Radon monitoring in a volcanic cave: El Viento Cave (Canary Islands, Spain)

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Introduction

- Radon (^{222}Rn, $t_{1/2}$ = 3.82 days) represents the largest natural source of ionizing radiation. In confined environments as caves, radon gas can accumulate, reaching harmful concentrations due to poor ventilation. To minimize the exposure risk, a radon monitoring program is required to adopt mitigation measures for the radiological protection of workers, speleologists and visitors.

- In this work, radon concentration and environmental variables were monitored in El Viento Cave during one year to evaluate dose exposure risks for cave guides and visitors.

Materials and methods

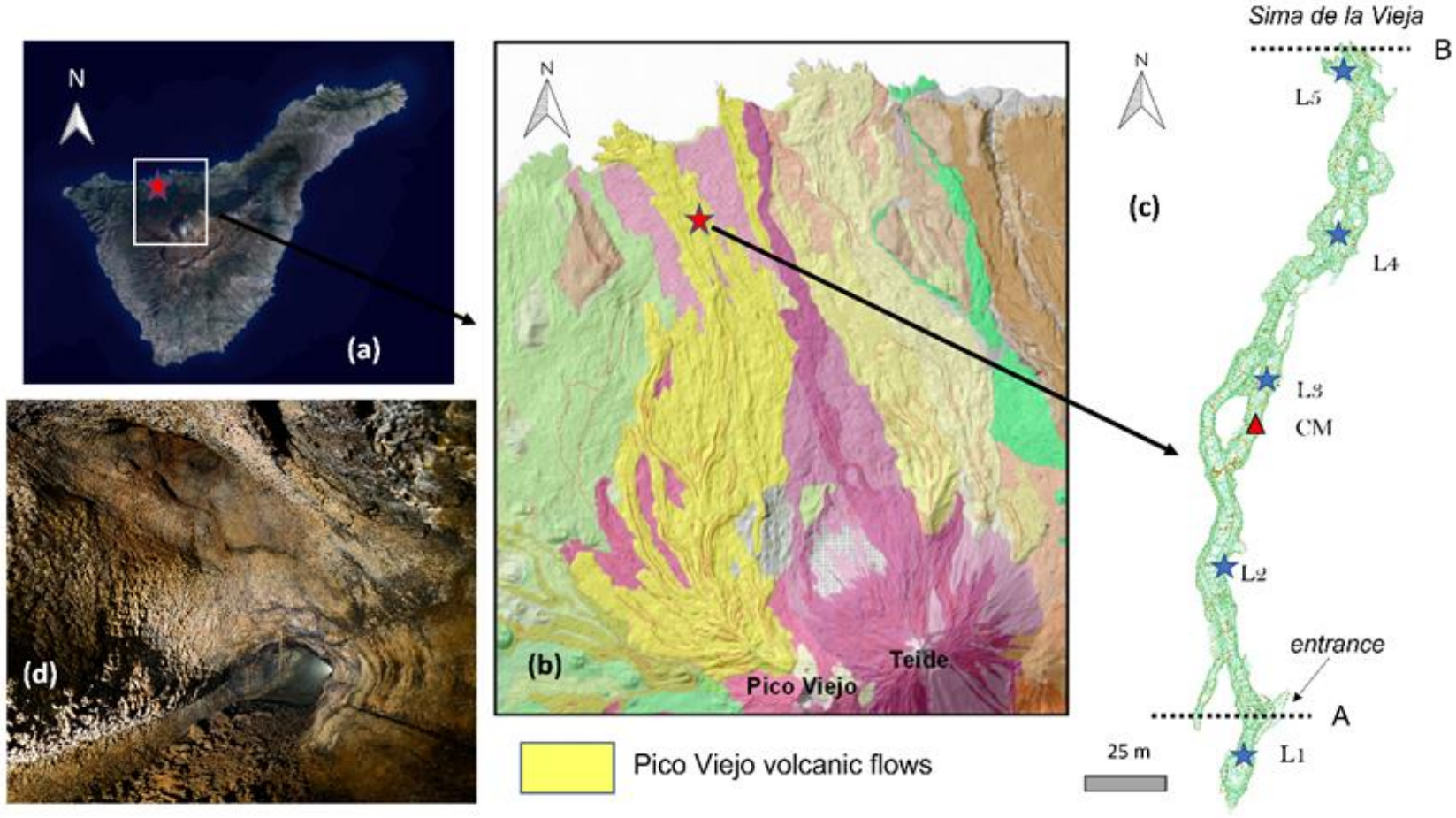

Figure 1. Location of El Viento Cave at Tenerife Island (a and b). (c) Spatial distribution of the passive detectors (L_1 to L_5) and the radon continuous monitoring (CM) device placement in the visitable section. (d) View of the visitable tube section.

Results and discussion

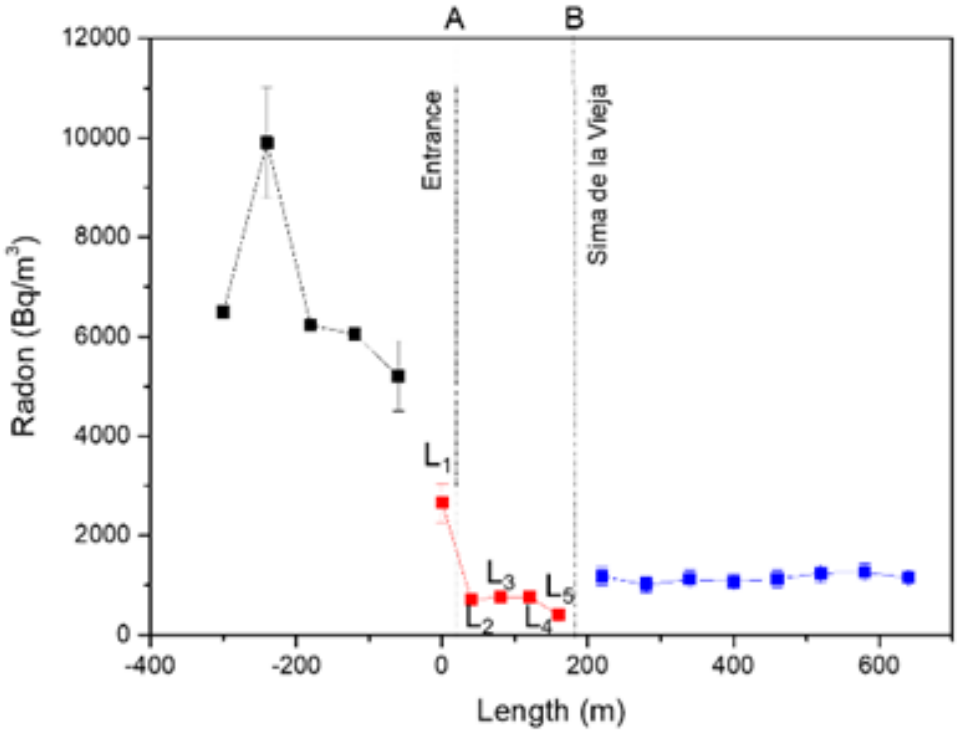

Figure 2. Radon concentration profile obtained in El Viento Cave using CR-39 passive track detectors, including the touristic section (red) and two non-visitable adjacent sections (southern sector in black and northern in blue)

