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A HISTORY OF HUNGARIAN SPELEOCLIMATOLOGY

Miklós Gádoros

The origins of Hungarian speleoclimatology date back to the early 19th century. By his measurements in 1826, *I. Vass (1831)* basically correctly claimed that the Baradla Cave of Aggtelek has an almost stable, 10 °C temperature. He recognized and confirmed by measurements that meltwater has a cooling effect on caves. It is worth mentioning that he also thought it necessary to record outside temperatures.

After I. Vass, others also published climatic data *(Fényes, 1851; Schmidl, 1856)*. Nevertheless, for dripstone caves in the 19th century, only sporadic data were collected before 1870. Today they have only historical value.

Research was given a new impetus by the exploration of the Dobsina Ice Cave (1870). The cave was a curiosity at the time, and its interior temperature was investigated by several researchers with increasing temporal and spatial detail *(Fehér, 1872; Krenner, 1874; Pelech, 1884* — data by the latter was first published by *Krieg* in *1883)*. Between 1882 and 1888 *E. Hanvay* measured, along with recording supplementary weather data, almost 2,000 points on the interior surface and 4 to 5 non-surface interior points in the cave. Unfortunately, only the calculated means of his data were published *(Fischer, 1888; Hanvay, 1900)*; the original record was recently found in a manuscript *(Dénes, 1970)*.

For a long time the peak of measurements in Dobsina was represented by the work of *Steiner (1922)*. From 1911 to the end of World War I he measured, besides air temperature, the temperature of the rock wall at various depths, with the precision and regularity of a meteorologist. (After the Trianon Peace Treaty Dobsina was annexed from Hungary and its research history by Hungarians was interrupted.)

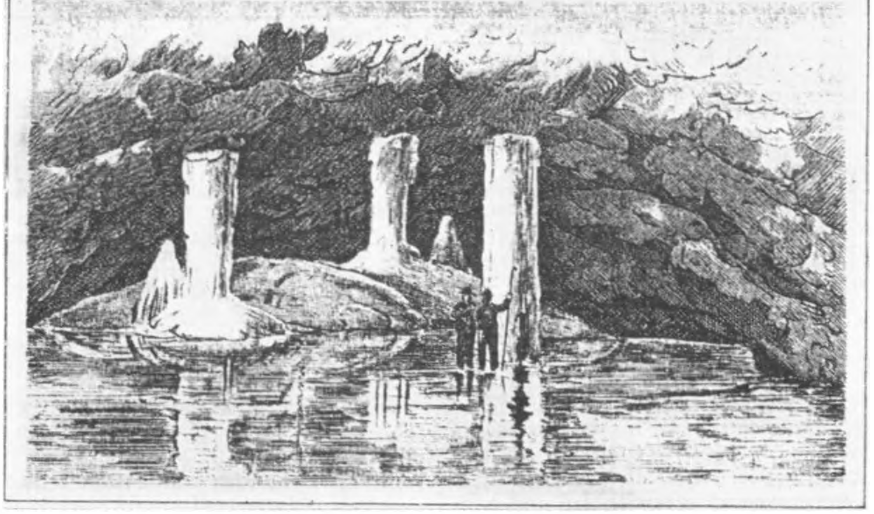
Climatological investigations in dripstone caves only intensified, after the initial steps, in this century. The work was begun by biologists who wanted to discover the physical conditions of cave habitats. The Abaliget Cave near Pécs was studied by *Gebhardt (1934)* and the Baradla Cave of Aggtelek by *Dudich (1932)*. In addition to the description of almost 300 animal species in each cave, they both stated that the annual range of air temperature is moderate in the caves studied and cave air is saturated with vapour most of the time and in most places.

In the last major publication in the first half of the century, *Béll (1945)* points toward a period of new attitudes. He investigated cave ventilation and in his evaluation compared the ventilation of mines and caves. The importance of his work lies in the analysis of ventilation.

The economic and political consequences following World War II brought about a decline in the research on cave climate for a long interval. It was not until 10 years after the war that the first publication appeared. *Dudich (1955)* disclosed that in Central Europe the climates of moist karst caves in low and mediumheight mountains are approximately the same and consequently the curative effect observed in the Klutert Cave must be characteristic of other caves too. Shortly after this recognition, *Markó* and *Jakucs (1956)*, studying air currents in the Béke Cave of Aggtelek, found that, related to the difference between outside and inside cave temperature, the role of air pressure, previously regarded predominant, was generally inconsequential.

