Vestnik Otdelenia nauk o Zemle RAN, VOL. 3, NZ6084, doi:10.2205/2011NZ000214, 2011

Comparative analyses of the radon and hydrogen fieldes in conditions of the seismoactive and platform regions

V. P. Rudakov, V. V. Tsyplakov
Schmidt Institute of Physics of the Earth RAS, Moscow
rudak@mail.ru, tel.: 8 (499) 254 9006

Key words: emanational monitoring, tidal deformations, spectral analyses

Citation: Rudakov V. P., V. V. Tsyplakov (2011), Comparative analyses of the radon and hydrogen fieldes in conditions of the seismoactive and platform regions, *Vestn. Otd. nauk Zemle, 3*, NZ6084, doi:10.2205/2011NZ000214.

We have previously shown that, realizing requirements of technology developed for the purpose of seimoprognostic emanation measurements, allowing measurement of variations of the earth crust deformation at the level of tidal disturbances, one can monitor the processes of regional and global changes in the stress-strain state of the lithosphere during periods of anticipating and accompanying the release of seismic and volcanic energy [*Rudakov,* 2009].

In development of methodological aspects of assessing the reaction of the fluid dynamic systems of fault structures of the Earth's crust to the processes of preparing geodynamic events the comparative analysis of time series of the emanation (radon and hydrogen) fields variations obtained in the geodynamically active region (Kamchatka) and passive seismic conditions of the Russian Platform (Moscow syneclise) have been made. Spectral components of time series data were compared with the results of spectral analysis of laser deformometry obtained in the Caucasus [*Miljukov, et al.,* 2007].

Continuous monitoring of the fluid dynamic regime variations of the Moscow depression was carried out in the area of dynamic influence of faults intersecting at the center of Moscow on radon and hydrogen emanations [*Rudakov, Tsyplakov*, 2008] using the original technology, which provides registration geodeformation processes at the level of 10^{-8}. Similar measurements were carried out on the Kamchatka Peninsula, near the village Paratunka where the geodynamic activity of the territory permanently appears by the output on the surface of the thermal mineral waters sources [*Firstov,* 1999].

Analyzed fragments of time series of simultaneous recording of these parameters (Fig. 1) represents the results of quasi-continuous records averaged at hourly intervals, a total duration of 13510 hours, i.e. more than 1.5 years.

Comparison of time series of the emanation fields obtained on the Kamchatka Peninsula and in the Russian Platform by calculating the sliding correlation function shows a certain general character of the geodeformation processes that determine the regimen of the fluid transmission in obviously different geodynamic conditions. This is indicated by correlation between the analyzed parameters (Fig. 2), which in the intervals that are multiples of the seasonal cycles lasting several months, ranging from one hundred percent positive to one hundred percent negative.

