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Abstract

Full Text

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GEOPHYSICS

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ON THE PLANETARY CHARACTER OF THE PHENOMENON CAUSING THE ZERO DRIFT OF SEISMOMETERS

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As is known, the zero drift of seismometers, especially its variable component, is the main obstacle in the creation of highly sensitive long-period instruments. Therefore, study of the causes of drift may prove useful for the further improvement of long-period seismometers and, moreover, may have independent significance in connection with phenomena that cause displacement of the zero point of instruments.

The first experiments on investigating possible causes of zero drift of seismometers were begun at the Department of Physics of the Earth of Leningrad University in the second half of 1965 and then continued in 1968. Continuous recording was carried out of the zero drift of an SVKD seismometer equipped with a magnetron transducer⁽¹⁾. The instrument had a thermocompensation circuit using thermistors, excluding the possibility of drift due to changes in the temperature of the surrounding air.

Fig. 1. Spectra of the zero-drift curves of a seismometer from 1 VII 1965 to 17 I 1966 (1) and from 24 I to 15 VI 1968 (2)

It turned out that the zero-drift curves are irregular oscillations with periods from several days to a month or more and with an amplitude (in displacements of the center of oscillation of the pendulum) reaching a value of 200-300 μ at the pendulum's natural period of oscillation of 8 sec. Figure 1 shows spectra of the drift curves for the periods from 1 VII 1965 to 17 I 1966 and from 24 I to 15 VI 1968. It is seen that the spectra practically coincide, which indicates stationarity, in the spectral sense, of the phenomenon causing the zero drift of

seismometers.

To clarify a possible connection between the drift and hydrometeorological phenomena, a correlation analysis was carried out between the drift curve for the first half of 1968 and the curves of changes in pressure p and water level in the Neva h (Table 1). It is seen that the maximum values of the correlation functions $r_p(\tau)$ and $r_h(\tau)$, characterizing the relation of the drift to p and h , are small. However, they indicate a lag of the curves p and h , equal to 4 days, which excludes the possibility of explaining the zero drift of the seismometer by hydrometeorological phenomena.

Thus, on the basis of the constancy of the spectral composition of the zero-drift curves over time and the absence of a connection with local hydrometeorological phenomena, one may conclude that the cause producing displacement of the zero point of the instrument has a planetary character. This is confirmed by the results of comparison of the zero-drift curves of the seismometer (Leningrad) and gravimeter (Talgar station, Alma-Ata), smoothed by the method of averaging over a trial period equal to 8 days (Fig. 2). A quantitative estimate of the comparability of the drift curves was carried out by the method of correlation analysis (Table 1). The maximum value of the correlation function $r_p(\tau) =$

$= 0.75$ indicates a fairly strong connection between the zero-drift curves of the seismometer and the gravimeter.

At the same time, the amplitudes of the zero drift and, consequently (when recalculated), of the accelerations are so large—especially according to the seismometric data (Fig. 2)—that they cannot be explained by displacements of the ground or by changes in the force of gravity due to migration of matter in the Earth's interior. Therefore, a satisfactory explanation of the experimental data can be

[Fig. 2 and Fig. 3]

Fig. 2. Zero-drift curves of the seismometer (curve 1—Leningrad) and the gravimeter (curve 2—Tolgar station, Alma-Ata)

Fig. 3. Histograms illustrating the relation of seismic activity to the zero-drift curve: **a**—to the relative number of earthquakes, **b**—to the relative energy of earthquakes

obtained only under the assumption that displacements of the Earth exist. Then the zero-drift curve can be interpreted as a record of accelerations during perturbations of the Earth's orbit.

Under the assumption that displacements of the Earth exist, one may expect a definite relation between this phenomenon and seismic activity. The physical meaning of this relation is obvious and consists in the fact that, at times close to the moments of extreme values of accelerations (drift), additional maximum stresses will arise in the body of the Earth, which may prove to be the cause (in the sense of a trigger mechanism) of the manifestation of seismic activity. Such

a relation does indeed exist and was found by comparing seismic activity with the zero-drift curve from 24 I 1968 to 31 III 1969.

