Hydrological control on carbon dioxide input into the atmosphere of the Chauvet-Pont d'Arc cave

by Bourges et al.

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Supplementary Figures
Fig. S1. Aerial photographs of the zone of the Chauvet cave in 2012 (a) compared with 1955 (b).
Fig. S2. Residual CDC at B versus residual CDC at A in the Chauvet cave from 2013 to 2019. Residual CO₂ concentrations correspond to the CDC after subtracting the long-term trend. The arrows indicate the direction of time. The two major slope trends are depicted. Two different regimes are suggested: a first regime from June to November with a larger slope CO₂ B/CO₂ A of the order of 1.2, and a second regime from December to May with a smaller characteristic slope of the order of 0.5.
Fig. S3  Yearly minima (diamonds), mean (circles) and maxima (triangles) from the time-series shown in Fig. 3. a) CDC in the Chauvet cave. The difference of the yearly average of CDC at B minus CDC at A is shown in thicker purple with the scale shown on the right hand side. b) Temperature in the Brunel Room T1 (left scale) and outside temperature in Orgnac (right scale). In contrast with the CDC at A and B examined separately, the difference of the yearly mean concentrations CO$_2$ B–CO$_2$ A, has remained remarkably stable over the 20 years of observation, with an average of 1.24±0.04 %. The mean outside temperature in Orgnac, when displacements of the temperature sensors were properly corrected for, remained stable from 1997 to 2018. The simultaneous increase CDC and temperature after 2013 was also observed during the transient increase of both parameters in 2008-2009. The temporal evolution, however, appeared different, with a rapid increase of temperature after 2013, slowly stabilizing after 2015, while a faster increase of CDC was observed after an approximately constant phase from 2012 to 2014. The temporal variations of CDC at A and B appeared best correlated with the minimum T1 temperature (Fig. S4), but the values of the correlation coefficient to this minimum temperature, 0.63 for CO$_2$ A and 0.74 for CO$_2$ B, remain low and smaller than the value of the correlation coefficient between CO$_2$ A and CO$_2$ B (0.89). The unexpected relationship, however, appears as an interesting clue.
Fig. S4. Mean yearly CDC in compartments A and B as a function of yearly minimum temperature T1.
Fig. S5. Microbiological monitoring in the Chauvet cave: counts of fungi (a) and bacteria (b), expressed in colony-forming units per cubic meter, at the 18 points regularly sampled since 1997. The map of the cave is simplified from Clottes et al. (2001).
Fig. S6. Profiles of CDC in the Chauvet cave along the pathway from the entrance to the end of the RR, obtained during the regular maintenance visits in the cave. The locations of the permanent measurement points A and B are indicated above the horizontal scale.
Fig. S7. Representative CDC vertical profiles along the pathway from the end part of the Hillaire Room, through the Megaceros Corridor to the end of the RR, obtained during regular maintenance visits in the cave.
Fig. S8. Carbon isotopic ratio $\delta^{13}C$ of atmospheric CO$_2$ in the Chauvet cave versus time. The dashed lines represent the average values separately for each location.
Fig. S9. Carbon isotopic ratio $\delta^{13}C$ of atmospheric CO$_2$ in the Chauvet cave versus time in the year.
Fig. S10. CDC relative to the mean CDC as a function of atmospheric pressure minus the mean atmospheric pressure for the corresponding time section, separately for the compartments A and B (RR). The green line corresponds to the coupling \( (\Delta C/C)/p \) of 0.15 % hPa\(^{-1}\) due to the IR sensor.
Fig. S11. a) Time-series of CDC residuals in the Chauvet cave, obtained by subtracting the seasonal trend given by a polynomial fit for the corresponding time section. The corresponding time-series for atmospheric pressure is shown in black with the scale given on the right hand side. b) Corresponding time-series of CDC residuals, corrected for the effect of atmospheric pressure on the CO$_2$ recording instrument (see text).
Fig. S12. Focus on the effect of infiltration into the Chauvet cave at the end of 2017 and 2018: a) CDC in the Chauvet cave (locations A and B, left scale) and temperature in the entrance debris zone (T0, right scale). In this graph, for an easier comparison, 1% has been subtracted from CO₂ B. b) Drip counts at Cierge and at Cactus (see Fig. 1b, left scale) and daily values of water level in the Orgnac borehole (right scale). The drip counts are filtered with a running window of 32 hours. c) Monthly rainfall (marine blue) and calculated Water Excess (sky blue) in Orgnac. Rainfall recorded in Vallon Pont d’Arc (dark grey) is also shown. The vertical red dashed line indicates the onset of positive water excess and the initiation of the infiltration leading to CDC reduction in the cave. The vertical dashed red lines refer to the change from water deficit to water excess conditions, leading systematically to CDC reduction, without immediate water seepage in November 2017, but with immediate regional infiltration in August 2018.
Fig. S13. a) Drip counts at Cierge and at Cactus (see Fig. 1b, left scale) and daily values of water level in the Orgnac borehole (right scale). The drip counts are filtered with a running window of 12 hours. b) Monthly rainfall and calculated Water Excess at Montélimar.
Fig. S14. Minimal yearly CDC in compartments A and B as a function of the cumulated calculated positive water excess in the year. Data from Montélimar meteorological station are used here to calculate the water excess.