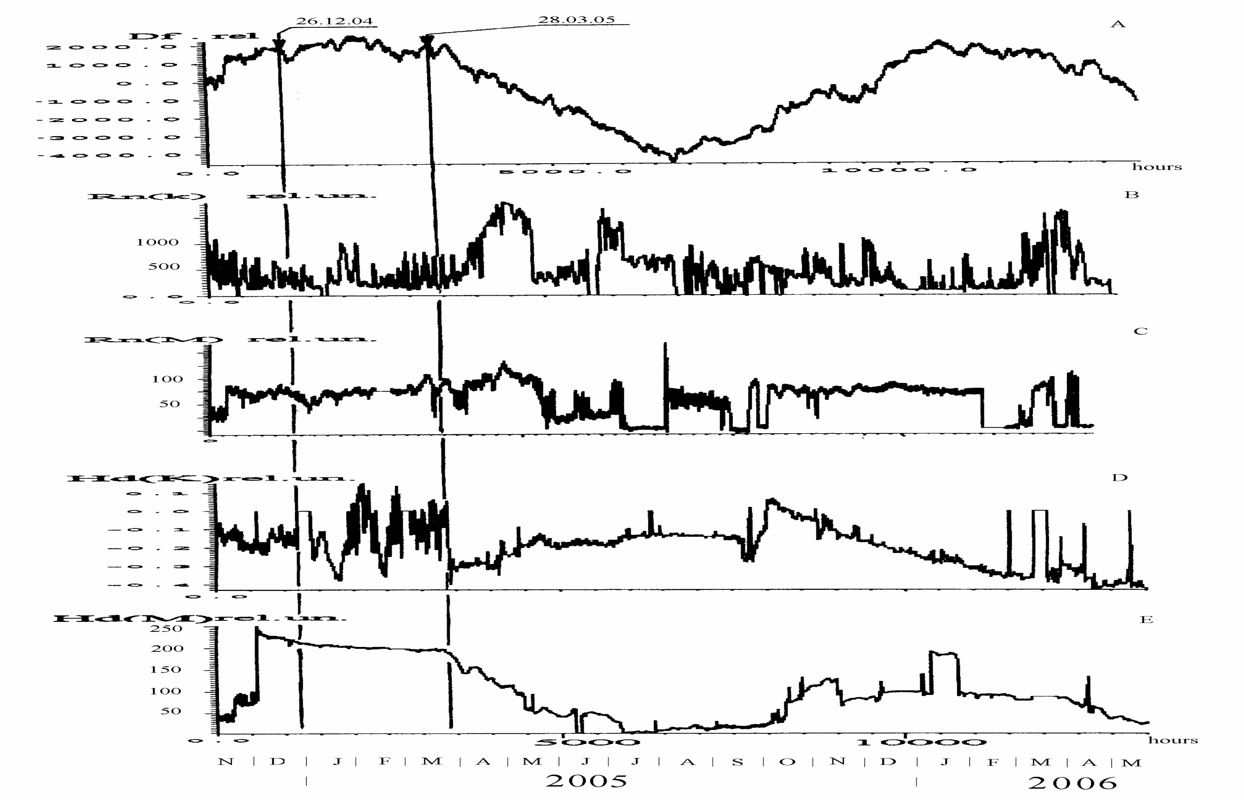

Fig.1. Time series of variations: a) deformation of rocks in the Caucasus, b) radon in Kamchatka, c) radon in Moscow, d) of hydrogen in Kamchatka, e) of hydrogen in Moscow. Arrows indicate the moments of catastrophic earthquakes in the Indian Ocean

