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Fluid dynamic effects in variations of radon seismic noise and telluric current fields

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At measurements of the geophysical fields having different origin where unknown effects of fields reaction on the fluid dynamic regimen change of the sedimentary cover in the point of investigations established.

Key words: geostructural elements karst-suffosion processes, fluid- transmission, seismic noise, subsoil radon magnetotelluric current

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In the investigations development on studies the effect of different geodeformation processes on the fluid dynamic regimen in the fault geostructural formations of the East European platform in August 2005 we conducted comparative measurements of the emanation (radon) and seismoemission fields variations and variations of magnetotelluric field in the point, located in Nizhny Novgorod oblast. The choice of the area to conduct investigations is related to the fact that the regional structural-tectonic features of the geological environment in the observation point, determining the dynamics of the fluid transportation in tectonically decompressed sediments, are forming by a zone of dynamic influence of regional arcade fault [*Makarov,1996*], bounding the morphostructural complex sedimentary cover neighborhoods of " Holy Lake ", on the south bank of which observations were made. Moreover, in the upper floors of stratigraphic sedimentary complex, presented a power layer of carbonate rocks, overlaid by a slight layer of sandy sediments, in point of observation are identical to those which are characterized by intensive development of karst-suffusion processes in Dzerzhinsk [*Natural hazards,2002; Mudler and others, 2004*], representing one of the major geo-ecological problems of the city. Moreover, in the environs of "Holy Lake" karst is also manifested by numerous sinkholes of various sizes and ages, reflecting the permanent nature of modern geodynamic activity in the territory that forms its morphological appearance. Therefore, the choice of place of observation, located at a considerable distance from industrial sites and cities, is exceptional in terms of assessing "natural background" and the possible anomalous effects in the measured parameters of the studied fields.

Monitoring of the subsoil radon concentration variations in the point of observation was carried out using passive (in situ without sampling) continuous measurements using the original sensor installed to a depth of 1 meter. Measurements of seismic noise were carried out using geophones CB-5, buried next to the radon sensor. The measurements of the magnetotelluric field variations were carried out in situ with the help of contour beyond the induction variometer with a diameter of 0.2 m on the inductance 1Gn and the resonant frequency of 5 kHz. Record of information received from the sensors was carried out using a microprocessor 12 bit device "Logger" with a frequency of 1 minute survey. Than, after the transfer of data in computer memory recording the results were averaged in intervals defined in the subsequent analysis of spectral characteristics and interrelation dependencies derived time series.

Fig. 1 shows a comparison of the fragments of continuous recording of the time-series variation of the telluric current subsoil radon and seismic noise envelopes.

Fig. 2 shows the inter-related functions corresponding time-series. Table 1 shows the most representative periods of the harmonic components, selected by the spectral analysis of the temporal realizations.

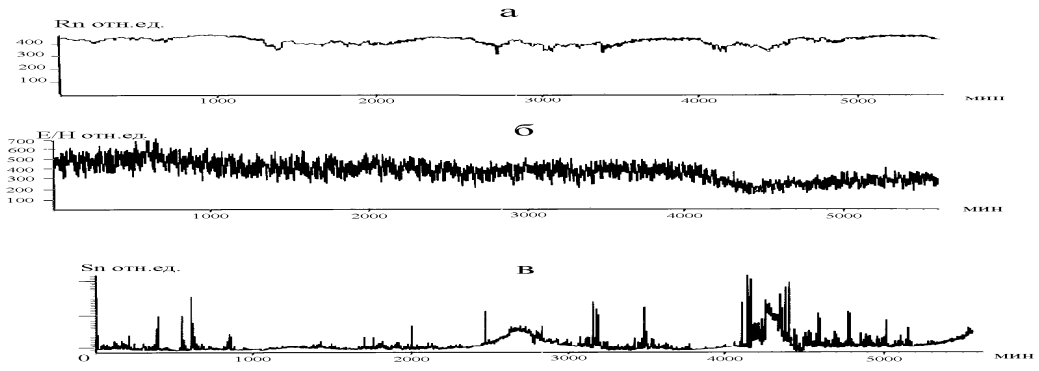

Fig. 1. Time series of variations: a) subsoil radon, b) magneto-telluric current, c) seismic noise in the point of observation. The relative magnitude of measured parameters are given in values of the voltage at the input of the recording device

