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Study of a cave's air exchange pattern based on radon concentration and the time dependence of radon concentration in Pál-völgy Cave (Budapest, Hungary)

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A long-term (one year and a half), high resolution, with an integration time of one hour, radon concentration monitoring was carried out in Pál-völgy Cave (Budapest, Hungary). Our major goal was to determine the time dependence of radon concentration in the cave and to understand the exchange pattern of the cave air with the outdoor air based on radon concentrations, and to determine the factors that affect the radon concentration in the cave air.

Pál-völgy Cave is situated in the Buda Hills, which is the NE part of the Transdanubian Central Range. The wall rock of the cave is dominantly Eocene Szépvölgy Limestone Formation. Above the limestone Eocene Buda Marl and Oligocene Tard Clay are deposited. A huge multiphase hydrothermal cave system developed in the Szépvölgy Limestone and partially in the Buda Marl resulted in a long-term complex paleokarstic evolution from the Late Eocene to the Quaternary.

The radon concentration in the cave air was measured continuously by an AlphaGuard radon monitor, and meteorological parameters outside the cave were also collected simultaneously. The arithmetic mean of the annual radon concentration was 1.9 kBq/m3 and the radon concentration varied between 104-7,776 Bq/m3. In addition, the results indicate a clear seasonal variability of radon concentration in the cave air: in winter the radon concentration fluctuates around a low mean value of 253 Bq/m3, in summer it oscillates around a high mean value of 5,504 Bq/m3, whereas in spring and autumn the radon level varies between the winter and summer values. The summer to winter radon concentration ratio (radon concentration in summer/radon concentration in winter) was high, 21.8. The outside air temperature showed the strongest correlation with the radon concentration in the cave, Pierson's linear correlation coefficient is 0.76. If the outdoor air temperature is lower than the cave air temperature (12 °C), especially in autumn and winter the air flows from outside into the cave and the radon concentration decreases in the cave. However, if the outdoor air temperature is higher than the cave air temperature the cave air stays where it is, thus, resulted in low rate ventilation.

Our long term observation provide the opportunity to characterize long term (seasonal changes) and short term (diurnal variation) events of radon concentration. Numerical analysis of these time-series indicated the presence of events potentially associated with meteorological and astronomical influences.