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RADON AND METALLIC AEROSOLS EMANATION BEFORE STRONG EARTHQUAKES AND THEIR ROLE IN ATMOSPHERE AND IONOSPHERE MODIFICATION

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ABSTRACT

One of the widely used techniques for earthquakes prediction research is radon concentration measurements within the seismo-active area. Radon concentration gradually grows during several months before a strong earthquake with a sharp increase few days before and abrupt drop few hours before the shock. This phenomenon usually is restricted to the region where the ground water trapped in the vicinity of the region of the earthquake, hollows out due to stress and escapes through the cracks developed. At the same time electromagnetic precursors exist showing the ionosphere modification before the earthquakes. One of them is the phase variations of the VLF signals passing over the region of anticipated earthquake. As it was shown by theoretical calculations this effect is connected with the changing of the conductivity of the "Earth-ionosphere " waveguide. The second effect is the ionosphere peak electron density variations. Scaled for particular local times (3 h, 6 h, 18 h LT) they show very high level of anti-correlation with the radon variations behavior.

The observed variations imply existence of a coupling between them and radon concentration in the ionosphere. This coupling is interpreted in terms of modification of electrodynamic properties of atmosphere-ionosphere system before the earthquakes over the seismo-active zone. The atmosphere conductivity changes itself cannot explain the observed variations. The submicron metal aerosols emanated from earth together with radon have great influence on the modification processes. The same combination of radiation and dust occurred during Chernobyl atomic plant catastrophe and similar phase variations of VLF transmitters signal were observed when the signal passed over the Chernobyl plant during active emanation of the radioactive dust from the exploded reactor. Radon and metallic aerosols monitoring over the seismo-active regions could be used for strong earthquake prediction, and their effects on the electrodynamics of atmosphere-ionosphere system can explain the observed variations within the ionosphere.

EXPERIMENTAL BACKGROUND

One can see in Figure 1 variations of radon concentration (triangles) measured in the well not far from epicenter of earthquake which happened on Dec., 13, 1980 near Tashkent (earthquake moment is shown at the X-axis by bold triangle). Three other curves show smoothed (running average) variations of peak electron density scaled during several months for three selected local time moments (3 h LT, 6 h LT, and 18 h LT). Anti-correlation for radon concentration and electron density for 18 h LT is evident: radon concentration increases (with sharp maximum few days before the shock) while electron concentration gradually falls with sharp oscillation (minimum before the shock and maximum after) in the vicinity of earthquake moment. Electron density variations for 3 h and 6 h tend to repeat in details variations of radon concentration, while the long time scale variations also anti-correlate with radon variations. The observed coupling of the radon concentration and ionosphere variations are still under investigation, because it is difficult to find direct cause-effect relationship between the two processes. Our estimates have shown that radon, in observed concentration within atmosphere, cannot change the atmosphere conductivity substantially, and therefore cannot be the source of electric field which

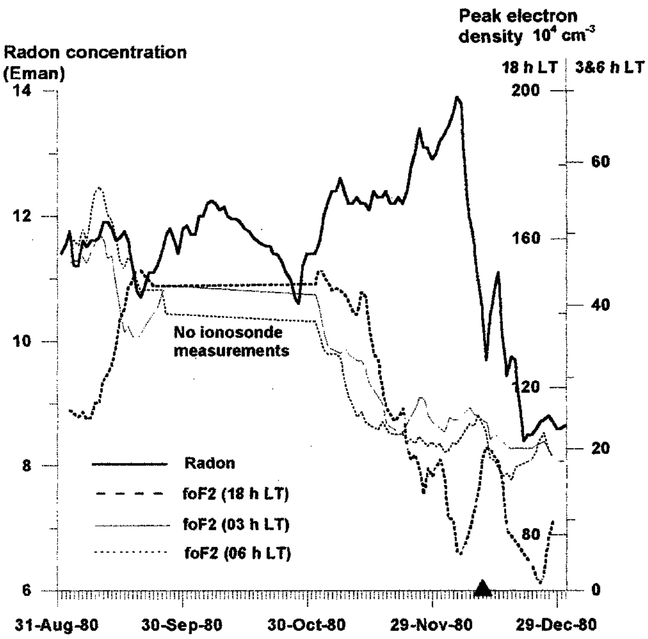

Figure 1 Variations of radon concentration in well and peak electron density of the ionosphere for 3 h, 6 h and 18 h of local time in the vicinity of the earthquake epicentre Earthquake moment is indicated by bold triangle

might be experienced by ionosphere. One of the possible causes of seismo-ionospheric variations was discussed by Pulinets *et al.* (1994): it is metallic aerosols emanating from the crust over the region of anticipated earthquake (Alekseev *et al.*, 1992). It was revealed that metallic aerosols get added to the radon release in the regions of earthquake (Alekseev *et al.*, 1995). So we could regard the radon mainly as a tracer and pay more attention to aerosols from the point of view of ionospheric effects. We will discuss two experimental results which could be regarded as examples for seismo-ionospheric effects. One of them being the phase variations of VLF signal (16 kHz) registered on radio pass Rugby (Great Britain) - Kharkov (Ukraine) during Chernobyl atomic plant catastrophe (Fux *et al.*, 1995). To make our arguments more evident we have to reproduce the figures from the cited paper (see Figure 2). At the upper panel the regular diurnal variations of amplitude and phase are shown for quiet geomagnetic conditions. At the middle panel, one can observe anomalous variations after the sharp increase of reactor temperature (even before explosion). These variations were of the same kind up to the reactor plying. And the lowest panel shows recovery to the normal variations when emanation of radioactive dust into atmosphere was stopped. So, one can mark that radioactive dust strongly changes the electromagnetic properties of the "earth-ionosphere" waveguide. Very similar variations of VLF signal phase are observed in signals passing over the regions of anticipated earthquakes (Gufeld and Rozhnoi, 1992). In this case, we can suppose that aerosols in atmosphere could be the possible cause of ionospheric variations. But the question about the possible causative mechanism of such an effect still remains opened. The answer could be found in results of electric field measurements when studying the atmosphere pollution (Kobets, 1996; Donchenko et al., 1996). It was revealed that the presence of submicron aerosols in atmosphere can substantially increase the atmosphere electric field. Depending on the meteorological conditions this field can increase from the background 200 V/m up to 500 V/m - several kV/m. So combination of radon and aerosols can change background electric field to a great extent: while radioactive emanations increase the atmosphere conductivity, thus decreasing the background electric field, aerosols, in contrary, can increase atmospheric electric field. Sometimes electric fields with opposite sign in relation to the background electric field were observed due to the presence of aerosols in atmosphere (Kobets, 1996)

