PRELIMINARY DATA ON AIR TEMPERATURE IN FOCUL VIU ICE CAVE (BIHOR MTS, ROMANIA)

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Abstract: In this paper we present the results after one year of air temperature monitoring in Focul Viu Ice Cave, a descendent cave in the central part of the Bihor Mountains, Romania, hosting a 25.000 m³ ice block at its bottom. The collected data show a strong correlation between the external and the internal air temperature as long as the outside temperatures are below 0 °C (with rapid inflow of cold air), while during summer the presence of the ice block preserves internal air temperatures close to 0 °C, and thus no air exchanges are noticeable between the exterior warm and light air masses and the internal, colder and heavier ones.

Key words: ice cave, air temperature, Romania

INTRODUCTION

Perennial ice is an important feature of many caves in Central and Eastern Europe. Their significance for science grew in the past years, as a series of studies have shown that the ice accumulations in caves may have a strong potential to provide important information on past climate and environmental changes in south-central Europe (Holmlund et al., 2005). However, an important step in order to be able to extract paleoclimatic information recorded in ice is the understanding of the way in which the cave and exterior climate are related.

Here we present preliminary results of a one year monitoring of air temperature in Focul Viu Ice Cave (Bihor Mts., Romania), highlighting the relations between cave and outside environment temperature, as well as its influence on cave air movement.

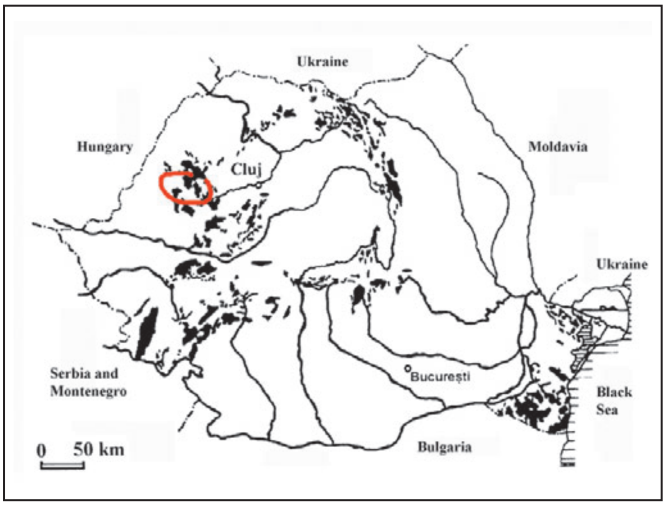

Fig. 1. Location of Focul Viu Ice Cave

SITE DESCRIPTION

Focul Viu Ice Cave is a small (107 m long), descendent cave in the central part of the Bihor Mountains, Romania (46.27° N, 22.68° E, Fig. 1). It is located at an altitude of 1165 m (Orghidan et al., 1984), in the upper part of a limestone ridge.

A small, descendent entrance (Fig. 2a) is giving access to a large chamber ("Big Hall", 68 x 46 m), followed by a smaller one ("Little Hall", 20 x 5 m). The ceiling of

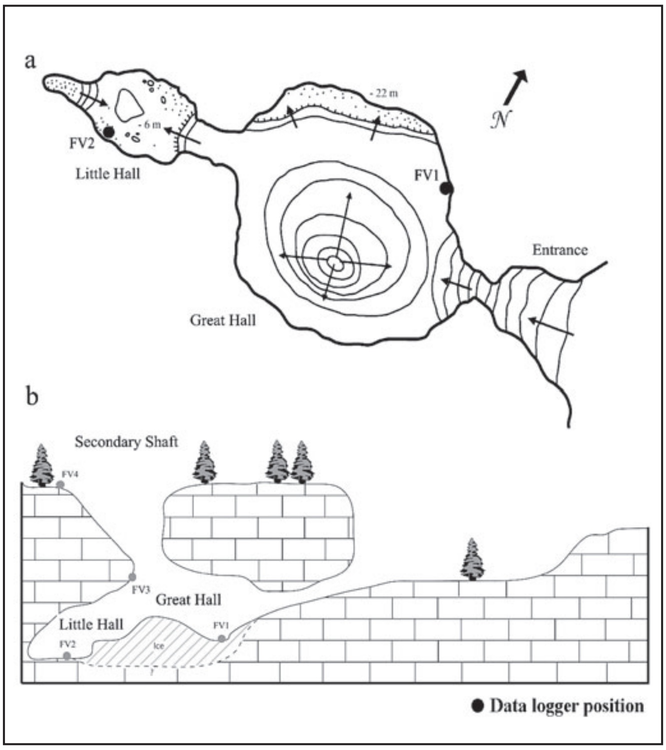

Fig. 2. a) Map of Focul Viu Ice Cave;
b) Cross section of the cave, with location of data loggers

