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Long term radion studies and transport processes in the Budapest thermal karst region

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Abstract
Radon is an excellent tracer of underground fluid motion in karstic systems. Radon concentration in the air is measured in four Budapest caves. Its variation shows annual periodicity, with maxima in summer and minima in winter, and good correlation with outside temperature. In the topsoil above a karst cave, on the contrary, the minimum of radon concentration is observed in summer (and the maximum in winter) because of seasonal reversed air flow directions.

Résumé
Le radon est un bon indicateur du mouvement des fluides souterrains dans des systèmes karstiques. La concentration en radon est mesurée dans quatre grottes de Budapest. Sa variation a une périodicité annuelle, avec des maxima en été et des minima en hiver. Au contraire, dans le sol au-dessus des grottes, la concentration en radon est la plus faible en été (et la plus forte en hiver) à cause des flux d'air qui s'inversent d'une saison à l'autre.

I. INTRODUCTION

In Budapest, capital of Hungary, there are some hundred caves of different size. They were predominantly formed by mixing corrosion along the interface between the upward moving hot (thermal) and infiltrating cold waters. Nowadays these caves, due to the tectonic movements which have raised the area, are dry (Fig. 1) (LIEBE, 1989).

The hot springs in the Buda Mountains were already known in Roman Ages, and recently they are used for feeding the world famous thermal baffles of Budapest. Since March, 1989 remedial therapy treatments are also taking place in some caves. Excellent results were achieved in the therapy of asthma and bronchitis.

Due to the expansion of the capital, the mountains of the thermal karst have been covered with buildings. Recently the infiltration of polluted water and air may pollute the remedial caves and bathes. Many national and international projects have been started to study the transport processes in this karstic region, with respect to the possible motion of the pollution.

Radon measurements are also included in these research programs because the radon is an excellent tracer of underground fluid motion in karstic systems (CSIGE *et al.* 1989).

II. METHOD

Since 1985 the radon concentration is continuously measured in the air of the Szemlö-hegy Cave and since 1990 the other three biggest caves of Budapest are also involved in this study. We used diffusion cup technique in order to obtain representative data about the temporal and spatial variation of the ^{222}Rn concentration in the caves (SOMOGYI *et al.*, 1981). The 10-20 track etch radon monitors/cave (LR-115 detectors) are changed monthly.

