, whereas those of the latitude begin in 1947 to be carried out incessantly up to this time. Such, relatively long, observational period can be used for the purpose of studies being of interest for the local necessities of Belgrade, especially for the examinations of the terrain of the site where the instruments, with which the astronomical observations are performed, are located.

The results of analysing the mean geographic latitudes of Belgrade obtained up to now (Grujić et al., 1989) have demonstrated the presence of a number of various influences (nonpolar influences) in addition to the influence on the terrestrial-pole position offering thus a real picture about the changes of the terrestrial-poles positions. These nonpolar influences contain in addition to the atmospherical and instrumental ones, also those due to the geophysical changes of the ground where the zenith-telescope

used in the astronomical observations is installed

One of the analyses of the data concerning the inclination of the pier on which the instrument lies (Djokić, 1970) revealed a tendency of the instrument's constant inclining to the southwest, an effect explaining partially the real diminishing in the Belgrade geographic latitude.

On the basis of the results of the geodynamical examinations obtained up to now, one can conclude that there are horizontal and vertical movements of the soil upon which Belgrade lies. Two years ago (1988) multidisciplinary studies of the variations in the mean Belgrade latitude including seismological, geodetic, astronomical, geological and geophysical examinations of the Belgrade area, aimed at establishing of a mutual connection in the measuring results (Sadžakov and Grujić, 1991), were initiated.

With regard that the astronomical determinations of the geographic coordinates have been performed since a significantly long time (without interruptions from 1949 to the present time), it is possible to use the astronomical material together with the available seismic data from the period 1964-1985

and in this way to attempt answering the question if the seismic processes within the ground cause the variations in the mean latitude. For this purpose one utilises the data concerning the earthquakes having taken place on the given area in order to discover some indicators of seismicity. The approach was defined by the necessity of incorporating the foci of those earthquakes having caused microseismical effects on the territory of Belgrade. This fact decided that in the paper only the earthquakes above a magnitude threshold of $M=3$ were included. This threshold value corresponds to the lower limit of reliability of the seismic data obtained with the Belgrade seismograph.

2. THE RESULTS AND ANALYSIS OF THE INVESTIGATIONS

2.1. Studies of Latitude Variations.

The astronomical observational material gathered between 1949 and 1985 is treated and presented in the FK4 System.

It is started from the basic formula

$$\phi = \phi_0 + \psi + \Delta\phi + \Delta\delta + z, \quad (1)$$

i.e.

$$\phi - \phi_0 = x \cos \lambda + y \sin \lambda + z \quad (2)$$

$$\lambda - \lambda_0 = \frac{1}{15}(x \sin \lambda - y \cos \lambda) \operatorname{tg} \phi, \quad (3)$$

where λ_0 and ϕ_0 are the mean geographic coordinates; x and y coordinates of the pole with respect to the mean one; z a term being a sum of all the nonpolar influences such as the errors in the positions of the observing-programme stars, refraction anomalies, instrument errors, shortcomings in the data treatment, various geophysical factors etc (Grujić et al., 1989). The mean latitude for a given moment ϕ_0 is that latitude value for a station when all the nonpolar and polar periodical terms are excluded. The results of ϕ_0 examination (Teleki and Grujić, 1969) have demonstrated its variable character. The variations may be due to the secular motion of the mean pole through the rectilinear motion, whereas the other ones are due to the local changes of the site (Kulikov, 1962). On account of this examinations of these variations are important to the multidisciplinary studies mentioned above.

By eliminating the periodic phenomena from the latitude variations one obtains the value of the mean latitude by use of Orlov's formula

$$\phi_0 = \frac{1}{20} \sum_{t=0}^{t=4} (\phi_t + \phi_{t+5} + \phi_{t+6} + \Phi_{t+11}). \quad (4)$$

The values of the mean latitude and those of its variations are presented in Figs. 1-2. In Fig. 1 there is a rectilinear trend, whereas in the other

figure the trend is on the parabolic part of the curve. By applying the spectral analysis to the mean-latitude-change data one discovers some periodicity. With regard that these quantities are insignificant and the influences negligible, no elimination of them is done.