the Big Hall is open to the sky through a large shaft, through which snow and tree trunks have fallen inside the cave to form a large, cone-shaped pile. The floor of the Big Hall is fully occupied by a massif layered ice block (20 m thick, 25.000 m^3), formed by snow diagenesis and freezing of percolating water. Between the northern side of the ice block and the host rock, a narrow opening give access to a lower, ice–free sector of the cave. ^{14}C dating of the numerous tree logs to be found in the ice gave 1800 years for the age of the ice block (Citterio et al., 2005).

Both internal and external controllers are influencing the dynamics of the ice block. Between June and October, due to dripping waters and heat transfer through conduction, the upper side of the ice block partly melts. In late autumn and early spring, the dripping waters and the melted snow from the central cone are freezing, adding a new, discontinuous, layer of ice to the existing ones. As the sediments washed inside the cave are trapped in the ice, they form distinctive layers within it, enriched in both organic and mineral particles. Thus, the block has a clearly visible horizontal stratified structure, with layers of ice up to 15 cm, in alternation with thin layers containing impurities (calcite, dust, pollen, wood remains etc). However, large water infiltrations and prolonged warmth could cause the partial melt of these layers, and thus leading to the formation of thicker sediment layers.

METHODS

In spring 2004 a number of three Gemini Tiny Tag Plus temperature data loggers were installed in Focul Viu Ice Cave: one in the Big Hall (FV1), close to the entrance, the second one (FV2) in the Small Hall (in the ice-free sector of the cave), while the third one was placed in the second shaft, at about 20 m above the floor (FV3). A fourth data logger (FV4) was installed outside the cave, to record the external air temperature. The data loggers were set to record the air temperature at every hour, with a resolution of 0.02 °C. The distribution of the data loggers (Fig. 2b) was chosen so that to record air temperature in three sensitive sections of the cave: 1) the Great Hall, influenced by external air inflow; 2) the internal sector, with constant values for air temperature; and 3) the secondary entrance, where air exchanges also occur between the cave and the exterior of it.

RESULTS AND DISCUSSION

Between April the 5th 2004 and April the 4th 2005, air temperature was continuously recorded (Fig. 3), with one hour intervals in three points inside Focul Viu Ice Cave and one point outside of it. The data loggers placed in the Little Hall (FV2) stopped recording in May 15, while for FV3, data is available only between May 15 and November 13, 2004.

Values of air temperatures outside the cave ranges between 25.95 °C and -21.37, with an average value of 4.21 °C. The maximum values are recorded in late summer, while the minimum are in early March. Negative temperatures are generalized from December through late March, but they occur as early as mid-October and also in April, for shorter periods.

In Great Hall air temperature values ranges between 0.69 °C and -14.12 °C, with an average of -1.27 °C and maximum amplitude of 14.81 °C. The daily amplitudes are close to 0 °C during summer and increase in the cold season, when they reach 5 °C. A slight increase in daily values during summer months is noted, the maximum being recorded between late October and mid-November.

In Little Hall air temperatures were bellow 0 °C for the entire interval (April 4 – May 14), showing a slight increase towards the end of it. The minimum was -0.33 °C, while the maximum was 0.01 °C, thus giving general amplitude of 0.34 °C for the entire period.

As long as external air temperature is above the internal one, there is no visible correlation between the two parameters (Fig. 3). However, as soon as external temperatures drop bellow 0 °C, a rapid response of cave air temperature is noticed, but with a smaller amplitude.

These external temperature changes are influencing the air circulation, too. There is a clear separation, throughout the year, of two types of air circulation between the external and the internal environment. As long as external air temperature is above 0 °C, there is not air inflow inside the cave (due to differences in air density), thus the above mentioned warming trend in the cave is due only to conductive heat transfer through