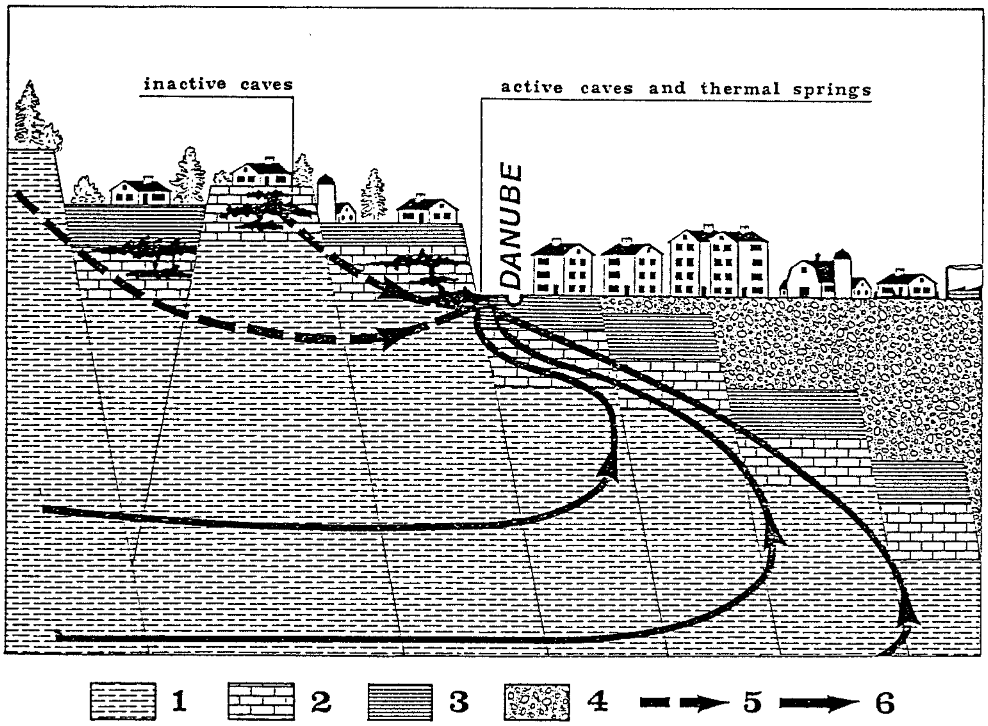

Figure 1 : Schematic profile of the speleogenesis and thermal water activity of the Buda Mountains.
1- Triassic dolomite 2- Eocene limestone with cavern 3- Oligocene clay and marl
4- Neogene sediments 5- Cold karst water motion 6- Thermal water motion

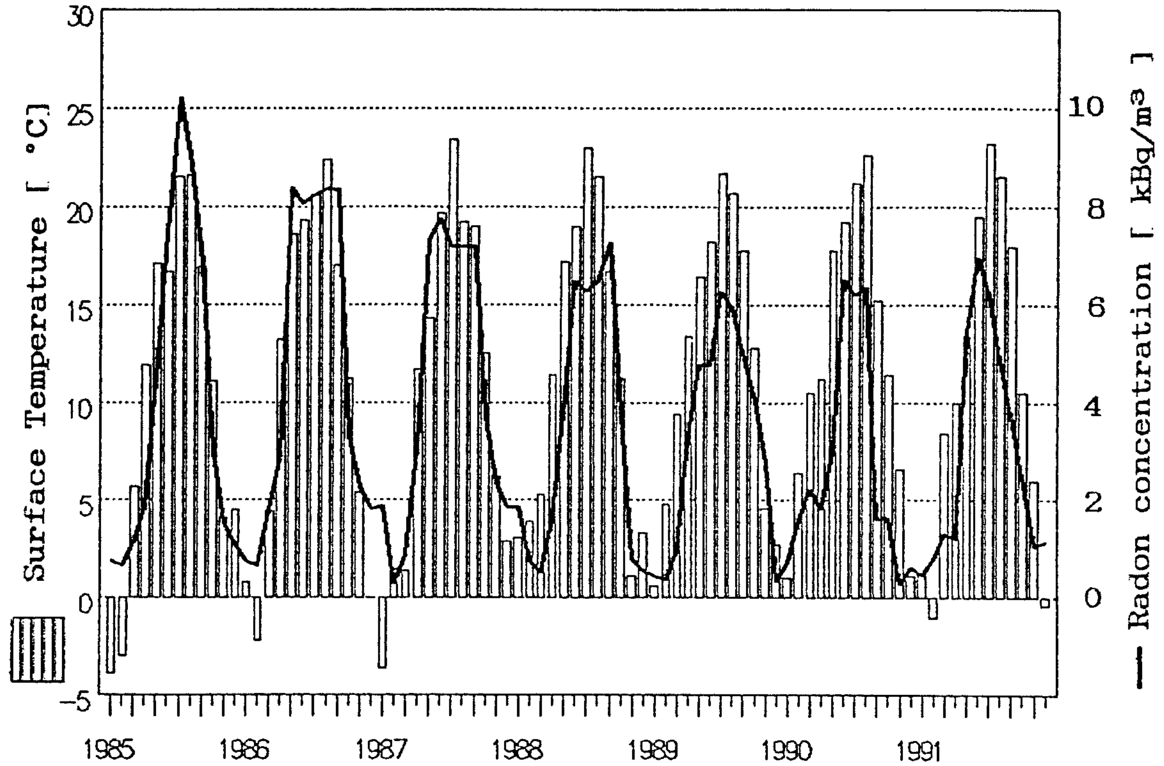

Figure 2 : A typical time series obtained in Semlö-hegy cave of Buda. The Rn activity concentration shows good correlation with the external temperature.

III. RESULTS

The experimental results are summarized in Fig. 2. The variation of the radon concentration in the caves shows an annual periodicity. The maxima are in summer, the minima are in winter. The values of radon concentration are in good correlation with the outside temperature (GÉCZY *et al.,* 1989).

