

Atmospheric electricity, geological heterogeneity and hydrogeological processes

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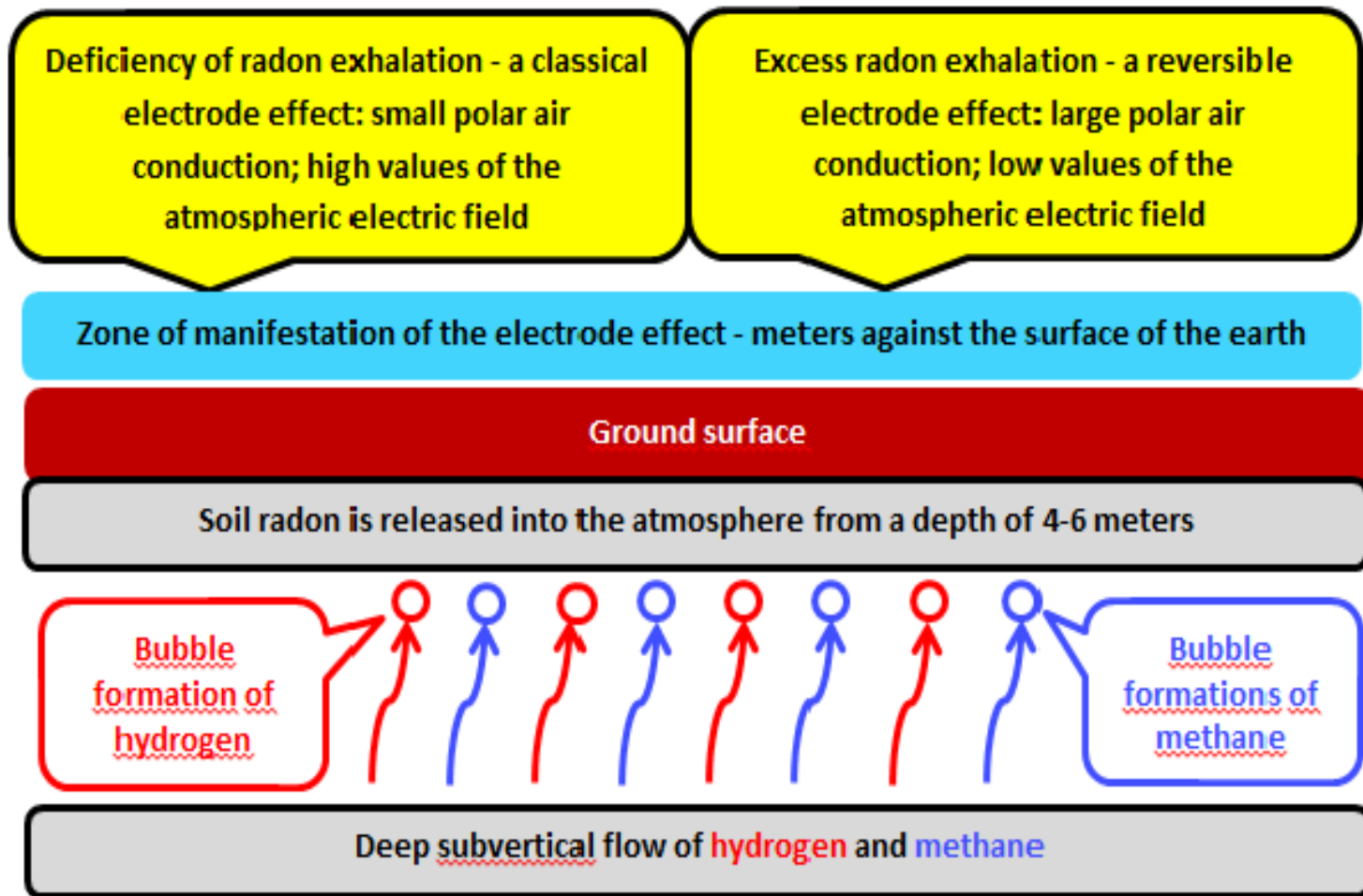
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The subvertical flow of hydrogen and methane captures radon from a depth of 4-6 meters and carries it to the near-surface layers of the soil and the atmosphere.