2.2. The Results of the Seismological Investigations.

The registered seismological activity is defined by means of parameters useful for some sort of energy-distance influences of seismicity on the territory of Belgrade. The macroseismic intensities of the earthquakes in the Belgrade area are defined on the basis of registrations and data of the seismographs with which the seismic activity on the territory of Central Serbia, as a relevant seismogenetic area for our necessities, has been permanently registered. The registrations are carried out with qualitative short-period seismographs of Vegik type. The manner of galvanometric registering of ground-oscillation time-histories during the earthquake occurrences enables an online seismological analysis.

The hypocentre coordinates are defined on the basis of tested methods suitable to analyses of seismological data of this sort.

The earthquake magnitudes as an indicator of their energetic characteristics are defined on the basis of the measured values of amplitudes and corresponding periods for maximal A/T amounts of different sorts of seismic waves at known epicentric distances according to the general expression

$$M = \log(A/T)_{\max} + \delta,$$

where A is the ground-displacement amplitude in μm , T is the corresponding period in seconds and δ the calibration function for different types of waves.

The macroseismic field, i. e. more precisely the intensities of the earthquakes on the territory of Belgrade, is defined on the basis of an equation involving the earthquake magnitude, the hypocentric distance and the coefficients satisfying the conditions existing on the territory of Central Serbia

$$I_{BG} = 1.5M - 3.1 \log D + 3.3,$$

where I_{BG} is the earthquake intensity on the Belgrade territory expressed in the MCS-Scale degrees, M is the earthquake magnitude expressed in the Richter-Scale degrees and D is the hypocentric distance in km.

On the basis of the data analysed a catalogue of the analysed earthquakes is compiled and a diagram presenting the seismic-activity distribution over the period studied is made. In Fig. 3 a peak corresponding to the period of intensified seismic activity in the Kopaonik area is noticeable, which in some way dictates a dominant seismic activity in the central part of Serbia, including Belgrade as well.

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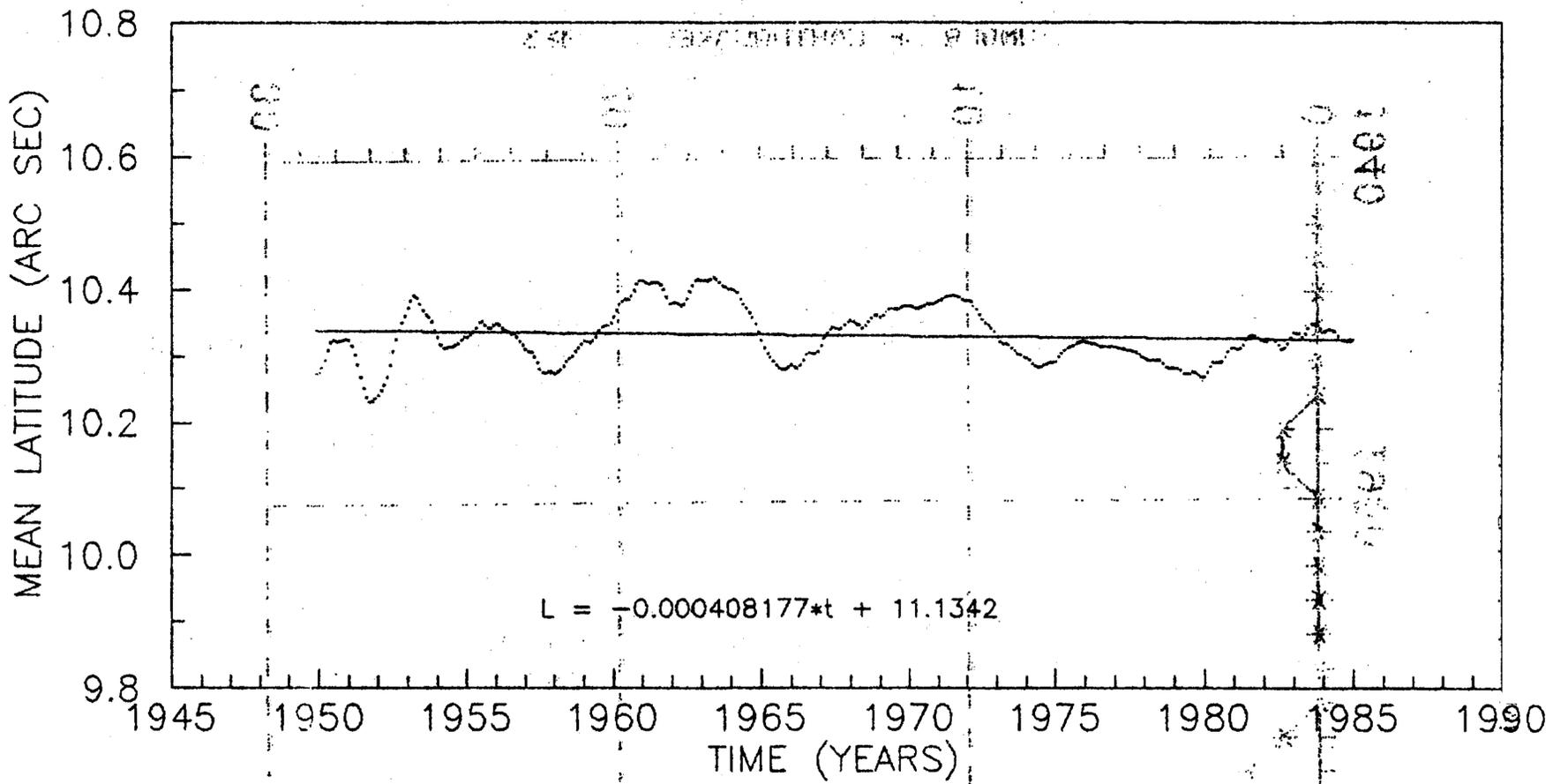