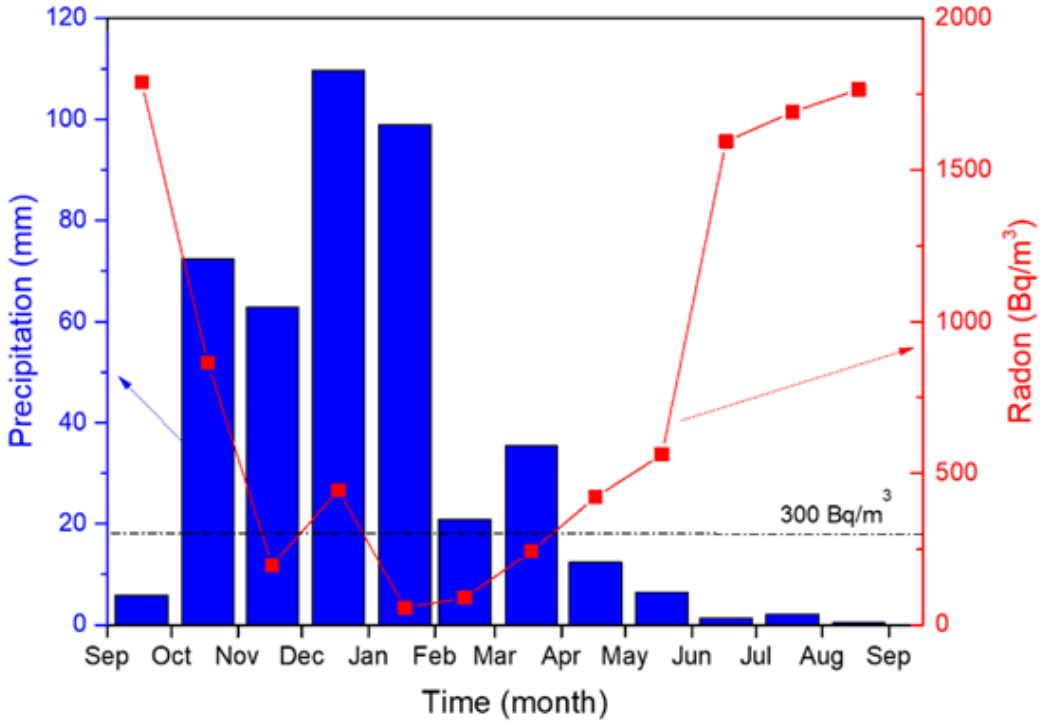

Figure 3. Temporal evolution of the monthly indoor radon concentration in El Viento Cave and the accumulated rainfall in a meteorological station situated at ca. 2 km from the volcanic tube