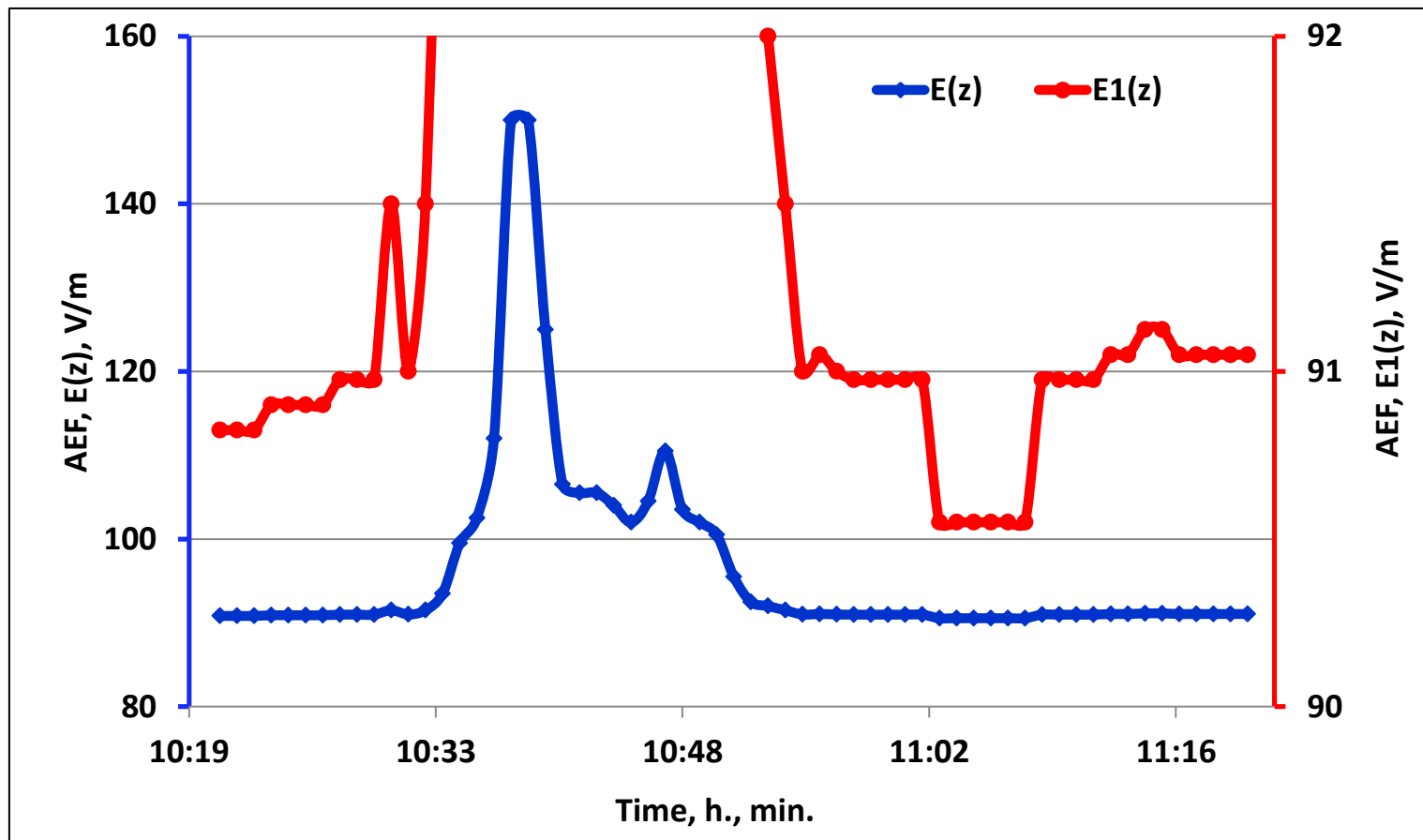
The light ions produced in the ionization process determine the polar conductivities of the air - PC; their recombination with neutral condensation nuclei sets the atmospheric electric field - AEF.



