ISSN 1028-334X, Doklady Earth Sciences, 2006, Vol. 408, No. 4, pp. 671–673. © Pleiades Publishing, Inc., 2006.
Original Russian Text © V.V. Adushkin, A.A. Spivak, 2006, published in Doklady Akademii Nauk, 2006, Vol. 408, No. 4, pp. 532–534.

GEOPHYSICS

Microseismicity and Intensity of Relaxation Processes in the Earth's Crust

Academician of the RAS V. V. Adushkin and A. A. Spivak

Received February 9, 2006

DOI: 10.1134/S1028334X06040362

While analyzing the relaxation processes in the earth's crust, the microseismic background should be considered a permanently present vibration impact, which can systematically influence processes of energy exchange, including seismotectonic and gas-and fluid-dynamic processes. In the most general form, the microseismic background consists of superposition of oscillations with a statistically small amplitude in the selected time interval (background), regular seismic signals of natural origin (remote earthquakes, noise of seas and oceans, baric variations, and so on), and technogenic (transport and other noises), and finally, pulsing microoscillations (PO), which accompany local relaxation processes in the earth's crust and can be considered an analog of earthquakes. Relaxation processes are related to a partial release of stresses in the earth's crust. They are accompanied with microdeformations in the form of steplike constrained rotation or shear of structural blocks of different sizes [1]. In this relation, it is interesting to compare the number of relaxation events in the medium and amplitude of microseismic background. We note that accompanying PO relaxations are represented by a wide spectrum of amplitudes and frequencies. In the case of earthquakes, the number of PO increases significantly, while their amplitude decreases. Relaxation processes, which are characterized by a small amount of released energy (hence, small amplitude of PO), are observed everywhere. The number of PO (N) with amplitude, for example, 2–3 times greater than the background amplitude A, can be considered a measure of intensity of relaxation processes in a specific region of the earth's crust.

In this paper, we present the experimental data on the influence of background amplitude A on intensity N of relaxation processes in the earth's crust. We have established that the intensity of relaxation processes correlates well with the amplitude of background microoscillations. The degree of correlation depends on spectral components of background microoscillations. The best correlation between N and A is observed in frequency range 0.5–40 Hz in region with high tectonic activity (the coefficient of linear correlation is $K = 0.73$ at the level of significance $r = 0.995$) and frequency range 0.1–10 Hz in the crustal region characterized by low tectonic activity ($K = 0.75$; $r = 0.995$).

This result agrees with the previously discovered influence of microoscillations of different frequency compositions and amplitudes on the variations in the mechanical characteristics of interblock intervals, which decreases, for example, the degree of cohesion between neighboring blocks and provides favorable conditions for their differential motions [2]. In particular, it becomes possible to explain that high-frequency microvibrations lead to a stepwise regime of deformation of both crystalline and amorphous materials [3] (in this case, vibroimpact triggers elementary deformations). Acoustic and seismic oscillations influence the filtration characteristics of the medium, transport of mass and heat, and sorption–desorption processes [4–6]. Individual spectral components of microseismic background notably intensify emanation processes [7].

In the present work, the analysis of the influence of macroseismic oscillations on intensity of medium relaxation is based on the results of seismic measurements carried out in 2003–2005 in two regions characterized by low and high tectonic activities, respectively. The first site corresponds to the Oka sector of the Nelidovo–Ryazan tectonic structure (NRTS) [8], while the second site is located in the source zone of the Altai earthquake of August 27, 2003 [9]. Operation measurements in the NRTS and Altai were carried out at the points of operative recording [10], while permanent recording was performed at seismic station MHV (NRTS region) included into the Mikhnevo Geophysical Observatory of the Institute of Geosphere Dynamics.