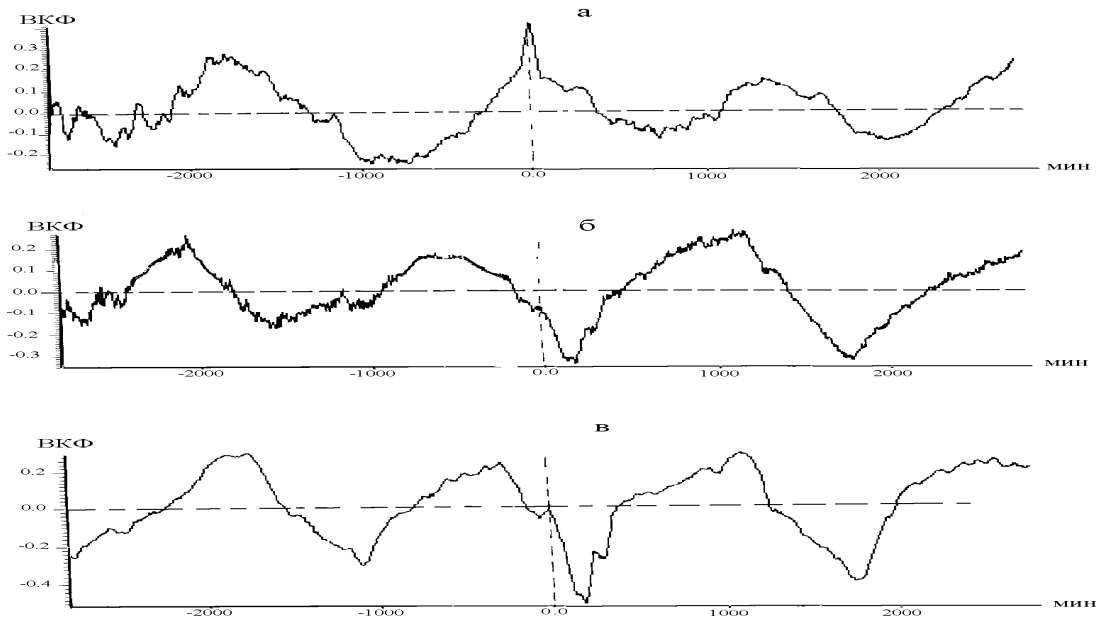

Fig. 2. Interrelation functions of time series: a) variations of radon and magnetotelluric current, b) the variation of magnetotelluric and seismic noise current, c) variations of radon and seismic noise

As can be seen from fig.2, between the time series of subsurface radon and magnetotelluric field current isobserved a significant correlation (R = 0.4) at two-minute delay field magnetotelluric current with respect to variations of the field of radon. This circumstance, in our view, indicates the existence of a common source controlling migration process in an upward fluid flow of radioactive emanations (radon and thoron) and their decay products and the process of forming the components of magnetotelluric variations of current. Such a source, in our opinion, reinforced by the experience of many years research in seismically active regions, is the edge of the capillary fringe above the fluctuating water table, which is sensitive to both the change in pressure in the aquifer, as well as to changes in atmospheric pressure. In addition, the atoms decay of radon, thoron and their decay products alter the conductivity of the capillary moisture, thus changing the magnitude of the electric component of the magnetotelluric current, i.e. its input impedance. Therefore, there is almost synchronous change these parameters – the field of radon and of the magnetotelluric current field.

Meanwhile, a significant negative correlation (R = -0.35) are indicated between the current time series of magnetotelluric current and seismic noise is characterized by the telluric current delay with respect to the noise with an interval of 180 minutes. At the same time, a significant negative

correlation (R = -0.46) was observed between the time series of radon and seismic noise with a delay relative to the noise of radon and 180 minutes. Earlier, similar relationship between variations of the emanation fields and variations of the seismic noise was observed by us in Moscow, where the main component of seismic noise is the noise of the city [*Parshikova et al., 2004*]. In this case, despite the absence of an express part of the daily variations in seismic noise (Fig. 1 d), characteristic of the urban environment, all functions of the interrelation of time provided implementations of circadian components, however, stand out.

Therefore, on the basis of received data the mechanism of formation of the relations of cause and effect in the formation of a dynamic component of the upward fluid flow is represented as a process of modulation affecting of the emanations transfer processes, including the process of forming a dynamic component of the magnetotelluric current, by local sources of seismic noise, existing in the geostructural elements of the sedimentary rocks of the "Holy Lake" neighborhoods. Although this view is not undisputed, it still gives some idea of the geological and geophysical processes occurring in the surface layers of the sedimentary cover, confirming the results of spectral analysis below.