Table 1

τ , days	-6	-5	-4	-3	-2	-1	0
r_p				0.03	0.04	-0.02	-0.06
r_h				0.10	0.00	-0.07	-0.05
r_Γ	0.66	0.70	0.72	0.73	0.74	0.74	0.75
r_w	0.50	0.55	0.59	0.62	0.62	0.60	0.56
r_L	0.42	0.49	0.55	0.58	0.60	0.59	0.56
r_{kp}		0.33	0.40	0.46	0.52	0.57	0.61

τ , days	+1	+2	+3	+4	+5	+6	+7
r_p	-0.01	0.08	0.14	0.15	0.13	0.10	0.07
r_h	-0.02	0.06	0.17	0.20	0.17	0.13	0.09
r_Γ	0.72	0.68	0.65				
r_w	0.51	0.46					
r_L	0.52	0.46					
r_{kp}	0.62	0.62	0.59	0.56	0.51		

As characteristics of seismic activity, the number N and energy E of earthquakes with magnitude $M \geq 6.3$ were used; these accounted, during the indicated period, for about 99% of all seismic energy. As a quali-

To determine a parameter of the seismometer zero-drift curve, relative times were used: $\tau = (t_{oa} - t_0)/(t_{za} - t_{oa})$, where t_{oa} is the time of the extremum preceding the moment of occurrence of the earthquake, t_{za} is the time of the lagging extremum, and t_0 is the time in the focus. These times characterize the proximity of the earthquake moment to the preceding extremum of the Earth-acceleration curve.

Histograms showing the distribution of the relative number of earthquakes n/N (n is the number of earthquakes for $\tau = 0.1$) and of the relative energies E_n/E (E_n is the energy of earthquakes released for $\tau = 0.1$) as a function of τ are shown in Fig. 3. To construct the histograms, 62 earthquakes from (3) were used. From Fig. 3 it is evident that 70% of the strongest earthquakes, with energy amounting to more than 90% of all that released, are grouped at the extrema of the zero-drift curve and occur with a delay not exceeding 0.4τ . Thus, this result confirms the possibility of interpreting the zero-drift curve as the curve of the Earth's accelerations during its displacements in orbit. Since no diurnal waves of appreciable amplitude were detected in the zero-drift record, it may be assumed that the displacements occur in directions close to the direction of the

Earth's axis of rotation. In this case positive accelerations (Fig. 2) correspond to displacements of the Earth in the S–N direction.

If it is assumed that the fact of the existence of displacements of the Earth in orbit has been established, then one should conclude that they may be connected with solar activity (as an energy source) and with magnetic activity, which reflects the geoeffectiveness of solar activity. The spectral composition of seismometer zero-drift curves indicates the possibility of such a connection. Indeed, in the spectra in Fig. 1, periods equal to 25 and 32 days stand out quite clearly; these coincide with the periods of rotation of the Sun at the equator and at the poles. Table 1 gives the values of correlation functions characterizing the connection of the zero-drift curve with indices of solar and magnetic activity. As indices of solar activity, Wolf numbers were used, whose physical meaning is that they take account of the role of groups in comparison with the number of individual spots, and the numbers L , which emphasize the important role of spots located closer to the center of the solar disk:

$$L = \sum_{i=1}^{i=g} 1 / \left(\frac{r_i}{R} \right)^2 \cdot f_i,$$

where r_i/R is the distance of a group of spots from the center of the visible solar disk, expressed in fractions of the solar radius, g is the number of groups, and f is the number of spots in a group. The necessary data were taken from (4). As a characteristic of magnetic activity the k_p -index from (5) was used. The corresponding correlation functions are denoted $r_w(\tau)$, $r_L(\tau)$, and $r_{kp}(\tau)$. As is seen from Table 1, the correlation coefficients are equal to 0.6–0.62 and are sufficiently significant to suggest the presence of a connection between the phenomena. At the same time, the course of solar activity leads the course of the drift curve by two days, while the course of magnetic activity is practically synchronous with zero drift. This apparently indicates that the excitation of oscillations of the Earth occurs when corpuscular radiation approaches the Earth's magnetosphere, since the travel time of particles from the Sun to the Earth fluctuates within the limits of 1.5–2 days.

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