Measuring equipment

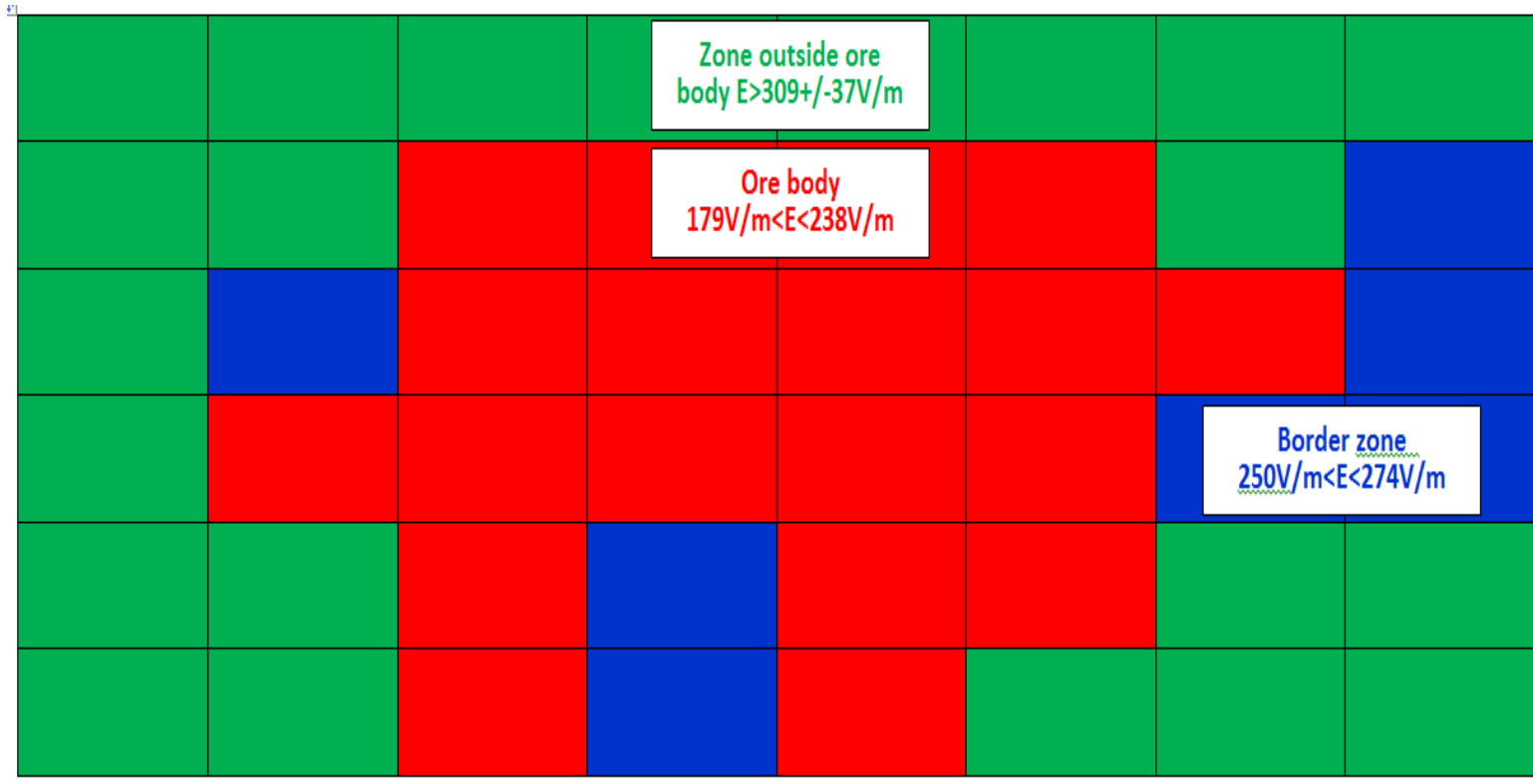
1. When measuring the volume activity of radon in the soil and atmosphere, the RGA-01 sensor was used. The error in the determination of the volumetric activity of radon in each sample after the averaging is reduced to 17%.
2. The atmospheric electric field was registered with «Pole-2» and «Gradient» field mills. The instruments provide the long continuous operation, have two automatically switch able measurement subranges (± 500 V/m and ± 5000 V/m) with the relative error of 5%.
3. Polar air conductivities were measured using an aspirating condenser unit. The relative measurement error is $\sim 10\%$.

The registered variations in the field were the effects of dew evaporation as a result of solar heating, namely, of the injection of neutral condensation nuclei to the surface atmosphere that caused the dramatic increase in AEF

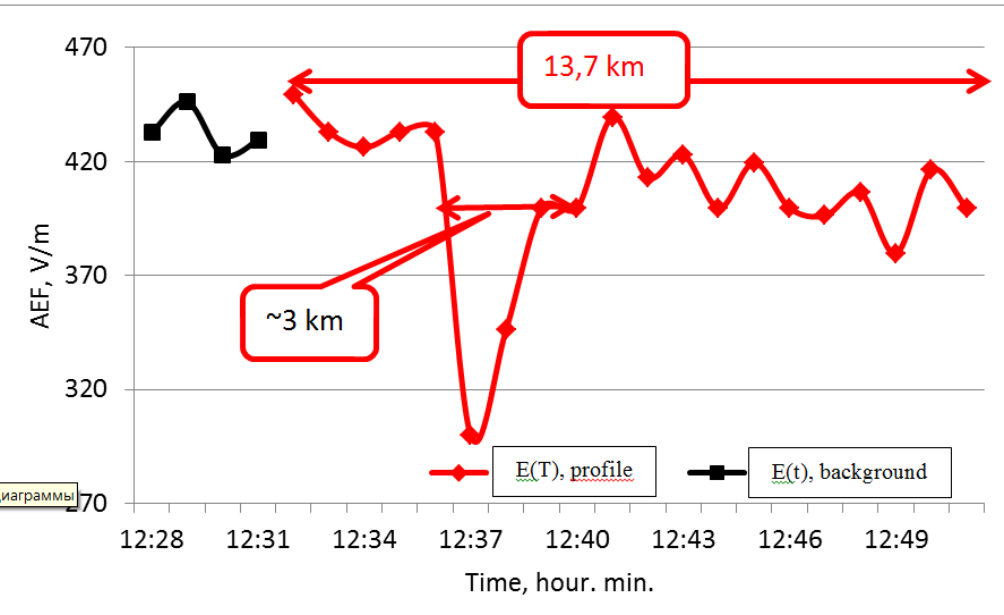


Above the zone of the ore body, a decay of the atmospheric electric field was registered on the order of 100 V/m