Results and discussion

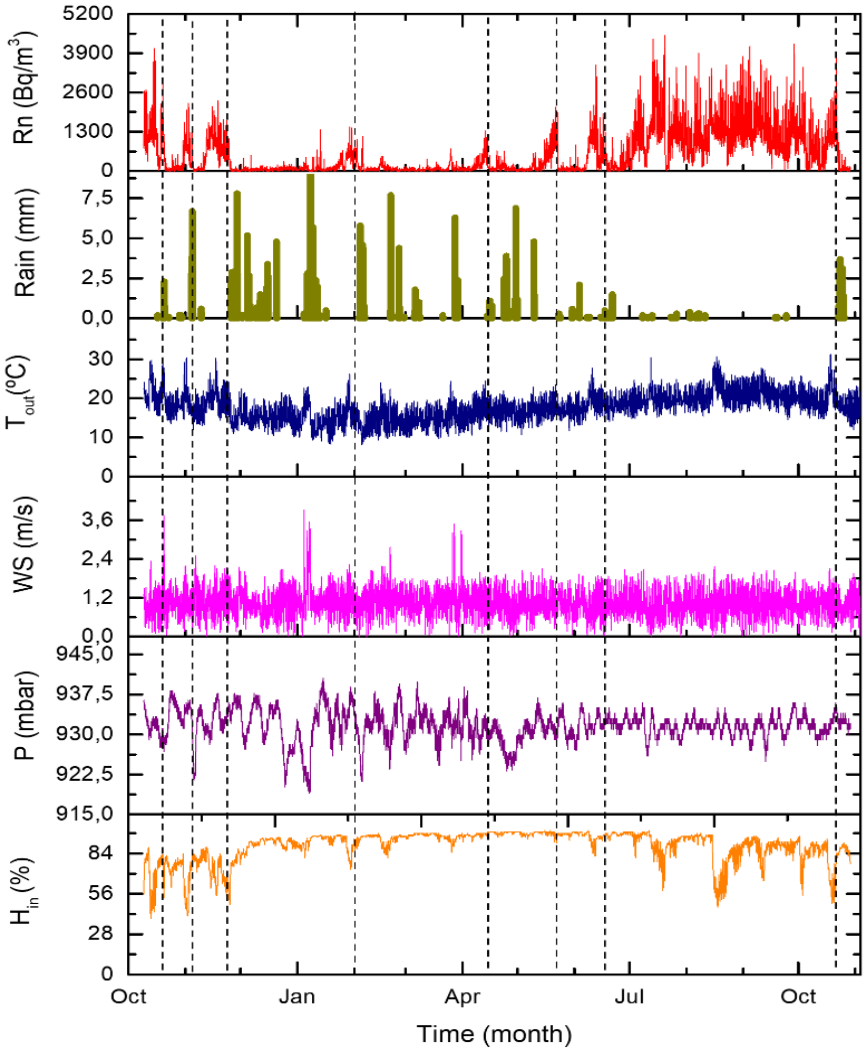

Figure 4. Hourly time series for indoor radon concentration (Rn), barometric pressure (P) and indoor air humidity (H) inside El Viento Cave and meteorological parameters (rain, outer air temperature (T_{out}) and wind speed (WS)) measured in a meteorological station located at 2 km from the cave entrance.

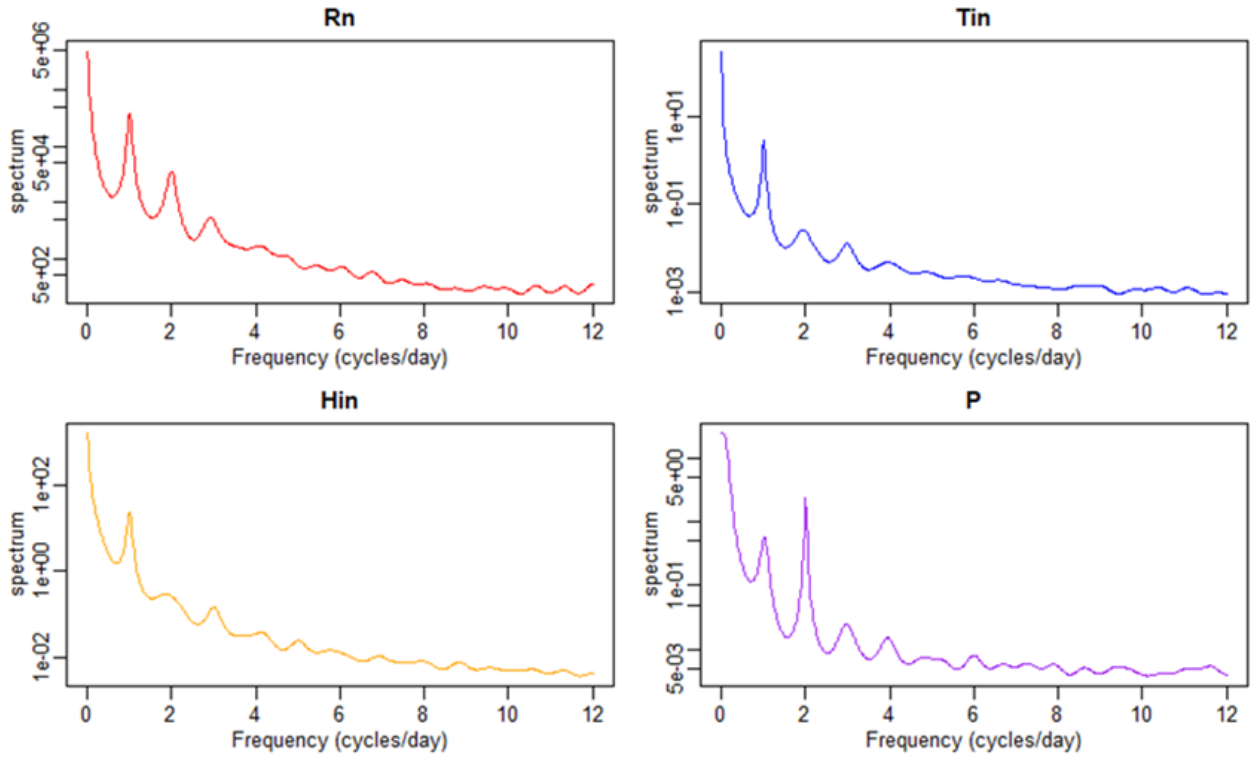

Figure 5. Fast Fourier transform power spectra for the indoor radon concentration (Rn), temperature (Tin), humidity (Hin) and barometric pressure (P).

