



Soil radon and electromagnetic anomalies before the Ileia(Greece) M6.8 earthquake

D. Nikolopoulos (1), E. Voggiannis (2), A. Louizi (3), and A. Zisos (4)

(1) Department of Physics, Chemistry and Material Science, Technological Educational Institution (TEI) of Piraeus, Petrou Ralli & Thivon 250, 122 44, Aigaleo, Athens, Greece (dniko@teipir.gr), (2) Department of Physics, Chemistry and Material Science, Technological Educational Institution (TEI) of Piraeus, Petrou Ralli & Thivon 250, 122 44, Aigaleo, Athens, Greece (svog@env.aegean.gr), (3) Medical Physics Department, Medical School, University of Athens, 11527 Goudi (alouizi@gmail.com), (4) Department of Physics, Chemistry and Material Science, Technological Educational Institution (TEI) of Piraeus, Petrou Ralli & Thivon 250, 122 44, Aigaleo, Athens, Greece

Radon (^{222}Rn) is a radioactive gas generated by the decay of the naturally occurring ^{238}U series. It is considered very important from radiological point of view, since it accounts for more than half of the natural exposure of the general public. Radon has been used as trace gas in several studies of Earth, hydrogeology and atmosphere, due to its 3.82-day half-life (which allows migration at long distances) and its alpha decay (which enables low level of detection). It has been accounted in the search of earthquake precursors, volcanic processes, fluid circulation in karstic sources and in the study of natural ventilation of underground cavities. Radon anomalies impending great earthquakes have been observed in groundwater, thermal waters soil gas and in underground tunnels.

Ileia is a very active tectonic site located in SW Greece, dominated by extensional active seismicity structures (e.g. Alfeios, Neda, Melpia, Kiparissia-Aetos). Its instrumental and felt seismicity is very high, with more than 600 earthquakes of magnitude greater than 4.0 R in the last 100 years two of which occurred during the last 15 years and were very destructive (5.8 R on 26/3/93 and 6.8 R on 8/6/08 respectively). Hence, it is an area benefiting from the installation of a geophysical monitoring station, where radon exhalation associated with the accumulation or release of tectonic strain can be studied.

In the aforementioned consensus, a station for the surveillance of soil radon has been installed in Kardamas Ileias, 3 km south from Amaliada which is the second highly populated city. The station consists of a high precision (calibration certified) active instrument (Alpha Guard-AG, Genitron Ltd.), equipped with an appropriate unit designed for pumping and measurement of radon in soil gas (Soil gas Unit, Genitron Ltd.). Soil radon is driven into AG via a 1-m probe (to minimize meteorological influences) and a 25-m radon proof 25-mm tube (to avoid simultaneous measurement of soil ^{220}Rn -Thoron) with the aid of a mechanical pump working continuously at a rate of 1 L/min. Radon is continuously measured every ten minutes. Additionally, calibrated passive radon dosimeters based on CR-39 Solid State Nuclear Track Detectors (SSNTD's) are periodically (every two weeks) installed in 50 cm holes dug near the 1-m probe and exposed (passively) to soil radon. After the end of each exposure period, the dosimeters are collected and the SSNTD's are measured via standard methods (optical microscopy track counting).

Both methods (active with AG and passive with SSNTD's) provide similar estimates of mean soil radon concentration. Active techniques are much more precise and quick, however, they indicated the necessity of periodical checks for the pumping and measurement status, especially after strong rainfalls. The mean soil radon concentration was found fairly constant (to within +/- 10%) and approximately equal to 25-27 kBq m⁻³. Numerous soil radon concentration anomalies (sudden statistically significant (p<0.001) transient concentration increase followed by consequent decrease) were detected. These anomalies were arbitrarily corresponded (in terms of magnitude and duration) to seismic events of the near area. A very interesting anomaly (magnitude of 400-500 kBq m⁻³, duration of 30-40 min) was detected about three months before the catastrophic 6.8 R earthquake (8.6.08). Similar finding (of lesser magnitude) was detected by a similar soil radon station installed (at the same time) in Mytilene (Greece) (East Aegean Islands). Active techniques can be quicker (at 1-min intervals) providing the opportunity of more precise monitoring of precursory seismic phenomena. Both methods can be correlated to electromagnetic (EM)

precursory data provided by the near Station (installed at Zante Island).

Anomalies of soil radon concentration can give evidence about tectonic disturbances in the Earth's crust, though the radon changes are also influenced by meteorological parameters. Further studies are needed to differentiate the changes that are due to tectonic disturbances from other causes, and to reduce the effect of the meteorological parameters on the measured radon concentration. However, probable explanations for these anomalies may be given through the dilatancy-diffusion (DD) model and crack-avalanche (CA) model. According to the DD model, a porous cracked saturated rock constitutes the initial medium. With the increase of the tectonic stresses the cracks extended as well and disengagement cracks appear near the pores, the favourably oriented cracks being opened. This results in a decrease of pore pressure in the total preparation zone and water flows into the zone from the surrounding medium. The return of pore pressure and crack increase brings about a main rupture at the end of the diffusion period. According to the CA model, the process is as follows: a cracked focal rock zone is formed by the increasing tectonic stresses. The shape and volume of this focal zone change slowly with time. After comparing both models, one can recognize a common principle: at a certain preparation stage a region with many cracks is formed. The mechanical processes of earthquake preparation are always accompanied by deformations, afterwards complex short- or long-term precursory phenomena can appear.