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Radon as a tool to monitor transient permeability changes: on-line measurements in a tri-axial cell

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Radon-222 is a radioactive gas of half-life of 3.8 days which is naturally produced in the Earth's crust. This informs generally about the transfers in the subsurface and is considered as a potential earthquake precursor. In this study, deformation experiments are performed in the laboratory on various granites, for which the radon source term is known (effective radium concentration). Radon concentration is continuously measured on-line under isotropic stress and deformation using a tri-axial cell, together with acoustic emissions, seismic velocity, deformation rates and geometry. Pore fluid pressure is fixed and maintains a flush of inert gas through the sample, which allows radon to be expelled from the porous network of the sample. This also leads to permeability determinations. Radon release shows a large sensitivity to various intrinsic and external parameters. While radon release is stable under constant isotropic conditions, it increases with confining pressure, because radon is more concentrated as the permeability decreases. However, above a given confining pressure threshold, radon release decreases while permeability continues to decrease, mainly due to the closure of cracks. Therefore, any change of permeability in the sample, even relatively small, is marked by a consecutive change of the radon release. At the macroscopic rupture of the sample, significant transient radon release is observed simultaneously to the rupture, or some time after. This transient radon peak results from isolated microporosity being newly connected to the permeable network rather than new crack surface creation per se. This hypothesis is sometimes proposed to account for radon anomalies observed before and after large earthquakes. As our transient radon signals are observed just after or near the time the rupture occurs, we might tentatively raise questions concerning some precursory observations. All these effects are now being quantified. This study and the developed procedures open interesting perspectives for the understanding of the relation between deformation and radon release from crustal rocks.