Results and discussion

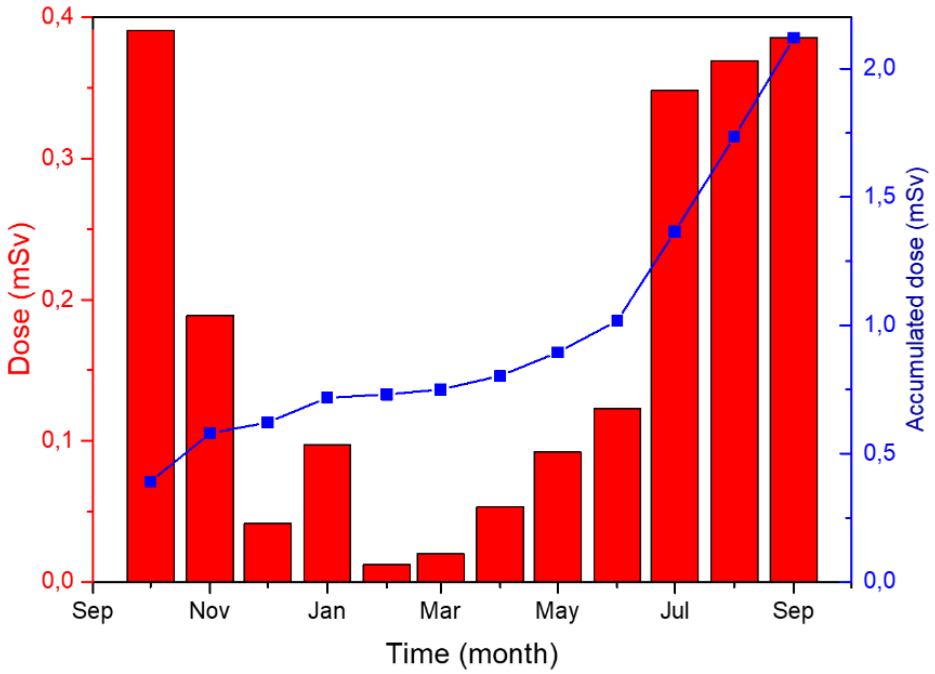

Figure 4. Monthly effective dose and accumulated dose calculated (using passive detectors) for tourist guides with an exposition time of ca. 10 h per week in the visitable section of El Viento Cave.

Annual mean effective dose due to radon exposure (H_{Rn}) was calculated from the mean radon concentration of the 60 measurements obtained with the CR-39 detectors during the sampling period (2020/10/01 – 2021/09/30) at the tourist sector of the cave.

H_{Rn} was calculated according to (UNSCEAR, 2000) recommendation as:

$$H_{Rn}\,(mSv/year) = C_{Rn}\ x\ F\ x\ O\ x\ DCF$$

C_{Rn} = indoor radon activity concentration [Bq/m^3]
F = equilibrium factor between radon and its decay products (0.56).
O = average occupational exposure time of a tour guide (ca. 480 h per year)
DCF = dose conversion factor for radon exposure ($9{\cdot}10^{-6}$) [mSv·m^3 / Bq·h]

Average indoor occupancy for guides was computed assuming 10 working hours/week for 48 weeks/year.

Conclusions

- ✓ At El Viento Cave, seasonal (annual), diurnal (24 h) and semidiurnal (12 h) variations are observed in radon concentration. In the annual cycle, precipitation seems to be the main driving factor modulating the radon level.

- ✓ From a dosimetric point of view, El Viento Cave is safe for tourists (4 µSv/year) and tour guides (2 mSv/year). However, according to the Spanish legislation, this cave must be classified as "Monitored Zone" (due to the risk for guides and workers to be exposed to effective doses of 1 to 6 mSv/year). Thus, a regular monitoring program should be implemented.