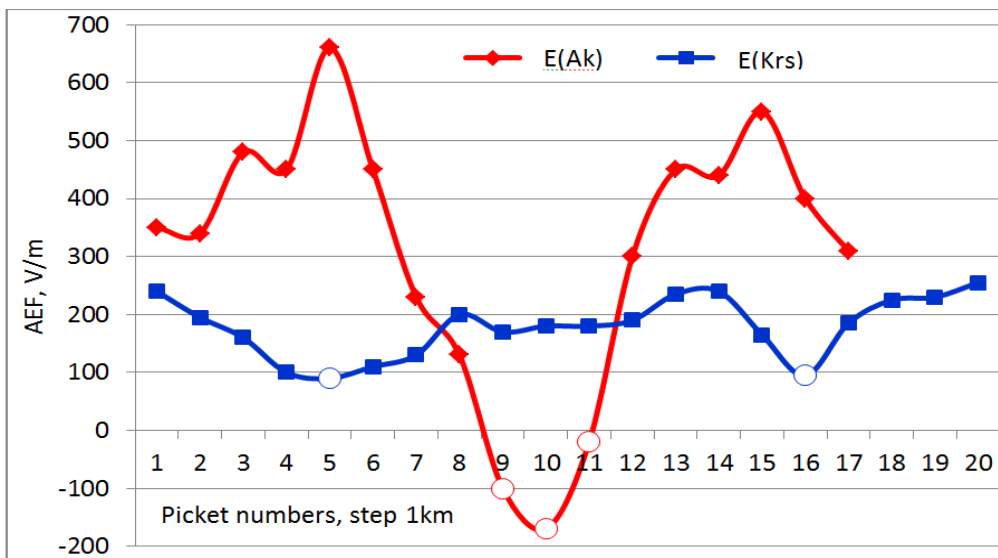
The reason for the observed decline AEF - hydrogen formed at the top of the ore-body at the expense of electrochemical processes.



An increase in the density of the deep subvertical flux of volatile gases, including hydrogen and methane



Increased radon exhalation over the zone of a sharp lowering of the basement roof - a sharp increase in the thickness of sedimentary rocks ~ 3 km (data from the geophysical expedition of Belarus). Reversible electrode effect

