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SHORT COMMUNICATIONS

Some Features of Fluid Dynamics at Platforms as Illustrated by the Example of Variations in Subsoil Radon and Seismic Noises in the Moscow and Nizhni Novgorod Regions

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Huge areas of ancient platforms are traditionally ascribed to geodynamically passive structures of the Earth's crust. This leads to some conservatism in the interpretation of diverse natural phenomena at platforms (landslide, karst–suffosional processes, rock impacts and gas explosions in mines, breakups of pipelines, and others), which are typically related to the exogenous change in the geological environment of the sedimentary cover [1].

However, following Kropotkin [2], who pointed to a possible relation of global change in the strain-deformational state of the Earth's crust with variations in the Earth's rotation, we demonstrated [3] that these processes affect fluid dynamics in both geosynclinal (seismically active) and platformal regions, thus defining the evolution dynamics of exogenous processes in decompressed areas of sedimentary cover that are formed above faults in the crystalline basement. The processes determine the rhythmic evolution of diverse geodynamic phenomena at platforms, including weak seismic activity [4].

Our previous research in seismically active regions showed that changes in the fluid dynamics of faults caused by variations in the strain-deformed state of the rocks is adequately correlated with variations in the radioactive and hydrocarbon emanation [5] and seismic noises [6]. Temporal series of the measured parameters of the aforementioned fields reflects the entire spectrum of variations in the strain-deformational state of the Earth's crust, from secular (60 to 70 years) to circadian tidals (12 h and less). This allows one to use the emanation and seismic emission methods as highly sensitive noise-proof technologies for monitoring the geological environment, especially suitable for urban agglomerations, where the level of electromagnetic and vibrational–noise emanation rules out or constrains the application of many methods of geophysical monitoring.

According to our earlier research conducted using the aforementioned technologies within the Moscow syneclise (at the territory of Moscow starting in April of 2002) [7], the changes in the fluid dynamics of the latter reflect not only regional variations in strain-deformed states of the rocks but also global dislocations of its geological structures [8]. This relation is most distinctly expressed in geodeformational processes of seasonal (annual) periodicity [9].

As a continuation of the studies devoted to the dynamics of diverse geodeformational processes and their effect on the fluid dynamics of faults of the East European Platform, we conducted comparator measurements of the variations of emanation (radon) and seismic emission fields in Moscow and at an observation site in Nizhni Novgorod oblast.

Radon monitoring at both sites was conducted in a manner identical with passive (in natural setting, without sampling) continuous measurements using original sensors, mounted (buried) at a depth of 1 m. The seismic noise was measured with a CB-10 seismic sensor buried near the radon sensor.

Information from the sensors was recorded with Logger microprocessor seismic receivers with a counting frequency of 10 s. Upon their storage in a computer, the recorded data were averaged over one-hour intervals with the subsequent analysis of the spectral characteristics and correlations between the obtained temporal series.

Regional structural–tectonic features of the geological environment at the observation site in Nizhni Novgorod oblast significantly differ from those of Moscow [7], primarily, in the formation of a zone of the dynamic effect of a regional arc-shaped fault [9], which frames the morphological–structural complex of the sedimentary cover near Svyato Lake, on the southern side of which measurements were carried out.

Stratigraphically, the upper stages of the sedimentary complex at both observation sites are nearly identical, including similarities in the karst–suffosion processes in Moscow and the town of Dzerzhinsk in Nizhni Novgorod oblast [10].

