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Radon and thoron emission from high and low porosity rocks under increasing deformation: An experimental study

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Cracking of a medium, observed before earthquake ruptures and/or volcanic eruptions, can produce anomalous increases in the rate of radon emission, as new exhaling surfaces enhance its mobility towards the surface. However, in several cases radon emission rate decreases or does not change significantly before seismic activity and hence the interpretation of such anomalies remains speculative. Quantitative assessment of the rate of radon emission in different rock types with increasing deformation is therefore required to address this problem.

Here we present a new experimental dataset where measurements of radon (^{222}Rn) and thoron (^{220}Rn) emissions were carried out on lithophysae-rich tuff (initial porosity = 47.01 %) and crystalline lava flow samples (initial porosity = 3.6 %) uniaxially loaded with the aim of analysing the relationships between incremental damage and the rate of radon emission.

Our results show that deformation in the high-porosity tuff resulted in a decrease in the rate of radon emission and can be explained by the fact that compactive pore collapse is the dominant deformation mechanism. On the other hand, the low porosity lava flow only showed a small change in radon emission rate with increasing deformation upon macroscopic failure. This indicates that microcrack damage, as evidenced by the output of acoustic emissions during deformation, did not improve exhalation surfaces and pathways sufficiently to result in an increase in radon emission rate. However, when microcracks coalesce to form a discrete fault plane, new exhaling surfaces are formed and radon emission rates increase.

It is now clear that the initial physical properties (e.g. porosity) of the rock appear crucial for understanding of radon emission anomalies. The interplay of the contrasting styles of deformation (compaction and fracturing) controls the formation/reduction of exhaling surfaces and thus the rate radon emission. These new experimental data can therefore help explain the complex trends seen in the field.