Fig. 1. The curve of variations in the mean latitude with linear trend (L).

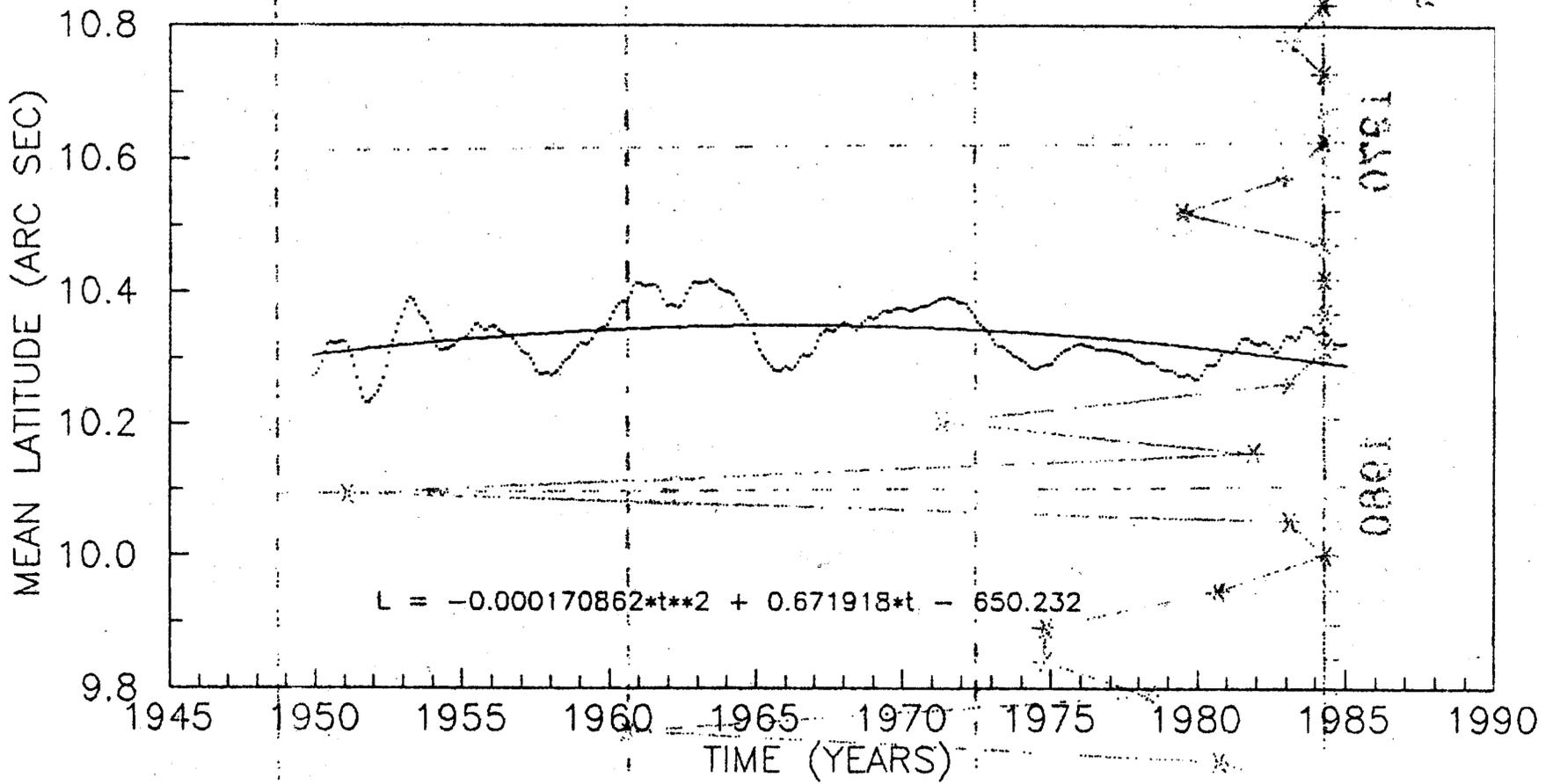


Fig. 2. The curve of variations in the mean latitude with the parabolic part of the curve (L).