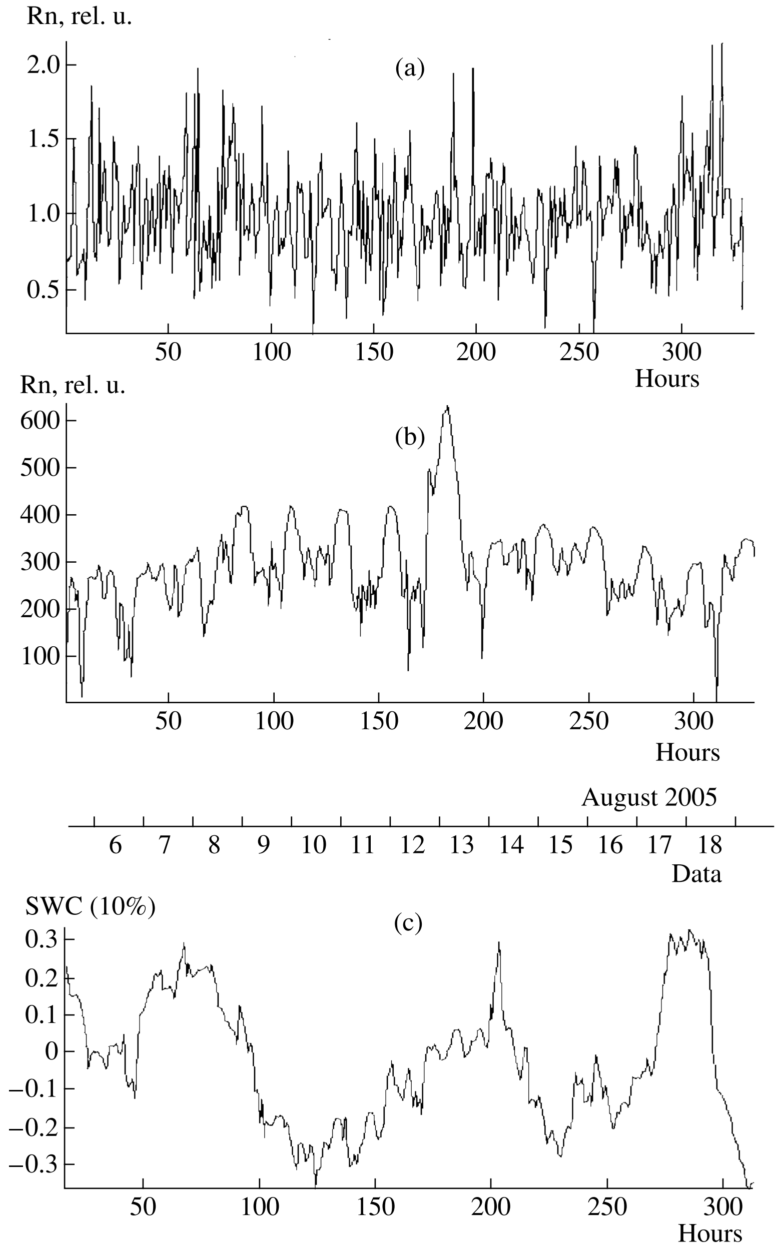

Fig. 1. Temporal variations of subsoil radon in Moscow (a) and Nizhni Novgorod (b) observation points; (c) plots of temporal variations (a) and (b) in a 10% sliding window. Relative parameters are given in values of strain at the input of recorder.

Figures 1 and 2 demonstrate fragments of temporal variations in the subsoil radon and seismic noise in Moscow and at Svyato Lake, respectively, as well as the plots of 10% sliding-window correlation of the corresponding temporal realizations. The table demonstrates periods of the most representative harmonic constituents, which were distinguished by spectral analysis of the corresponding temporal series.

Our data revealed significant correlations between the variations in the radon and seismic noise fields at the observation sites, as well as between the radon field and seismic noise field at the Svyato Lake site. However, unlike the correlation previously observed in Moscow [6], this correlation cannot be explained by variations in the urban seismic noise affecting the dynamics of ascending fluid flows, because the nearest town of Murom is located ~30 km of Svyato Lake. Both the radon and the seismic noise fields show a sign-variable correlation, varying from significant positive to significant negative values. Such variations in the correlation coefficient between the fields of seismic noise, radon, and hydrogen (Fig. 3) in Moscow can be related to a change in the strain-deformed state of the rocks in

