M1: CO_2 evolution in cave atmospheres: new insights, concerns and mitigation strategies

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There are growing concerns about CO_2 concentration upward drifts in cave atmospheres as many sites are affected by worrying levels of CO_2 concentration for human safety and underground patrimony preservation. In some cases, speleological and touristic activities and some scientific operations have been restricted and could be prevented by further increase in CO_2 concentration. Unprecedented situations occurred in southern France at two neighboring sites monitored for CO_2 since 1997: In June 2016, CO_2 concentrations in the Aven d'Orgnac reached the safety level of 3% Vol., whereas in September 2017, after 5 years of rise, the CO_2 topped at 4.4% in the Chauvet-Pont d'Arc cave rear room.

In the Aven d'Orgnac tourist cave, CO_2% atmosphere variations are controlled by ventilation regimes. During the hot season, some air is drained from the karst porosity (2.5 to 3 %Vol. CO_2 in the visited rooms, and 3 to 5% in remote networks) and fills the cave. During the cold season, ventilation switches to a density driven regime: mixing with outside air falling from the upper entrance dilutes the CO_2 concentration (<0.5%).
In the Chauvet cave, permanent confinement has preserved the 360 centuries old rock art. Two stable compartments with contrasted compositions (an average 2.2% CO_2 concentration in the main volume, and an average 3.4% CO_2 concentration in the rear room) are subject to smooth, 1.6 to 2% in amplitude, annual sinusoidal variations.

Recent work showed that high CO_2 concentration is associated with low water excess periods and that infiltration in the upper karst control the gas fluxes in the cave volume. However, the long-term upward drift can also be attributed to increasing carbon stock in soil and epikarst due to growing vegetation density in earlier decades.

The remediation in the Orgnac visited sector has consisted in an artificial ventilation circulation that mimics the winter regime. The set point value of 0.5% CO_2 for diluted extracted air was optimized with a 3 000 to 5 000 m^3/h flux. Until now, the monitoring has revealed that the original thermo-hygrometric conditions are preserved. In Chauvet cave, neither ventilation nor hydrological conditions can possibly be modified. Critical situations could be triggered by long lasting droughts expected in the Mediterranean climate foreseeable evolution. Only the vegetal cover could be a factor of control pending confirmation of the preliminary results.

M2: Stalactite drip rate variations in French Caves: causes and interest for karstic reservoir knowledge

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Stalactite dripping time series, originally set up in order to better understand the stalagmite growth environment in relationships with paleoclimatologic studies, appear to be a source of valuable information on infiltration and recharge processes in micro-fissured karstic terrains. The synthesis of several years long monitoring (drip number/15 min) from 25 drippings stations in ten different caves have been compared with local meteorological data, revealing common causes of dripping pacing at different time scale: rainfall (RR) and evapotranspiration (ETP) constrain seasonal and monthly-weekly drip rate variations while atmospheric air pressure controls daily-hours scale drip variations. More precisely, we observed the following:

1) RR minus ETP baseline displays a well-marked seasonality that is the precursor of the dripping yearly seasonality;

2) water excess (or efficient rainfall) explains monthly-weekly drip rate variations during humid period with more or less delay of the order of 1-2 days;

3) large atmospheric air pressure changes linked to atmospheric circulation controls daily scale drip variations;