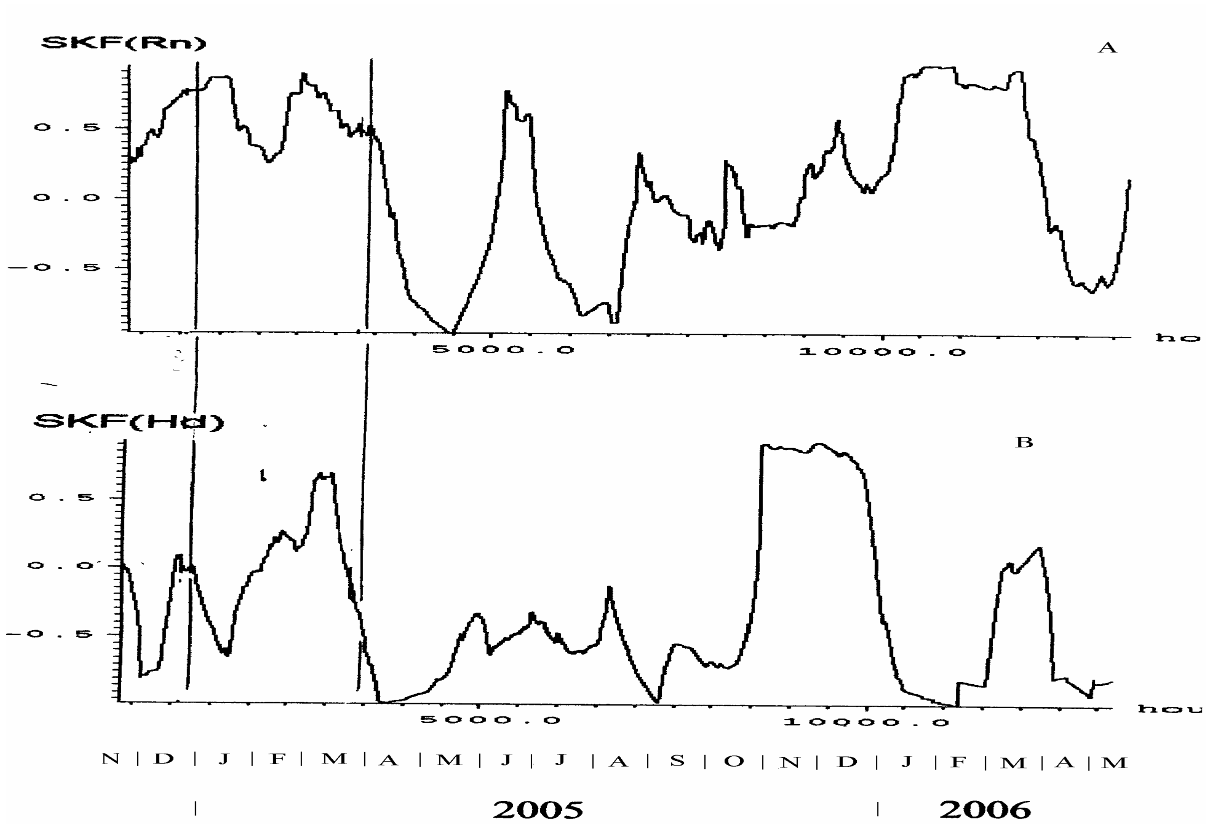

Fig.2. Graphs of the sliding correlation functions of time series: a) radon, b) hydrogen received in Kamchatka and in the Moscow depression

And, for the time series of radon a wholly positive correlation is observed from December to March and negative - in April - May. At the same time, the time series of hydrogen absolutely positive correlation is noted in late February - early March and from November to December, and negative - from August to September and from January to February. At the same trend components of the strain in the Caucasus and strains defending the fluid transmission in the Moscow depression and on Kamchatka, have a pronounced seasonal (annual) character.

Spectral analysis of the time series of deformometric measurements, filtered in the tidal range of frequencies with periods from 30 to 5 hours and subsequent spectral analysis of time series interrelation functions fields of radon and hydrogen within the selected fragment made it possible to identify the components of the measured parameters in the variations spectrum due to lunar solar tides (Table 1). The results of this identification, indicate the adequacy of global mapping geodeformation processes, which are primarily terrestrial tides, in the measured parameters of the geosynclinal (seismically) and platform regions. In addition, as shown in the table, the nature of the response emanation fields on the tidal deformation of the earth's crust in the most characteristic components of the spectrum is almost identical to the character of deformation in the Caucasus mountain massif detected by the deformometric observations.

Table 1. Tidal components of the mutual correlation spectrum of the filtered data in the Baksan laser strainmeters and variations of radon and hydrogen in Moscow and Kamchatka, in comparison with the tidal components of the deformometry data (1stitch)

	T hour	A(rel) $*10^{-3}$	T hour	A(rel) $*10^{-3}$	T hour	A(rel) $*10^{-3}$	T hour	A(rel) $*10^{-3}$	T hour	A rel $*10^{-3}$	T hour	Arel* 10^{-3}
Def.			25.75	0.7	24.0	0.7	12.7	0.13	12.4	2.6	12.0	0.5
1rd/d.	26.9	0.08	25.75	4.9	24.0	0.35	12.7	0.1	12.4	0.6	12.0	0.17
1hd/d.	26.9	0.04	25.9	0.2	24.0	1.1	12.7	0.02	12.4	0.15	12.0	0.09
2rd/d.	26.9	0.17	25.75	0.6	24.0	1.1	12.7	0.16	12.4	0.5	12.0	0.6
2hd/d.			25.75	0.13	24.0	0.93	12.7	0.04	12.4	0.2	12.0	0.3
Km/rd			25..9	1.0	24.0	1.85	12.7	0.11	12.4	0.8	12.0	2.0
Km/hd	26.9	0.3	25.8	1.6	24.0	1.6			12.4	1.1	12.0	0.5