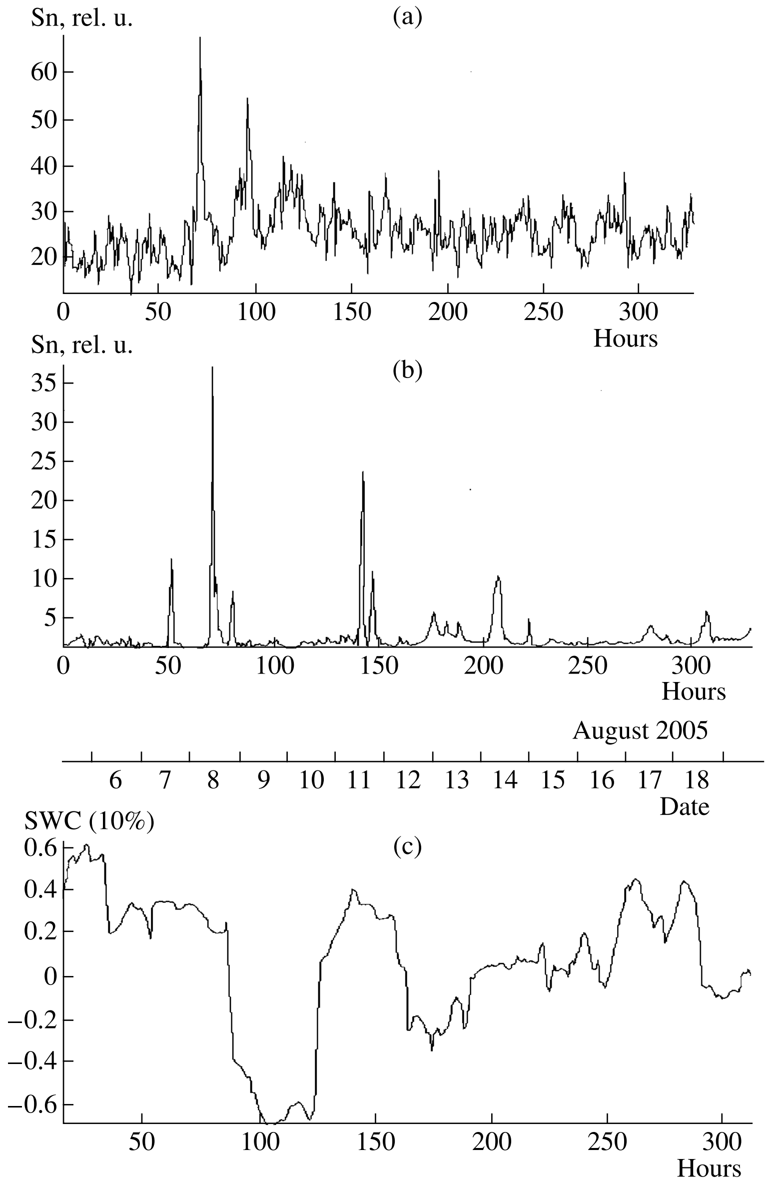

Fig. 2. Temporal variations of seismic noise in Moscow (a) and Nizhni Novgorod (b) observation points; (c) plots of temporal variations (a) and (b) in a 10% sliding window.

the tectonic structure within which the observation point is located.

The effect of the aforementioned regional curved tectonic structure on the permeability anisotropy of sedimentary rocks in the vicinity of Svyato Lake remains uncertain, as is, correspondingly, its effect on the dynamics of ascending fluid transfer, which was studied by a radial–azimuthal survey. This permeability anisotropy of the sedimentary cover is observed at the zone of ring structures [11], at which the deformation of the rocks in sedimentary cover has no distinct one- or two-sided orientation.

At the same time, spectral analysis of the temporal series (table) highlights the effect of the geodeformational tidal components on the dynamics of vertical fluid transfer, which is expressed in diurnal and semidiurnal harmonics in the temporal variations of the spectrum. The analysis of mutual correlations between the variations in the emanation (radon) and seismic noise fields in order to reveal their possible temporal shifts (which can suggest spatial displacements of, for example, tidal or seasonal geodeformational waves) showed no significant extremes corresponding to these processes. At the same time, the weak correlation between the radon fields with a 15-min delay in Moscow and the seismic noise fields with a 35-min delay in Moscow presumably support the earlier suggestion that the East European Platform oscillates as a single con-