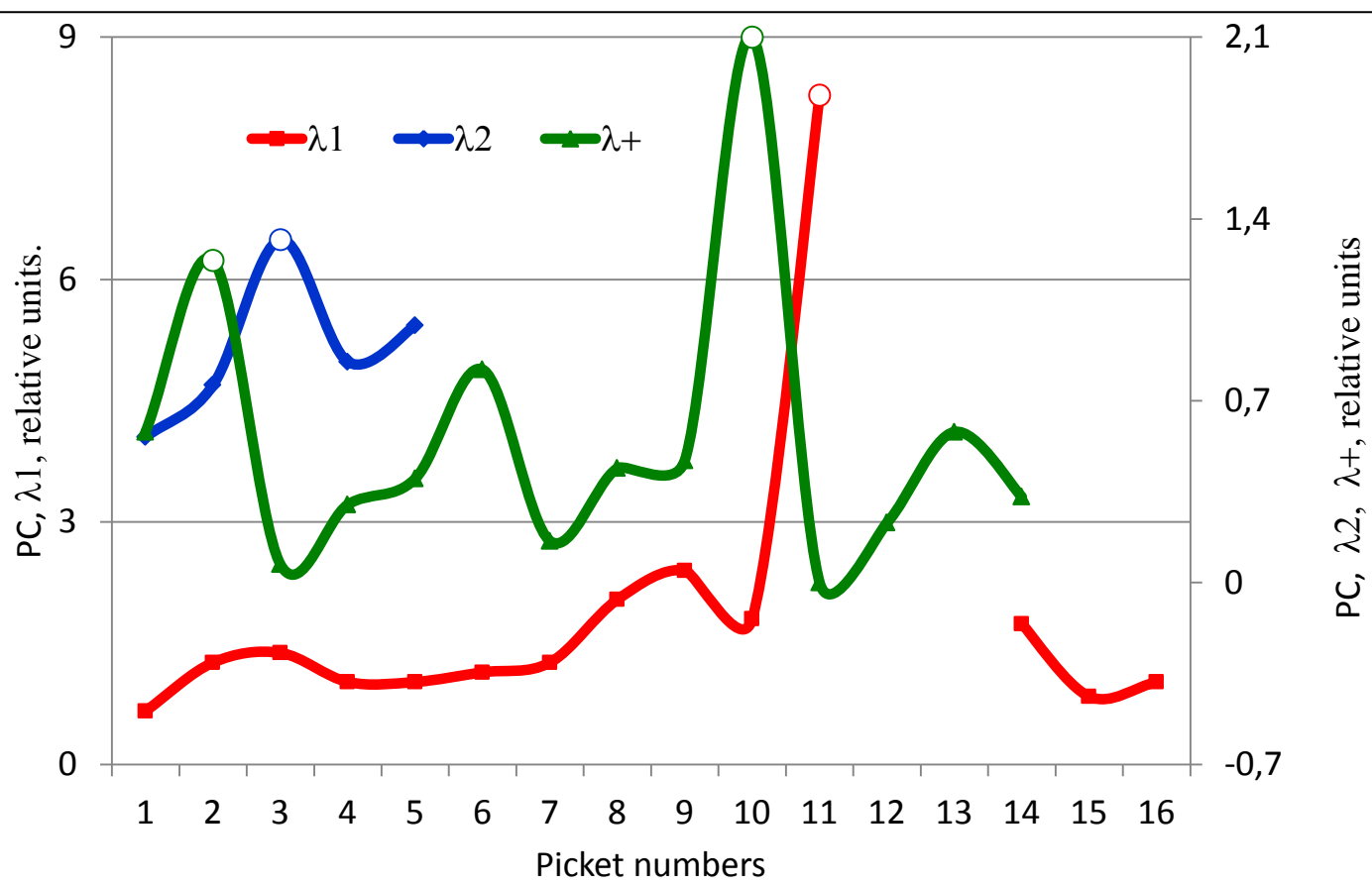


Increased radon exhalation over fault zones:

- the fault zone of the Aktash river $E(Ak)$ (Dagestan);
- the Kaluga ring structure $E(Krs)$. Reversible electrode effect.

Variations in the polar conductivities of air during observations:

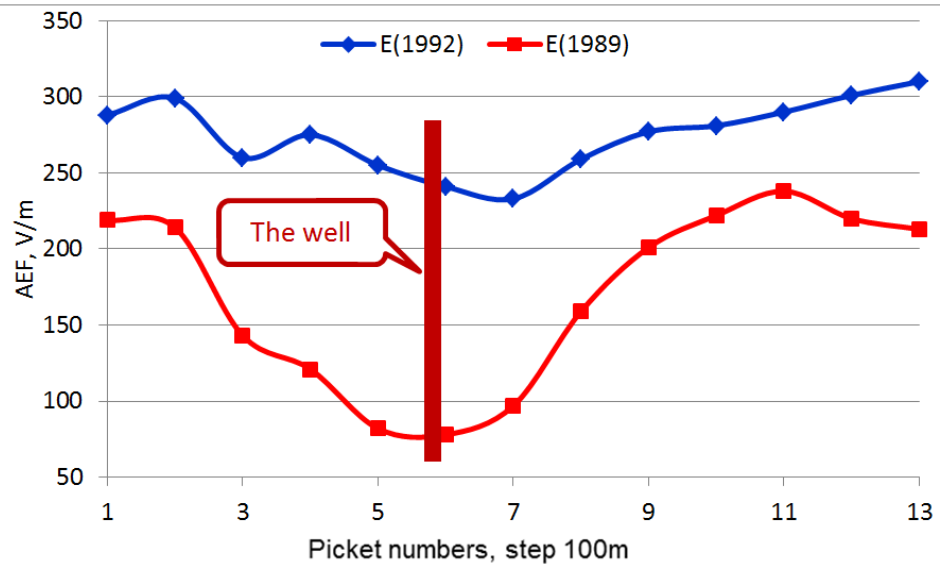
- on the profile in the "cross" with a line of subway metro - λ_1 , metro Kon'kovo, observation step 4 m;
- on the profile in the "cross" with a deep underground line - λ_2 , Metro University, observation step 12m;
- on the horseshoe profile, twice crossing the karst cavity - λ_+ (Tula, Soyuzny lane), the observation step is 4-12 m.



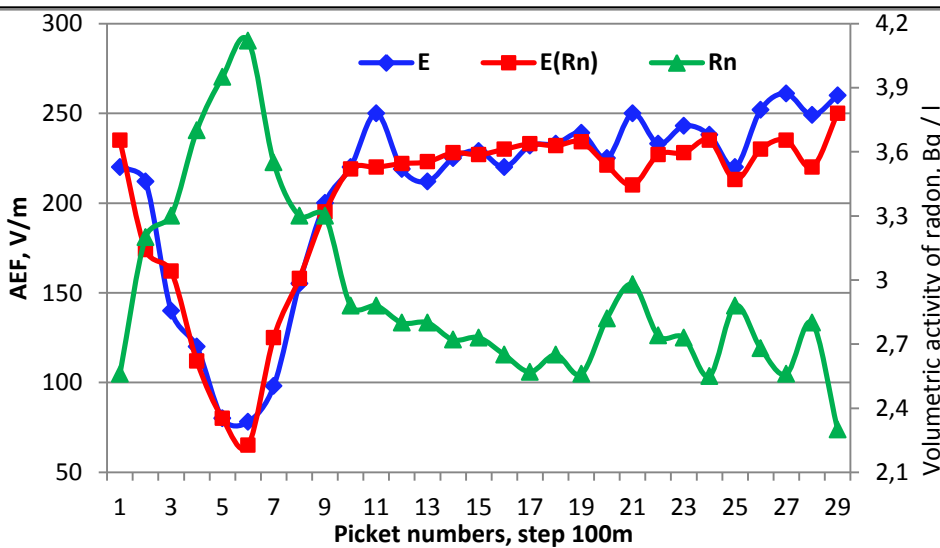
The increased exhalation of radon - the growth of polar air conductivities over the regions of decompaction of the earth's crust

Variations of AEF - E(1989), E(1992) near the well on the 3rd Rechitsa oilfield .