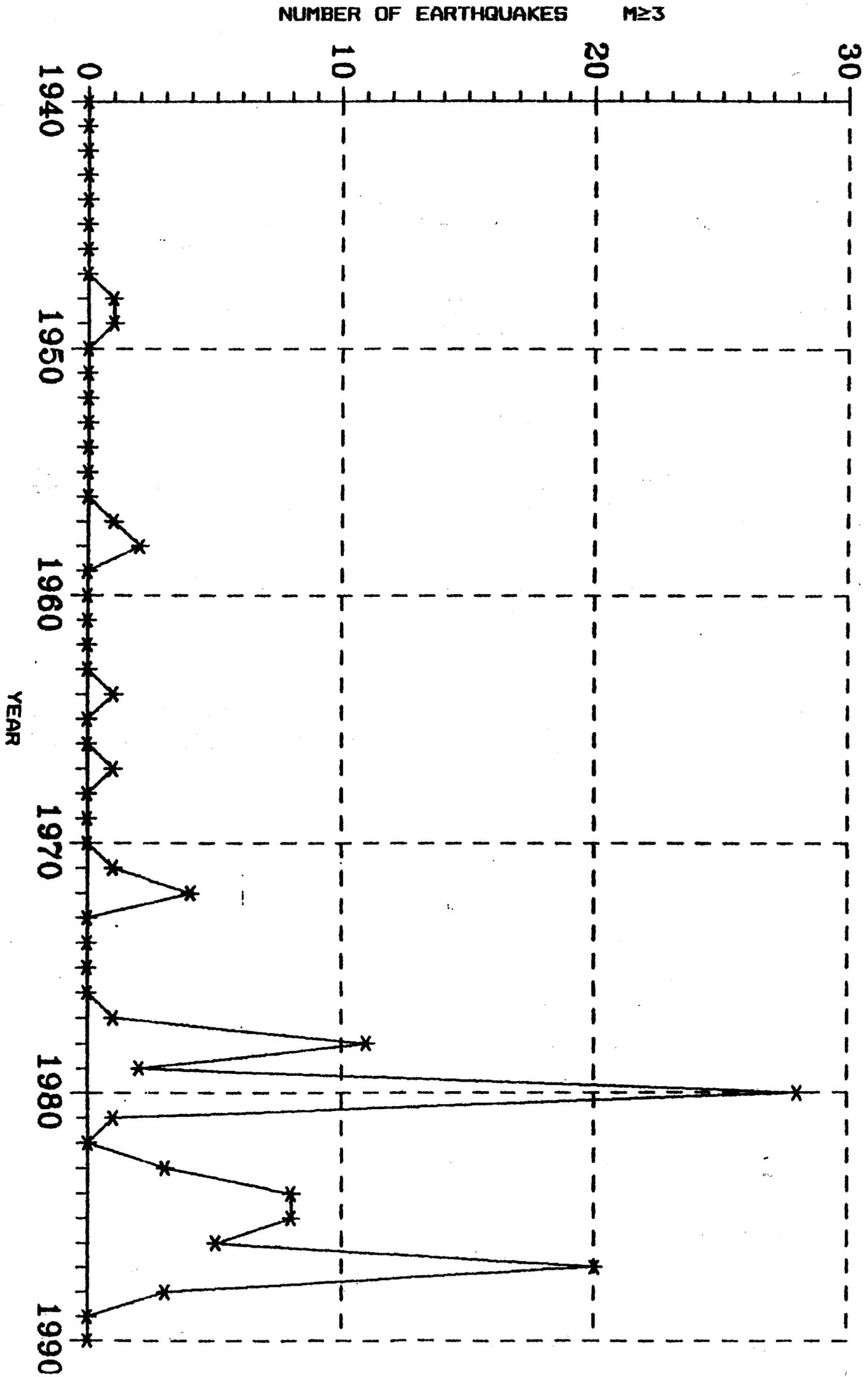


Fig. 3. Seismical activity in Central Serbia between 1940 - 1990.

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3. ANALYSIS OF THE OBTAINED RESULTS

By comparing the values of the variations in the mean latitude of Belgrade and the seismic activity in the central part of Serbia for the period 1964-1985 exceeding $M \geq 3$ presented in Table 1 and Fig. 3 one establishes existence of a correlation between the earthquake intensity (I_{BG}) and the mean latitude (ϕ_0) ($r=-0.30$). This means that the earthquakes are evident and that they can affect the change of the mean geographic latitude of Belgrade. If the period 1980-1990 characterised by a high seismic activity is treated, then the correlation coefficient becomes significantly larger, i.e. $r=-0.699$

4. CONCLUSION

The obtained values presented in Figs. 1-3 and Table 1 point out that there is a mutual connection between the change of the mean latitude and the

seismological phenomena.

Such a kind of examining the natural phenomena deserves a multidisciplinary approach and also multidisciplinary answering.