Table 1 shows the components of the spectrum interrelation functions shown in Figure 2., which were obtained after removal from spectrum of the daily dominant, allowing in the time series of considered parameters separate a high frequency harmonics, indicating the nonlinear nature of the processes, confirming the presence in the environment local seismic sources.

Table1. Periods of spectral components interrelation functions of the measured time series of parameters after exclusion of the daily component

R Ref. spectrum	T T2(h)	T T3 (h)	T4 T4(h) (h)	T5 T5 (h)	T6 T6(h) (h)
Radon/current	12 12.4	6 6.8	4 4.9	3. 3..9	2 2.8
C Current/seism	1 11.4	6 6.8	4 4.9	3. 3..9	2 2.8
S Seism/radon	1 12.4	6 6.8	4 4.9	4. 4.0	3 3.3

To reveal more of the fine structure of the interdependence of the investigated time series were calculated by the correlation function of a sliding window width of 1.8% on the value of time realizations and calculate their spectra, the periods are given in Table 2.

Table 2. Periods of the correlation functions spectra of the sliding time series

Re Ref. spectrum	T1 T1(h)	T T2(h)	T T3(h)	T T4(h)	T T5 (h)	T T6(h)
Radon/current	2 27.3 12.4	12.4	9.1	4.9	3.25	2.6
Current/seism	27.3	13.7	5 5.5	4 4.3	3.25	2.8
Se Seism/radon	22.8	8.0	5.5	4.0	2.8	2.6

As follows from the data, with the overall positive correlation between these time series of radon and magnetotelluric current relationship between them is of alternating sign. The values of the correlation function reaches almost one hundred per cent level as for direct, so for inverse relationship of the parameters. A similar pattern (for a total of negative correlation) observed for the time series of telluric currents and seismic noise, as well as for time series of radon and seismic noise.

The periods of variations of components of investigated time series, are listed in Table 2, do not always coincide with periods of harmonics in Table 1, which apparently indicates a more diverse combination of factors determining the dynamics of fluid transportation in the point of measurements. However, the interrelation relationship between the variation of the field of radon and the field of seismic noise in the point of observation, as well as correlated with the field of radon field in one of the components of the spectrum of magnetotelluric currents is significant. However, in contrast to that

observed previously in Moscow [*Parshikova, et al, 2004*], this dependence can not be explained by variations in the urban seismic noise acting on the dynamics of the ascending fluid flows, as the nearest of the "Holy Lake" town Murom is located about 30 kilometers on the opposite bank of the river Oka, absorbing the noise of the city. Interecorrelation connection between the fields of radon and seismic noise, as well as between the fields of seismic noise and telluric current is an alternating character, changing from wavy significant positive to significant negative values. Such variation of the correlation coefficients between the fields of seismic noise and emanations of radon and magnetotelluric current can be attributed to the nature of the changes fluid transportation under of the stress-strain state of rocks changes in the structural-tectonic formation in the area of dynamic influence of which is the point of observation. The influence of the above named regional arcade structural-tectonic formation on a nature of the sedimentary rocks anisotropy permeability the environs of the "Holy Lake" and, respectively, on the dynamics of the rising fluid transportation, studied by us via the radial-azimuth surveys, does not have an explicit nature. This type of the anisotropy permeability formation of the sedimentary cover was noted in the area of the annular geostructural formation [*Kozlova and others, 1999*], when deformation of the sedimentary cover rocks have no pronounced one or two-way orientation. At the same time, the spectral analysis of time series (see table) shows the effect of the tidal deformations on the dynamics of the vertical components of fluid transportation that is manifested by the presence of the time series of the periodic spectral components of the diurnal and semidiurnal harmonics.

Thus, the existing preconditions for the establishment in the studied fields the more fine structure of the interaction of hydro and physic-chemical processes allow us to hope that getting a longer time series will allow implementations to identify those features of the formation vertically upward fluid flow, which occur under the influence of the processes that accelerate the development of karst-suffusion phenomena of one of the major geo-ecological problems of the region. In this case, the results of complex monitoring of the fluid dynamic processes using measurements of variations of emanation and seismoemission fields, together with the registration of high-frequency component magnetotelluric currents, carried out in geodynamic active area of the Nizhny Novgorod region, showed that on the basis of the data, one can create an effective set of monitoring of the geological environment and development of geo-ecological processes.

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