A. Air circulation in caves

We assume that the radon content of the cave air cornes from the radium content of bedrock. Limestones have relatively low U and Th content, but, because of their opened crack system, a significant amount of their radon production can escape to the cave space. Beside the characteristics of the bedrock, the Rn concentration in the cave air is influenced mostly by the ventilation induced by the temperature difference between the outside and inside air. To describe this ventilation and its effect on the Rn concentration, we propose a simple model as sketched on Fig. 3/a-b (GÉczY *et al.,* 1989). The assumptions of this model are well supported by other observations (ATKINSON *et al.,* 1983).

B. Air motion inside the karst

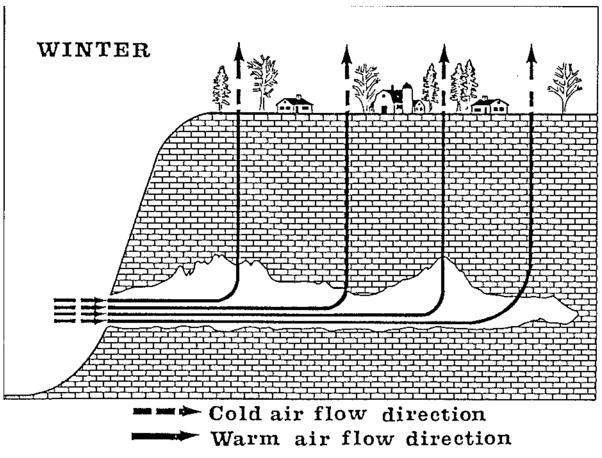

Figure 3 a : In winter, fresh air blows through the entrance into the cave; getting warm, it rises up and is enriched in radon on its way up to the surface.

The presence of caves is not absolutely necessary for the functioning of the model described above. It is well known from the geology that along the infiltration surface a so-called mixing corrosion takes place between the infiltrating and the karstic waters. Horizontally, the air can move almost freely, entering the karst at the valley-bottom and moving along the cavity system which was dissolved by mixing

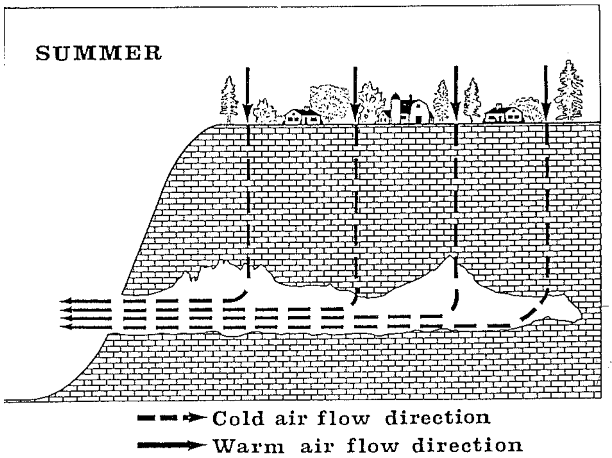

Figure 3 b : In summer, fresh air is getting into the cave through the fracture system of the bedrock; cooling down, it sinks and washes out a great amount of radon from the cracks into the cave air.

corrosion. The air can move also vertically, due to the presence of the crack system, resulting in a circular air motion inside the karst in seasonally reversed directions.

The consequence of the model is experimentally demonstrated by direct radon observations in the topsoil above a karst cave. The minimum of radon concentration was observed in summer and the maximum in winter (HUNYADI *et al.,* 1991).

IV. CONCLUSION

Experiments show that hourly several thousands m^3 of air are filtrated through an ordinary sized cave. If one assumes 1 mg/m^3 solid contamination in the polluted atmospheric air, many kg of material remain yearly inside the karst. On the other hand, polluted waters which flow across the karst can reach the thermal spring zone without filtering. The observation of radon traced fluid motions may give useful information for the environmental protection.

An other problem can be predicted in convection with the enhanced surface radon exhalation in winter. In houses built above the karst, higher indoor radon concentration can be expected in this season. As the ventilation in winter is generally pour, the enrichment of the indoor radon may be critical from the point of view of radioprotection (HUNYADI *et al.,* 1991).

On the basis of described preliminary results, a complex measuring system is to be installed to study the vertical transport processes from the surface to the cave.

V. ACKNOWLEDGEMENT

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