Prehistoric caves facing the climate change: New sensors for an effective conservation strategy

B. Lartiges, F. Bourges, A. Honiat, S. Skali-Lami, R. Losno, L. Drigo, T. Fayard, P. Gisquet, J. Briot

Over the past few years, the environmental monitoring of shallow decorated caves (less than 40 m deep) has revealed a general increase of underground temperatures that can locally reach 1.3°C per decade. The disparity in heating between deeper parts and shallower parts of caves may trigger significant changes in the internal aerology. Prehistoric paintings and engravings are generally situated at a rock/thin water-film/atmosphere interface that should remain as constant as possible to limit the deterioration of rock art heritage. Indeed, according to the moisture content of cave air and the relative temperatures of cave wall and humid air, any change in cave aerology may either grow by condensation or dry up the thin liquid film that covers the cave paintings. When the thin water film evaporates, a carbonate precipitate is deposited on the wall that impairs the readability of paintings. When the water film thickens, the painting pigments may be re-suspended in water and the cave painting may be washed out in the extreme case.

The previous conservation strategy that has relied on a stable underground microclimate cannot be sustained any longer. To address the current climatic changes that are observed in prehistoric caves, new observational techniques are being developed by our team: (a) to assess the slow air motions in cave galleries, a flag sensor made from a mylar sheet stiffened by balsa sticks which deflection is followed by a position sensor, was set-up to detect air velocities as low as 1 cm/s after calibration. (b) The thickness of the thin water-film in the 25-200 µm range can be measured on-site using a confocal optical sensor (Micro-Epsilon); from our experience on 6 prehistoric caves, the dynamics of the water-film is controlled by surface tension effects on cave walls, whereas it is controlled by the dripping rate on speleothems. (c) Piche evaporimeters are frequently used in caves to monitor the evaporation rate in cave air; an automated version was developed from a capacitive measurement carried out by a printed circuit in the graduated glass tube; data are stored on a SD card which enables the increase of survey frequency while decreasing the number of field missions. (d) Laser optical particle counters were used to detect air directly incoming from outside, aerosols from speleothem dripping, and local contamination due to the motion of people around. (e) Finally, to reduce the carbon footprint of field missions, an IoT solution was developed to remotely control the correct functioning of measuring devices and to transfer part of the data to the lab. A local LoRa/ESP32 network is used to export the data from the devices inside the cave to a gateway placed at the cave entrance. This gateway then sends the data to the lab via the Iridium satellite constellation.