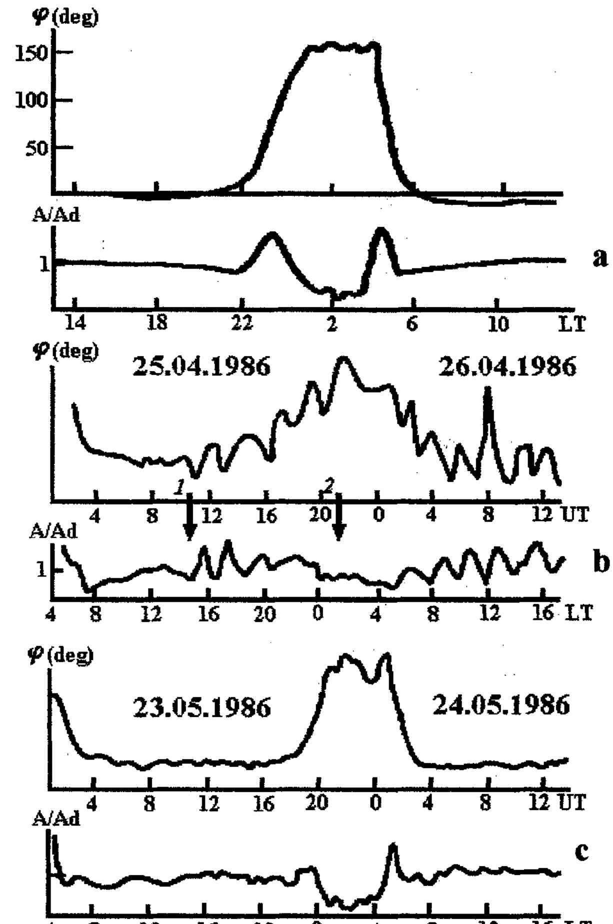

Figure 2 Phase and amplitude variations of VLF signal before Chernobyl incident (a), during incident (b) and after reactor plying (c)

Effect of vertical electric field on the ionosphere was studied by Kim *et al.*, (1995). The vertical electric field on the surface of the Earth leads to generation of horizontal electric field within the ionosphere and as a consequence to modification of vertical distribution of the electron density. 1000 V/m of vertical electric field at the ground level is equivalent to horizontal electric field of order 1 mV/m at the ionospheric heights. Taking into account that the area of the earth surface over the so called «earthquake preparation region» is large: for strong earthquakes its radius is of order 1000 km, and degassing takes place over all this surface, one could expect the large scale modification of electron distribution within the ionosphere both in horizontal and in vertical directions (Pulinets *et al.*, 1994). The main feature of all ionospheric disturbances connected with seismic activity is their dependence on the local time. This effect could be explained as due to the daily variations of solar ultraviolet radiation and connected with it the daily variations of ionospheric plasma convection, particularly O^+. Effectiveness of vertical electric field penetration into ionosphere also changes with local time and is maximum during night-time (Kim *et al.*, 1994). The second feature common to practically all ionospheric precursors is the advance time of their appearance. All precursors manifest themselves with the time scale 3-2 days before the main shock with the maximum amplitude at least one day before the shock.

Observed seismo-ionospheric variations could be explained not only by anomalous electric field effects but by direct penetration of metallic aerosols into ionosphere which are dragged by anomalous electric field. This assumption is supported by experimental measurements showing sharp increase in the occurrence of night-time sporadic E-layers (E_s) before the earthquakes. Formation of such layers is used to be explained by the presence of metallic ions within the ionosphere. The existing model of atmosphere conductivity and ion mobility was used to calculate the time necessary to lift the heavy metallic ions up to ionospheric heights. Our calculations have shown that ~ 4.5 days was needed to lift ions up to height ~65 km by an electric field ~ 1000 V/m at the earth surface. Assuming that the lifting up of the metallic aerosols to be linear with time, 1000 V/m is probably far from limit estimation for the vertical seismogenic electric field, we obtained the reasonable agreement between the time-scale of ionospheric precursors and time scale of dragging of metallic ions into the ionosphere.

CONCLUSION

As it was shown above, radon itself cannot change substantially the electric field within atmosphere and ionosphere but it could be used as a tracer and indicator of preparing earthquake. Taking into account that metallic aerosols emanations about to experience and always accompany the radon emanations we could expect the changes in electric field over the region of preparing earthquake, and hence result in the redistribution of electron density versus height

Satellite monitoring of the ionosphere, especially with topside sounding technique, could be used to obtain the spatial maps of the regions within the ionosphere, disturbed by seismic activity (Pulinets, 1996). Once these results are validated and systematized, they could be used in future for the seismic prediction and warning with the help of satellite technique.

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