Acknowledgments – This work has been supported by the Republic Fund for science in Serbia through the project "Physic and Motions of Celestial Bodies".

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Table 1.

date	epicentre coord.		distance km	magnitude I_{BG}	mean latitude ϕ_0
	λ	ϕ			
29.10.1964.	19° 90	43° 32	170	3.7	10'' 348
01.10.1972	21.53	43.52	165	4.1	10.346
18.03.1978	20.96	43.30	142	3.4	10.293
13.04.1978	20.99	43.30	195	3.7	10.294
18.05.1980	20.87	43.31	180	5.3	10.290
11.04.1982	20.97	43.32	185	3.4	10.322
02.06.1982	20.94	43.35	178	3.5	10.322
02.04.1983	20.90	43.28	176	3.7	10.349
10.09.1983	20.83	43.23	178	3.5	10.349
07.09.1984	20.97	43.31	183	3.3	10.321
09.05.1985	20.93	42.58	178	3.8	10.323

РЕЗУЛТАТИ ИСТРАЖИВАЊА УЗРОКА ПРОМЕНА СРЕДЊЕ
ШИРИНЕ БЕОГРАДА

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УДК 521.936/.938
Претходно саопштење

У раду су дати основни подаци о изучавању средње ширине и сеизмичке активности Београда у периоду 1964-1985, као и резултати тих истраживања.