Variations of AEF - E, E(Rn) and volume activity of ground radon - Rn on the Aleksandrovskaya oil deposit (Belarus).

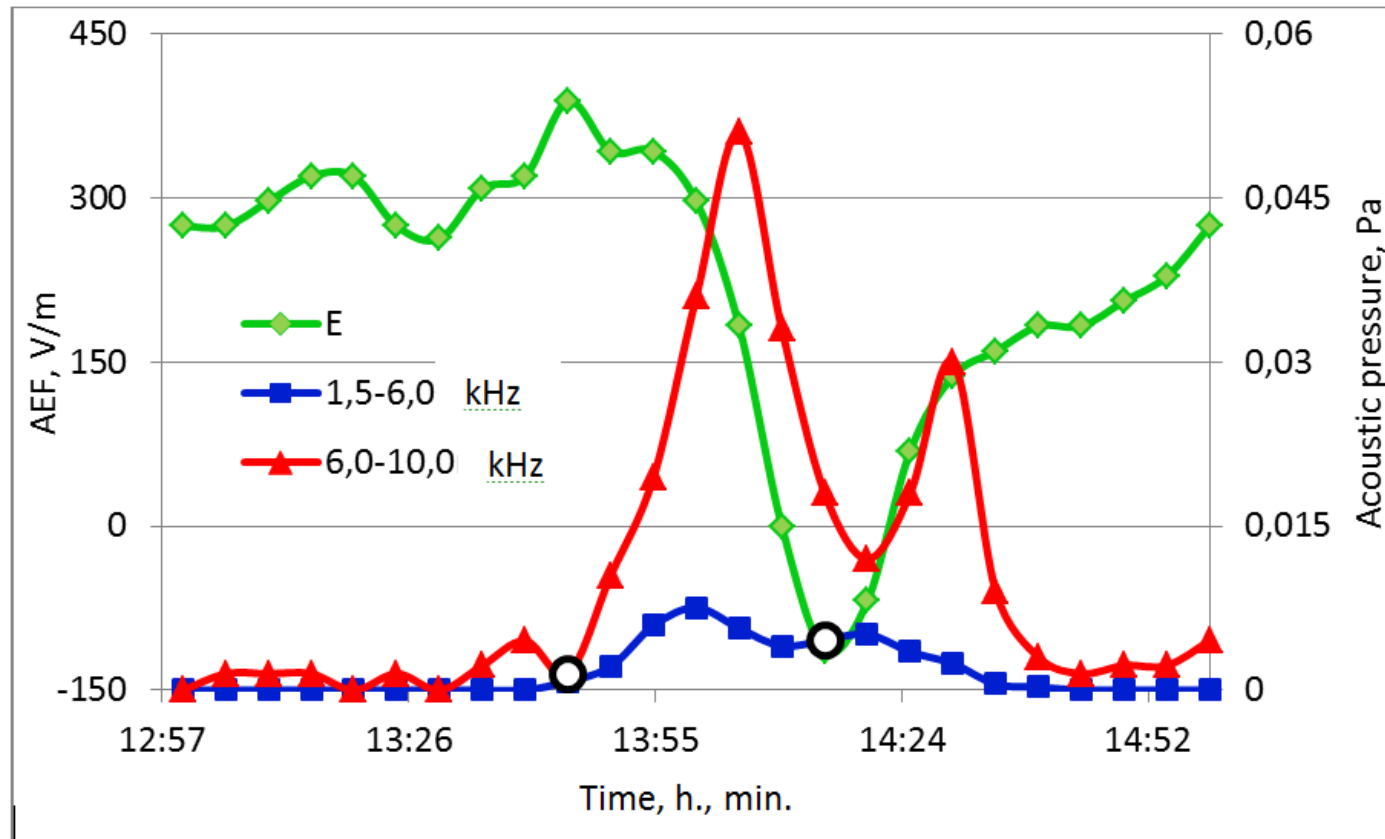


A small subvertical flow of methane is present in plumes of oil deposits. At the 3rd Rechitsa oilfield at the new production well in 1989 and 1992, profile AEF observations were made twice: E (1989) and E (1992)



Simultaneously with observations of AEF - E, the volumetric activity of ground radon, Rn, was recorded at observational pickets. Linear approximations of AEF were constructed, as functions of volumetric soil radon activity - E(Rn).

Decay of AEF as a result of a sharp increase in the pressure of seismoacoustic noise in the ranges 1.5-6.0 kHz and 6.0-10.0 kHz.