Legend: 1 rd, 1hd – sensors of radon and hydrogen in the first point of measurement; 2 rd, 2 hd – radon and hydrogen sensors in the second point of measurement in Moscow. Km /rd – radon in Kamchatka; Km /hd – hydrogen in Kamchatka

To mark out the low-frequency variations of the radon and hydrogen fields, similar to the corresponding components of the earth crust deformations the envelope of the filtered data of the strainmeter records was obtained, on which the spectrum envelope of the tidal deformations was calculated used for testing the mutual spectrum of the radon and hydrogen fields (Table 2).

Table 2. Spectral components of mutual-correlation spectrum of variations of the envelope of the filtered data series of laser strainmeter in Baksan and variations of radon and hydrogen in Moscow and Kamchatka

LD, T	28.4d	14.8d	26.9h	25.8h	24.0h	22.4h		12.9h	12.4h	12.0h	8.4h	8.2h	8.0h	6.2h	6.1h
A($*10^{-3}$)	2.8	8.7	1.7	6.6	6.3	2.2		0.7	1.2	0.5	1.2	1.2	0.6	1.6	1.2
KRd, T	27.3d	14.5d		25.8h	24.0h	22.4h	16.5h		12.4h	12.0h	8.4h	8.2h	8.0h	6.2h	6.1h
A($*10^{-3}$)	13.8	8.4		11.7	9.6	4.3	1.4		0.7	1.1	0.4	0.43	0.4	0.5	0.6
1Rd, T	27.3d	14.8d	26.9h	25.8h	24.0h	22.4h	17.3h		12.4h	12.0h	8.4h	8.2h	8.0h	6.2h	6.1h
A($*10^{-3}$)	14.7	28.7	3.5	17.8	10.0	5.7	0.2		0.2	0.6	0.1	0.25	0.05	0.15	0.15
2Rd, T	27.3d	14.5d	26.9d	25.8h	24.0h	22.4h	17.2h	12.9h	12.4h	12.0h	8.4h	8.2h	8.0h	6.2h	6.1h
A($*10^{-3}$)	12.1	11.6	0.7	2.1	4.0	0.6	0.3	0.2	0.13	0.12	0.1	0.23	0.1	0.2	
KHd, T	27.3d	14.8d	13.9d	25.8d	24.0h	22.4h	16.6h		12.4h	12.0h	8.4h	8.2h	8.0h	6.2h	6.1h
A($*10^{-3}$)	17.6	19.2	10.0	2.9	1.6	0.7	0.1		0.1						
1Hd, T	28.4d	14.5d	26.9h	25.8h				12.8h	12.4h		8.4h	8.2h		6.2h	6.1h
A($*10^{-3}$)	3.0	7.6	0.13	0.6				0.05	0.05		0.06	0.05		0.03	0.04
2Hd, T	28.4d	14.5d		25.6h	24.0h	22.4h		12.8h	12.4h	12.0h	8.4h	8.2h	8.0h	6.2h	6.1h
A($*10^{-3}$)	5.6	11.4		0.4	2.4	0.2		0.07	0.06	0.06	0.05	0.04	0.05	0.06	

Legend: LD – laser deformograph; KRd – radon in Kamchatka; 1Rd (1Hd) – first radon detector (hydrogen) in Moscow

And this testing (as shown in table) also reveal subordination of the fluid transmission in the geodynamically differing regions to influence of the planetary geodeformation processes determined primarily by the tidal influence of the moon and sun. At the same time, as can be seen, the spectral composition of the emanation field's time series is somewhat different from deformometric data that is associated with the technology of emanation measurements that can extract information about the volumetric massif deformations, whose spectrum is much richer the spectrum of linear strain. Apparently, this also explains the nature of the emanation field's reaction (Fig. 1) to global change of the stress-strain state of earth's crust, triggered the release of seismic energy near the island of Sumatra on Dec. 26, 2004 and on March 28, 2005. The level of seismic energy release during these earthquakes reached 9-ball marks on the Magnitude Scale, reflecting the extraordinary geodeformation processes involved in their preparation, and, apparently, affecting the Earth's crust as a whole.

