Communication

Radon and CO2 as markers of cave atmosphere dynamics : evidence and pitfalls in underground confinement analysis; application to cave conservation.

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François BOURGES mel@geconseil.com
Géologie Environnement Conseil
30, rue de la République, 09200 Saint-Girons, France

Alain MANGIN mangin@lsm.cnrs.fr
Laboratoire d'Ecologie des Hydrosystèmes. Laboratoire de Moulis
09200 Saint-Girons, France

Dominique D'HULST
Laboratoire d'Ecologie des Hydrosystèmes. Laboratoire de Moulis
09200 Saint-Girons, France

Résumé:

Abstract

Confinement is a key parameter in karst system cavities analysis, as most of the properties of this environment are dependent on the quality and the rate of matter and energy exchanges with the surface. CO2 concentration (%Vol) and Radon (222 Rn) activity (Bq/m 3) time series recorded in caves from Ardeche (France) exemplify two situations in which underground dynamics are revealed using these gas components as confinement markers. In the Aven d'Orgnac, a Rn-CO 2 survey of a confined volume (the Canyon zone) carried out in winter 2001-2002 showed a succession of filling and release episodes, due to the successive installation and breaking up of an aerodynamic front at the top of this zone. Surface meteorological variations and related aerodynamic conditions inside the cavity are the causes of this evolution. Since the two gas time series showed striking parallel evolutions identifying a similar response to these dynamics, both radon and CO2 can evidently be used equaly well as confinement markers. In the nearby prehistoric Grotte Chauvet, CO2 distribution indicates a similar partition of the cavity into two zones : a larger outer zone with homogeneous moderate CO2 rates (1 to 2%), and an inner zone (Salle du Fond) with permanently high CO 2 rates (2.5 to 3.5 %) previously interpreted as a confined cave segment. Radon was recorded for 6 weeks in each zone. Surprisingly, Rn activity is equal in the two parts of the cave. The clear CO 2 based contrast which partitions the cavity is interpreted as a result from spatial differences in the CO 2 supply enhanced by the location of air convection cells whose extension is severely restricted due to the geometry of the cave. As convection tend to homogenises the air composition in each zone, the CO 2 step could therefore be a mixing interface caused by slight differences in physical properties between two air volumes. As the radon production rate is identical throughout the cave, interpretation of radon activity data in the Chauvet cave is consistent with homogeneous confinement conditions prevailing throughout the whole cavity and that can only be related to the arrangement of its natural openings. In the Aven d'Orgnac, the two markers revealed a dilution process as incoming air from the outside causes the sudden opening of the confined volume. In the Grotte Chauvet, the underground atmosphere is exclusively generated by air transfers through the microfissural network and is permanently drained through the cave towards the exterior; an homogeneous radon signature and contrasting CO 2 compositions are therefore compatible. In this case, a CO 2 based analysis of the dynamics is somewhat tricky. These dynamics have probably prevailed for a long time in the Grotte Chauvet and could partly explain the extraordinary conservation conditions of the wonderful paintings which are nearly 35.000 years old.