It is evident that the conclusion about the influence of microseismic oscillations on the intensity of a medium relaxation can be made only on the basis of a sufficiently high correlation between amplitude of background microoscillations and number of relaxation

Institute of Geosphere Dynamics, Russian Academy of Sciences, Leninskii pr. 38/6, Moscow, 117334 Russia; e-mail: spivak@idg4.chph.ras.ru

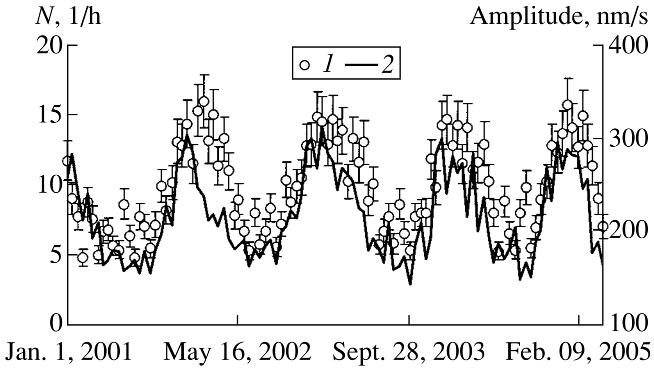

Fig. 1. Intensity of PO (*1*) and amplitude of microseismic background in frequency range 0.1–10 Hz (*2*) in the Oka segment of NRTS (vertical dashes denote dispersion of *N*).

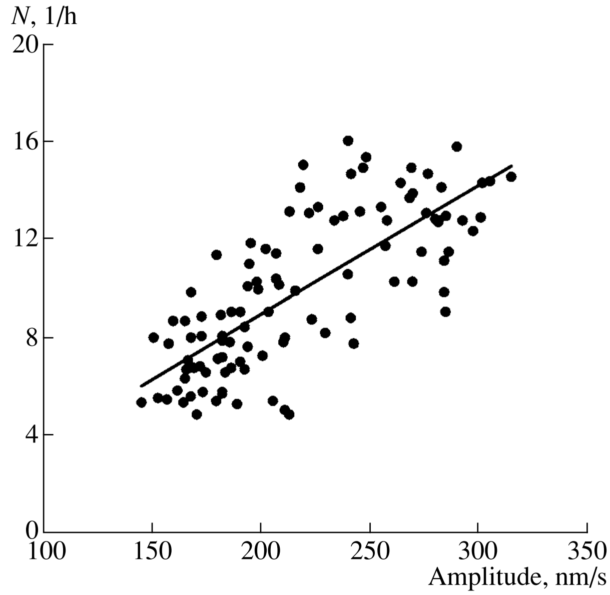

Fig. 2. Ratio *N*(*A*) for the NRTS region.

events. In this work, the degree of *A*–*N* correlation was based on the comparative analysis of time variations of these parameters and the *N*(*A*) dependence plots compiled from seismic data on different structural blocks recorded during the same time period [9, 10].

Figure 1 shows variation in the number of relaxation events during a >4-yr-long period (January 2001–February 2005) and the amplitude of background microoscillations at station MHV (hereafter, *N* denotes the number of PO with a 2.5-times greater amplitude than the background one). One can see that time variations in the intensity of relaxation processes are determined to a high degree of probability ($K = 0.75$) by the amplitude of background microseismic oscillations in the frequency range 0.1–10 Hz. Figure 2 shows dependence *N*(*A*) determined by the direct comparison of *A* and *N* shown in Fig. 1 (averaging interval is 10 days).

Unlike the NRTS region located in the central East European Platform, the region of high tectonic activity (source zone of the Altai earthquake) is characterized by a significantly greater intensity of relaxation processes in the earth's crust (on average, the number of PO with amplitudes exceeding 20 μm/s was ~200 events/h). The highest correlation between the number of relaxation events and amplitude of background microoscillations is observed for the spectral component of macroseismic oscillations in the range 0.5–40 Hz. Time variations of *A*(*t*) and *N*(*t*) obtained from the results of seismic

