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Multiparametric surveillance of conservation measures at subterranean rock-art sites: case of Altamira cave

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Altamira cave (North of Spain) contains one of the most worldwide important representations of Palaeolithic art. Changes introduced in the cave environment due to the numerous conditioning projects and massive amounts of visitors in the past led in severe disruptions on the pattern of energy-matter exchange with the external atmosphere.

Once the Altamira Cave was definitely closed to visitors in 2002, several conservation actions were progressively carried out with the aim to reinforce the isolation of the main cave emplacement with rock art (Polychrome Hall) and, therefore, limiting the dispersion of microorganisms and the supply of nutrients by airflow, water condensation on rock surfaces or seepage water. Main preservation measure was the installation of new access doors equipped with a thermal insulation system.

Multi-annual instrumental monitoring of the atmosphere-soil-cave system has allowed us to control the degree of environmental recovery of cave environment and its trend towards the equilibrium and quasi-natural conditions. The monitoring program was focused on the main microclimatic parameters (air temperature, relative humidity, carbon dioxide, radon, air velocity, among others) in several profiles from floor to ceiling along the main rooms of the cave.

Since the entrance system was modified in 2008 several changes in cave environment have been registered. Absolute annual values of temperature, velocity of air and their annual ranges variation have progressively been reduced. Observed ^{222}Rn and CO_2 convective short period fluctuations have been reduced, mainly during the winter season. The beginning of the degassing period in the cave has been delayed. Differences between inner and outer zones of the cavity have increased reaching the maximum value during the summer season (period of greater connexion with outside environment). For instance: in Polychrome Hall the range temperature falls from 1.41^{o}C in 2007-2008 to 1.28^{o}C in 2010-2011; in Crossing Hall the maximum value of the air velocity have been reduced from 0.2 m/s in the period 2007-2008 to 0.1 m/s in 2010-2011; while in august 2008 the difference in ^{222}Rn Concentration between Polychrome Hall and the Entrance was 28 Bq/m^3, in august 2011 the difference reached 379 Bq/m^3.

Those facts point to a lower interchanging ratio between outside and inside the cave that means a microclimatic situation closer to the natural conditions. As a consequence the atmosphere of Polychromes hall operates as a motionless atmosphere that does not take part in the aerodynamic exchange with the external atmosphere. Thus, an air thermal stratification creates a static trap of warm and less dense air inside cave that contributes to the gas entrapment process. The obtained results reinforce the significance of the environmental monitoring program in order to ensure the cave protection, as well as providing guidance on conservation strategies.