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Estimation of deterioration induced in hypogean monuments by anthropic influence

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Caves are hypogean monument that due to the existence of peculiar minerals and speleothems, paintings or engravings, are made open to public and are therefore called monuments. In turn, the anthropic influence causes significant changes in the cave atmosphere affecting air temperature, humidity and CO2 concentration. In this paper we purpose a chemical –kinetic model for quantitative estimation of the deterioration of the walls and ceilings induced by the visitors. The evaluation of the amount of dissolved rock is performed for Castañar de Ibor cave (Cáceres, Spain) with the goal of preservation of the hypogean monument from the anthropic influence.

Concerning the methodology it is used a MMS (micro environmental monitoring station) specifically designed to know the temperature and the partial pressure of carbon dioxide (PCO2) and the atmospheric pressure inside the cave. The automatic recording system is programmed to store a record every hour during the whole annual cycle and every ten minutes during the daily visiting period.

The micro-corrosion process that occurs at the rock-air interface involves consecutive chemical reactions (1 to 4), used in the kinetic model (rather than a thermodynamic model) as the reaction 1 to 3 occurs relatively fast.

(1) H 2O (w) =H2O (aq) (the condensation)

(2) CO2 (g)=CO2 (aq) (incorporation of the CO2 emitted by the visitors)

(3) CO2 (aq) + H2O =H2CO3 (carbonic acid formation)

(4) CaCO3 (calcite)+CO2 +H2O = Ca2+ + 2HCO3 – (calcite dissolution)

The recent increase of the CO2 concentration at the atmosphere due to the increasing CO2 emission enhance the future application of such kinetic–chemical models to predict the weathering of limestone at any type of environment (urban, rural, underground, etc) .

Keywords: chemical-kinetic, deterioration, rock-water interaction, calcite dissolution