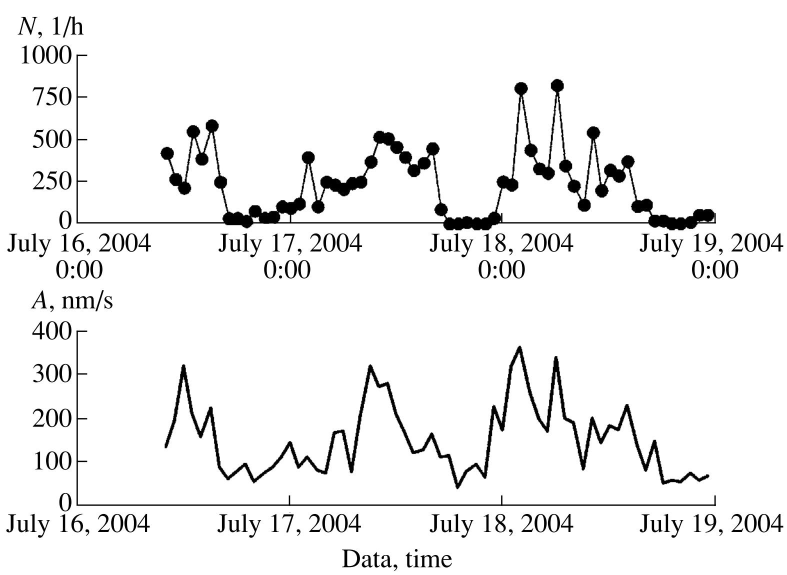

Fig. 3. Time variations of *N* (*1*) and amplitudes of microseismic background in frequency range 0.5–40 Hz (*2*) in the region with high tectonic activity (Settlement of Aktash, Altai).

recordings in Aktash during the period from July 16 to July 18, 2004 are shown together in Fig. 3 as an example (the correlation coefficient between A and N is equal to 0.73).

Thus, the analysis of the obtained data testifies to a sufficiently high correlation between N and A (Figs. 1, 3) and, in particular, to the evident trend of direct correlation between the PO and the amplitude of microseismic background (Fig. 2). Taking into account previously obtained experimental data about the influence of microseismic background on the activity of tectonic structures [8], this result allows us to make the following important conclusion: the role of microseismic oscillations in the earth's crust is very significant. It is conceivable that microseismic oscillations not only facilitate the accumulation of elastic energy in inhomogeneities of the earth's crust, but they also trigger its release.

ACKNOWLEDGMENTS

This work was supported by the Division of Earth Sciences of the Russian Academy of Sciences (program "Geophysics of Intergeospheric Interactions").

REFERENCES

1. A. A. Spivak, FTPRPI, No. 5, 8 (1994).
2. G. G. Kocharyan and A. A. Spivak, *Dynamics of Deformed Block Rock Massifs* (IKTs Akademkniga, Moscow, 2003) [in Russian].
3. M. A. Sadovskii, K. M. Mirzoev, S. Kh. Negmatullaev, and N. G. Salomov, Izv. Akad. Nauk SSSR, Ser. Fizika Zemli, No. 6, 32 (1981).
4. S. M. Ammosov, G. I. Voitov, G. S. Korobeinok, et al., Dokl. Akad. Nauk **290**, 1172 (1986).
5. O. L. Kuznetsov, E. M. Simkin, and G. Chilingar, *Physical Principles of Vibration and Acoustic Influence on Oil- and Gas-Bearing Beds* (Moscow. Mir, 2001) [in Russian].
6. Yu. M. Zaslavskii, Geofizika, No. 3, 40 (2004).
7. V. V. Adushkin, A. A. Spivak, S. A. Kozhukhov, and Yu. V. Kukushkin, Dokl. Akad. Nauk **400**, 369 (2005) [Dokl. Earth Sci. **400**, 124 (2005)].
8. A. A. Spivak, S. B. Kishkina, D. N. Loktev, et al., in *Dynamics of Interacting Geospheres* (IDG RAN, Moscow, 2004), pp. 13–25 [in Russian].
9. V. V. Adushkin and A. A. Spivak, in *Dynamic Processes in the System of Interacting Internal and External Geospheres* (GEOS, Moscow, 2005), pp. 142–163 [in Russian].
10. V. V. Adushkin and A. A. Spivak, Dokl. Akad. Nauk **402**, 92 (2005) [Dokl. Earth Sci. **402**, 556 (2005)].