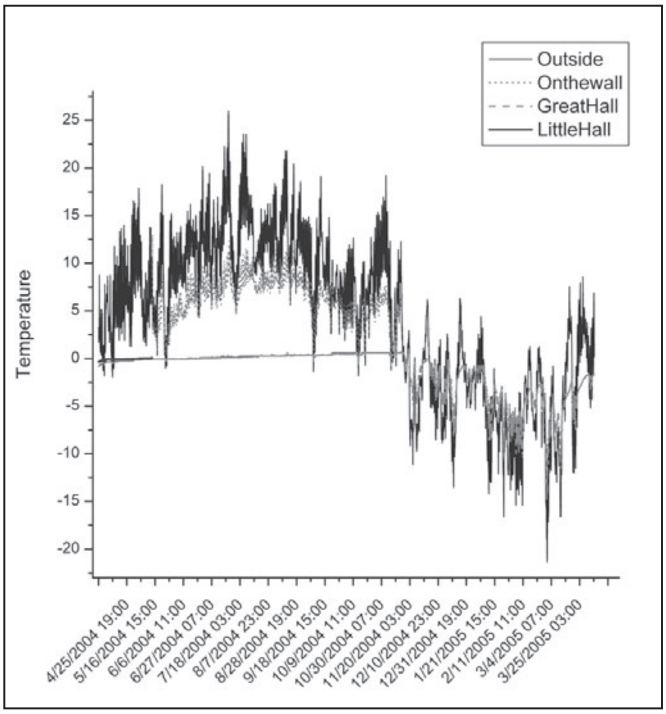

Fig. 3. Air temperature variations in Focul Viu Ice Cave

air and rock (Perşoiu, 2004). However, due to differences in air temperature and density, a convective cell develops, transporting air between the two rooms of the cave (summer type circulation). As soon as external temperature drops bellow internal ones, a rapid inflow of cold air occurs through the lower entrance, leading to a general drop of temperature throughout the cave. During these periods, internal air temperature variations are clearly following the external ones. By this mechanism, large quantities of cold air are entering the cave (which acts as a "cold trap"), leading to freezing of water and building up of new layers of ice.

In the secondary shaft air temperature variations are following the external ones, but they are always lower than these due the influence of the ice block (cooling by conductive transfer of heat). When temperature outside drops below the internal one, the cold air that is entering through the lower entrance is sweeping through the entire cave and pushes out the warm air from the inner parts of it through the secondary shaft. In spite of this invasion by cold air, warmer temperatures than outside are recorded here, and they last as long as the external temperature is lower than the internal one (Fig. 4).

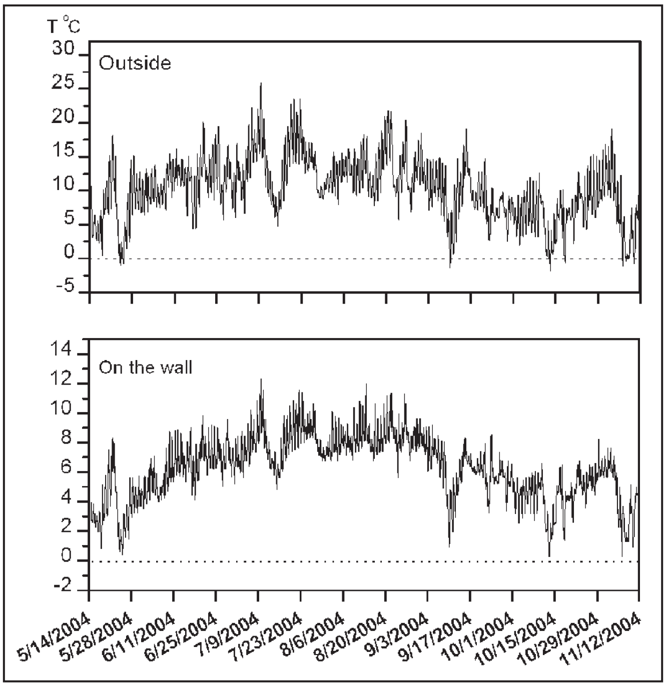

Fig. 4. Air temperature variations in the secondary shaft of the cave

Differences in air temperatures within different parts of the cave and exterior are also responsible for air circulation. In winter, airflow is directed from the surface downward into the cave. The cold air replaces the warm air from the cave, which rises and exits the cave through the upper opening. In summer, since the cold air in the cave is denser than the external one, there is no air mass exchange between the two environments.

CONCLUSIONS

The ice in Focul Viu Cave is preserved due to periglacial conditions in the cave. At present the ice block is slowly thinning due to both surface and basal ablation, mainly caused by warm percolating waters and geothermal heat, respectively. The external climate plays an important role in the dynamics of the ice, cold winter air infiltrations maintaining the periglacial conditions in the cave. Summer air temperatures play a minor role in the dynamics of the air temperature in the cave, as warmer exterior air cannot penetrate inside.

Acknowledgments

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