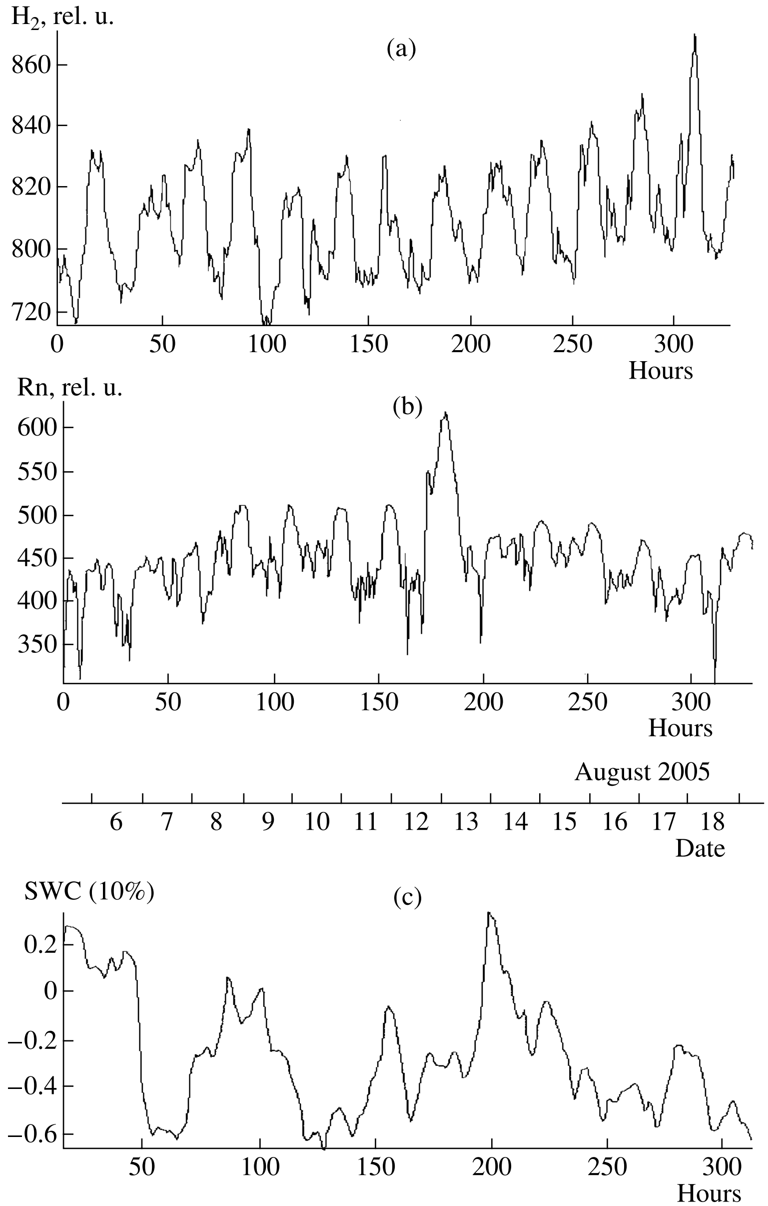

Fig. 3. Temporal variations of subsoil hydrogen in the Moscow observation point (a) and subsoil radon in the Nizhni Novgorod observation point (b); (c) plots of temporal variations (a) and (b) in 10% sliding window.

solidated massif depending on variations in the Earth's rotation velocity [12].

The existing prerequisites provide grounds to hope that obtaining longer-term temporal variations will enable revealing the features of vertically ascending fluid flows that accelerate karst–suffosion processes, one of the major geoecological hazards of the region.

Thus, our two-week monitoring of geodeformational processes by emanation and seismic emission methods in a geodynamically active area in Nizhni Novgorod oblast compared to the analogous monitoring results for Moscow led us to the following conclusions:

1. There is a weak but significant correlation between the emanation fields in sites spaced more than 300 km apart. The sign-variable and undulatory sliding correlation suggests simultaneous fluctuations in the fluid flows at the observation sites and the operation of processes responsible for certain local characteristics of fluid transfer in tectonically decompressed areas of the sedimentary cover.

2. The character and intensity of seismic noise effect on the dynamics of the emanation (radon) fields at the observation sites significantly differ, indicating that fluid flows in Moscow are modulated by a powerful flow of the urban seismic noise, while that at the obser-

Periods of the most representative constituents of the spectrum of temporal variations in measured parameters and relative amplitudes of their extreme values

Measured parameters	No/T (day) A (rel.u.)	1 (day)	2 (h)	3 (h)	4 (h)	5 (h)	6 (h)
Radon	T	10.7	56.8	32	12.2	8	–
	A	275	157	185	90	71	–
Radon	T	4.3	42.7	20.4	14.2	9	–
SWC	A	752	350	116	124	83	–
Hydrogen	T	10. 7	–	24.3	11.9	8	6
	A	561	–	1802	190	70	75
Hydrogen	T	7.1	64	27	22.3	13.8	7.6
SWC	A	778	868	350	357	232	81
Seismic noise	T	7.1	–	23.5	–	9	6.5
	A	204	–	329	–	96	105
Seismic noise	T	4.3	25.6	22.3	14.2	10.7	8.5
of SWC	A	1200	321	266	194	114	92

vation site in Nizhni Novgorod oblast is modulated primarily by the forest and climatic conditions.

3. The various permeability anisotropy of the sedimentary cover at the observation sites caused by the influence of tectonic structures of different morphology and size define the response of the emanation and seismic emission fields on the geodeformational processes of different nature. In Moscow, this reaction is expressed more clearly and is more adequate than at the observation site in Nizhni Novrorod oblast.

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