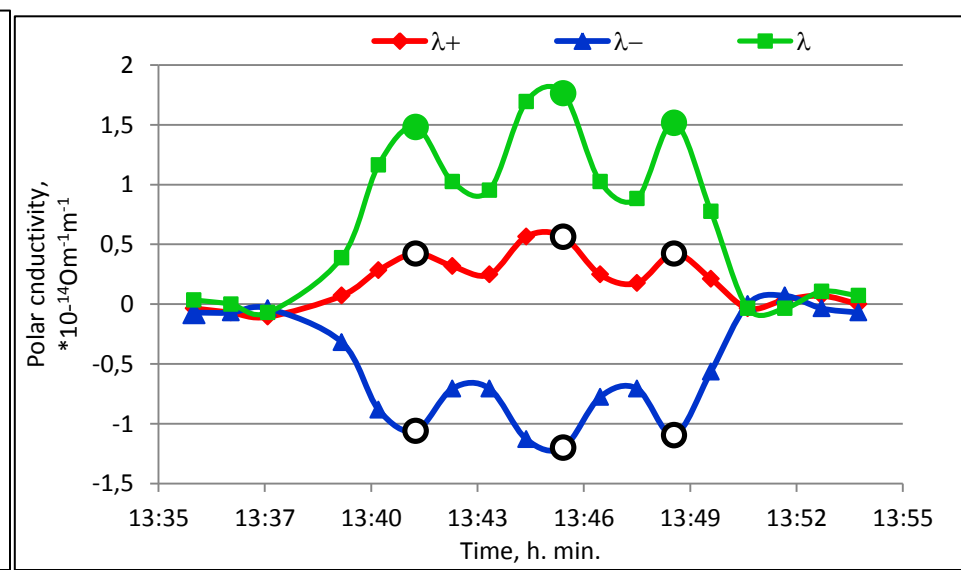
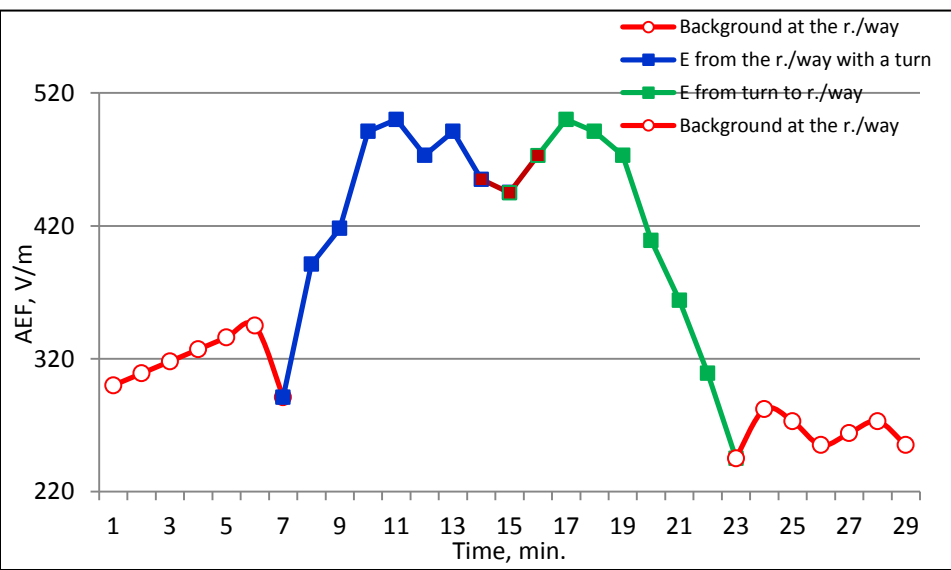


Decay of AEF (increase in radon exhalation) is mainly influenced by acoustic noises of the range 6.0 – 10.0 kHz.

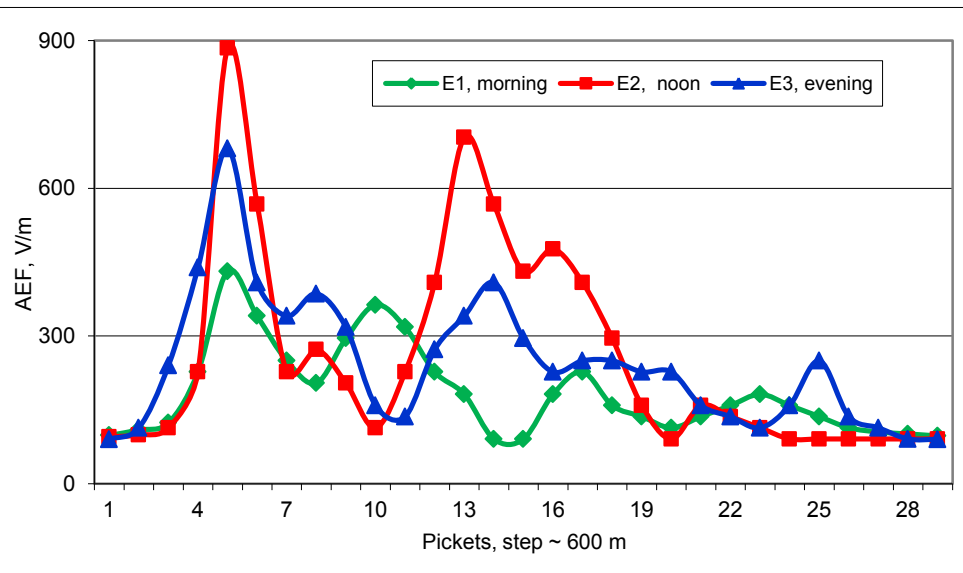
Minimal AEF values take place about 30 minutes after the beginning of acoustic noise growth; approximately at the middle of the lifetime of heavy ions.

