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Carbon dioxide concentration in air within the Nerja Cave (Malaga, Andalusia, Spain)

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Abstract:

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From 2001 to 2005 the CO_2 concentration of the air in the interior and exterior of the Nerja Cave was studied and its relation with the air temperature and visitor number. The average annual CO_2 concentration outside of the cave is 320 ppmv, whilst inside, the mean concentration increases to 525 ppmv during autumn and winter, and in the order of 750 ppmv during spring and summer. The temporal variation of CO_2 content in the air of the cave is strongly influenced by its degree of natural ventilation which is, in turn, determined by the difference between external and internal air temperatures. During autumn, winter and spring, a positive correlation between the CO_2 content of the air inside the cave and the temperature difference between the external and internal air was observed, such that when this difference increased, there was a higher level of CO_2 within the cave. Then, the ventilation is high and CO_2 levels are mainly of human origin. During summer, there was a negative correlation between CO_2 and the temperature difference between the air outside and that inside the cave: when the temperature difference increases, the CO_2 content within the cave is lower. At this time of the year, the renovation of the air is much slower due to the lower ventilation. A positive correlation between CO_2 concentration of the air in the cave and the visitor number can only be observed during August, the month that receives the most visits throughout the year averaging 100,000.

Keywords: carbon dioxide, Nerja Cave, air temperature, visitor number, cave ventilation.

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INTRODUCTION

In caves adapted for tourism, the control of carbon dioxide levels is crucial for the cave's conservation as well as for public health, so that an adequate air quality is maintained for the visitors. On one hand, the CO_2 concentration in the air in karstic caves conditions the development of different speleogenetic processes within these caves given that it directly influences the precipitation/dissolution of carbonates (White, 1988, 1997; Dreybrodt, 2000; Dreybodt & Eisenlohr, 2000). On the other hand, the CO_2 concentration determines the cave's air quality, as elevated CO_2 concentrations above 5000 ppmv are noxious to human health (Halbert, 1982).

Numerous authors have studied CO_2 from diverse standpoints. Pioneering studies have been made on the presence and dynamics of CO_2 in caves with respect to the exterior environment, for example Renault (1968), Ek (1968, 1979, 1981), James (1977) and Troester & White (1984). Other authors have focused on studying the spatial and/or temporal distribution of CO_2 (Atkinson, 1977; Wood & Petraitis, 1984; Wood, 1985), or the dynamics within the caves (Ek & Gewelt, 1985; Bourges et al., 2001; Batiot, 2002; Baldini et al., 2006; Batiot et al., 2006). The human impact on tourist caves, using CO_2 content as one of the reference parameters, is another research line that has been widely developed in recent decades (Villar et al., 1986; Dragovich & Grose, 1990; Craven, 1996; Hoyos et al., 1998; De Freitas & Banbury, 1999, Liang et al., 2000; Carrasco et al., 2002; Zelinka, 2002). Other interesting recent references dealing with CO_2 are: Spötl et al., 2005; Denis et al., 2005; Faimon et al., 2006 ; Bourges et al., 2006; Fernández-Cortés et al., 2006 and Batiot-Guilhe et al., 2007.

CHARACTERISTICS OF THE STUDY AREA

The Nerja Cave is located in Andalusia (southern Spain), in the province of Malaga, about 5 km east of the coastal town Nerja. The climate outside the cave is typically Mediterranean, with a wet season from October to February and a long dry season that is especially notable during the summer. The mean annual values for rainfall and temperature are 490 mm and 18.8 ºC respectively.

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