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Permanent monitoring of velocity and flow of gases released at ground surface using ^{222}Rn signal processing from a 3 solid-state sensor probe

Applications for seismic and volcanic surveillance, evaluation of sealing efficiency of underground gas storage (CO_2)

Jean-Claude Baubron (1), Claude Bertrand (2), Jean-Louis Pinault (3)

(1) JcbConsulting, 45640 Sandillon, France

(2) ALGADE, 87250 Bessines sur Gartempe, France

(3) 45370 Dry, France

(jc.baubron@cegetel.net)

Last decade saw numerous studies of soil gas surveillance through ^{222}Rn monitoring, mainly using solid state silicon detectors devices, which allow permanent static records of radon concentration in soil air. Review of the data strengthened the primordial action of meteorological parameters on near surface soil gases composition, and then its ^{222}Rn concentration (atmospheric pressure, soil moisture and temperature, etc.), but transient events are suggested to be correlated with deep phenomenon, as crustal stress change, may be related with seismic event, or volcanic activity resume for instance.

Modelling of ^{222}Rn signal from atmospheric parameters allows explaining most of the recorded soil air radon concentration variation (Pinault & Baubron, 1996). A previous attempt was done, using the possible modification of soil gas velocity, through modelling of soil air ^{222}Rn from diurnal and semi-diurnal variation of atmospheric

pressure (Pinault & Baubron, 1997). Field experiments ascertain the reliability of this method giving the mean gas velocity at depth, but minimum time laps of about two months are needed for data processing, which rule out the possibility of explaining transient radon concentration events.

Design of a new probe (patented) is presented, using three radon sensors in an elongated vertical chamber inserted into the ground. Pressure and temperature are monitored as well. Radon concentrations that are recorded at a 15 min rate allow calculating fluxes, with a temporal resolution of some hours. Indeed, the flux that is simply the ratio of the distance between two detectors by the time it takes a pulse of radon to move from a detector to another is expressed as a function of time. Due to diffusion of radon into the chamber – the apparent velocity of radon is higher than it would be if only advection occurred – a correction factor is determined from the calibration of the equipment. Actually, the flux is determined on a continuous basis by comparing the concentration of radon observed by each of the detectors, utilizing the daily variations due to changes in atmospheric pressure, temperature, etc. For every couple of detectors, the flux is deduced by comparing the upward and downward cross-correlograms in order to remove the noise due to the perception of radon fluctuations that do not result in advection processes (statistical errors of counting, etc.). The comparison of fluxes deduced from the different couples of sensors allows taking into account air dilution from the upper exit of the probe, low signal/noise ratio, low flows of gas, etc.

A two year checking period of this new device indicates, on one hand, that brief and high increases of flows can be observed on volcanoes, not correlated with significant radon concentration increases, which implies a deep radon source and a high gas transfer velocity. On another hand, low gas fluxes can be efficiently monitored at surface, as for deep gas underground sequestration or storage effectiveness evaluation.

Pinault & Baubron, 1996, JGR Vol 101, pp 3157-3171.

Pinault & Baubron, 1997, JGR Vol 102, pp 18101-18120.