Relatively low AEF values for the railway and its subsequent growth when moving along the profile by ~ 200 V/m are determined by the high level of technogenic seismic noise (5-25 Hz) generated by the movement of the rolling stock.

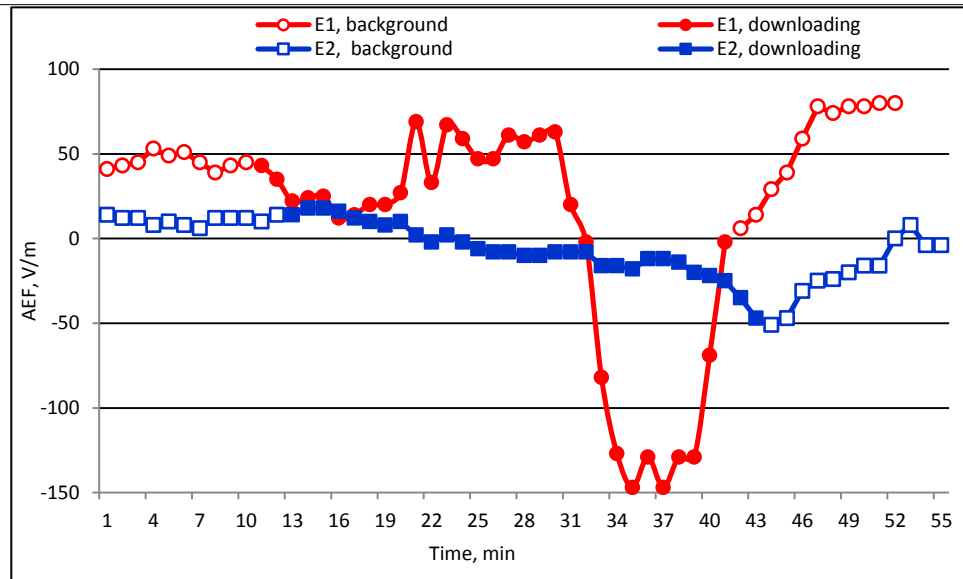
Temporal variations of positive, negative and total PP over the metro line. Intervals $13^{\text{h}}35^{\text{m}} - 13^{\text{h}}39^{\text{m}}$ and $13^{\text{h}}50^{\text{m}} - 13^{\text{h}}54^{\text{m}}$ - record zero level of the PP; $13^{\text{h}}41^{\text{m}}$, $13^{\text{h}}45^{\text{m}}$ and $13^{\text{h}}49^{\text{m}}$ - the passage of the metro trains under the observation picket. Due to the growth of seismic noise during the passage of trains, there is an almost twofold increase in signal levels.



Variation of the atmospheric electric field above the sampling/injection zones of the fluid



Spatial variations of the AEF on the Svetlogorsk-Uznozh highway over the urban water intake zone. Peak values of the field on the traverse of the intake station ~ 400, 900 and 600 V/m. The reason for this is the depression funnel formed in the reservoir during the water intake



Variations of the atmospheric electric field during 1 and 2 cycles of pumping 30 m³ of fluid into the ground to a depth of 50 m. A sharp drop in the signal with a change in the sign of the field ~ [(-140) - (-50)] V/m somewhere in the 20th minute from the start of injection. The reason for this - a powerful local release of the ionizer at the time of formation of hydraulic fracturing - the reverse of the classical electrode effect (See AEP with increasing seismoacoustic noise).

Conclusion:

- growth of gas permeability of rocks in the zone of heterogeneity: fault zones, increase in the thickness of sedimentary rocks, decompaction of the earth's crust (underground engineering structures, karstic cavities), leading to growth of PC and AEF decline;
- presence of a small subvertical flow of hydrogen or methane over the geological heterogeneity: iron ore deposit, oil deposit, underground gas storage, cause AEF decline;
- natural gas deposits possessing high-tight tires, on the contrary lead to a decrease in the density of subvertical flows of hydrogen and methane, which is accompanied by the growth of AEF;
- seismic noise of natural and man-made nature stimulates air-soil-atmosphere air exchange - growth of PC and AEF decline. The effectiveness of the impact will increase with the fall of the oscillation frequency, and reach a maximum under deformations;
- an increase in groundwater level will lead to an increase in soil radon exhalation - growth in PC and AEF decline; the decline in the levels to the reverse process - to the decline in PC and the growth of AEF.

Executed assessments and materials of field observations clearly illustrate the possibility of using elements of surface atmospheric electricity for solving applied geophysical problems.



Thank you for attention