As can be seen from figure 1, the disposition of the emanation fields reaction in Kamchatka and the Russian platform and strains in the Caucasus on the global changes of the stress-strain state of earth's crust, triggered the release of seismic energy in the Indian Ocean, are significantly different. So in the field of the hydrogen field of Moscow depression practically one month prior to tragic events there was a sharp jump, five times exceeded level of the concentration of previous months. In a field of radon this effect was on the contrary noted more than double (on fig.1 it is not shown because of limitation of the time series) by reduction of the concentration level [*Rudakov, Tsyplakov*, 2008]. In Kamchatka, the field of hydrogen and radon have changed at this time is not so anomalous. However, almost one hundred percent correlation between the fields of radon before the events in December 2004 and March 2005, as well as wholly-correlation fields of hydrogen in March 2005 in the points of measurement, separated by a distance equal to nearly one third of the globe perimeter, show the global nature of the stress-strained state of the earth's crust, caused the catastrophic events in the Indian Ocean.

After the earthquake realization on 28.03.05 within 3 months there was a decrease of the hydrogen concentration up to initial, and the next months practically up to a zero level. Concentration of radon on an initial level has not returned, that, probably, is connected with descending trend in the emanation fields time series, connected with the wave geodeformation processes influence of the higher hierarchical level [*Rudakov*, 2009]. In addition, it confirms that the field variations of radon mediated variations of the hydrodynamic regimen of tectonic structures that are used for fluid dynamic monitoring, while the field variation of hydrogen directly reflect the regimen of earth crust deformations [*Rudakov, Tsyplakov*, 2008].

In the deformometric measurements the effect of global changes in the stress-strain state of the Earth's crust emerged in the results of the joint analysis of records obtained in the Caucasus and in the settlement Protvino (Moscow region) [*Latynina, et al*, 2006], in which the period of preparation and implementation of the earthquake is characterized by a monotonous change in the registered parameters.

Consequently, according to the fluid dynamic (emanation) monitoring of the geodeformation processes in the geodynamically active region – in Kamchatka and in the Russian platform, based on data deformometric observations in the Caucasus, in the preparation and realization of catastrophic geodynamic events such as, for example, earthquakes near the island Sumatra on Dec. 26, 2004 and March 28, 2005, the processes of the global change in the stress-strain state of the crust are involved. The rational use of data tracking changes in fluid dynamic regimes of the geostructural formations in the geodynamically active and platform regions allows to control these processes and predict periods of the seismotectonic areas formation of rock's massif destruction.

The authors express their gratitude to the worker of SAI, Dr. Science Miliukov VK for the provision of laser deformometry data and for his attention to the work, as well as to the worker of the Institute of Volcanology and Seismology Dr. Science Firstov P.P. for the provision of emanation monitoring data in Kamchatka and fellow-fightering in the emanation investigations.

References

Firstov, P. P. (1999), Monitoring of the volume activity of subsurface radon (Rn-222) on Paratunka hydrothermal system in 1997-1998 to search for precursors of strong earthquakes of Kamchatka, *Volcanology and Seismology*, № 6, pp.1–11

Latynina, L. A., V. K. Miliukov, V. I. Vasil'ev (2006), The strongest earthquakes and global tectonic processes, *Science and Technology in Russia*, № 1–2, pp. 4–6.

Miljukov, V.,K., A. V. Kopaev, A. V. Lagutkina, A. P. Mironov, A. V. Myasnikov (2007),. Observations of tidal deformations of the earth's crust in the Elbrus region, *Earth physics, v.43,* № 11, pp. 922–930.

Rudakov, V. P. (2009), *Emanation monitoring of the geoenvironments and processes,* Moscow: Scientific World, 176 p.

Rudakov, V. P., V. V. Tsyplakov (2008), Fluid dynamic effects of the fault structures of the Moscow sineclise in relation to global geodeformation processes, *Geochemistry,* № 11, pp. 1238–1244.