The climate of the Béke Cave of Jósvafő was first studied by *Jakucs (1959)*. Workers of the Public Hygiene and Epidemics Station of Borsod-Abaúj-Zemplén county investigated temperature, moisture, CO_2 concentration, ventilation and the calcium content of aerosol, in 1959, 1960, 1961 and in 1965 *(Kerényi—Bíró—Kirchknopf, no date)*. In 1963 or 1964 *Szabó* and others conducted similar investigations, and *Urbán* carried out a general climatological survey in the Abaliget Cave, Mecsek Mountains in 1964. A similar general climatological investigation took place in the Baradla Cave *(Berényi—Justyák, 1960)* showing air current, temperature and air moisture differences along the same cross-sections. Parallel studies went on in the Béke and Baradla Caves *(Csomor—Zalavári, 1964)*, while *Gy. Szabó* conducted climatic measurements in the caves of Lillafüred.

At the Jósvafő research station measurement techniques were further developed *(Gádoros, 1966)* and the relationship between aerosol and helictits formation was studied *(Cser—Maucha, 1964)*



Dobsina Ice Cave, where the first detailed climatological investigation was taken in the 1870s

in the Vass Imre Cave, which belonged to the station.

In the same period, *I. Fodor* began speleoclimatological investigations in the Baradla Cave in 1959—63 and in the Abaliget Cave between 1966 and 1975. In the meantime he also made numerous measurements in the two caves of Tapolca. Besides temperature, air moisture and air current velocity measurements, he also conducted CO_2 measurements, aerosol analyses and bacteria countings. He wrote a lage-scale treatise based on more than 11,500 (!) temperature measurements, more than 10,000 air moisture measurements and other data (of unknown number) and provided a statistical analysis of the averages and fluctuations of various climatic elements in various caves. He analyzed the vertical gradients of temperature and moisture, introduced a new bioclimatological classification, and extended Gressel's climatological classification with a 'quasi-dynamic' type. For his work he was awarded a scientific degree by the Hungarian Academy of Sciences *(Fodor, 1981)*.

In order to study radioactivity, large-scale serial measurements began at the Jósvafő research station in 1966. During 10 years time, more than 30 caves were surveyed *(Gádoros, 1986b)*. At the end of the decade *Rónaki (1973)* investigated the radioactivity of the air and stream of the Abaliget Cave.

The next step was the aerial extension of the investigation. *Walkovszky (1970)* studies the Vecsembükk Shaft (Alsó-hegy) and *Lénárt (1975)* the Létrási-vizes Cave (Bükk Plateau) while *Kordos (1975)* analyzed the intricate climatic conditions of the entrance parts of caves. *Miklós (1978)* described the climatic conditions of the Hajnóczy Cave and then conducted detailed measurements in the Remény Shaft, Mecsek Mountains *(Miklós, 1980)*. The research of the Béke Cave continued, and aerosol samples were taken using modern technology. This allowed the precise determination of the calcium content of the cave air *(Takács et al. 1984)*.

The year 1978 saw a turn in the investigation of cave radioactivity. Trace detector measurements began in the Hajnóczy Cave, Bükk Mountains *(Somogyi et al., 1983)*, and after a short time a survey of 10 caves was under way by this method (partly unpublished results; *Somogyi—Lénárt, 1986)*.

A new advance in speleoclimatology was realized by regular ionization measurements, initiated long ago by *H. Kessler*. In 1985, under the guidance of *J. Tardy (1987)* this type of investigation began in the Szemlő-hegy Cave of Budapest as part of abroad research project which was directed at the specification of the impact of urban development on the underlying caves *(Bolner—Tardy, 1988; Tardy, 1988.)*

For lack of publication we cannot say much about the most recent activities. What is known, however, is that ionization measurements have been extended to four caves, radioactivity determination by the trace detector method is going on, and regular CO_2 measurements are being conducted in the Baradla and Alba Regia Caves (Tés Plateau), and, naturally, the extended conventional climatological measurements are continuing.

This brief summary indicates that Hungarian speleoclimatology, relying on a century of traditions, developed in three main directions during the past decades:

1. Aerial extension of the study of traditional climatic elements, reducing the time intervals of measurements and increasing measurement sensitivity;

2. Introduction of the analyses of more and more, previously unstudied climatic components (e. g. radioactivity, aerosols and ionization);

3. Disclosing physical foundations and interactions on the basis of accumulating measured data and making advances towards the synthesis of these elements of cave climate into a complex physical system.

The latter purpose is efficiently promoted by progress in related disciplines. For instance, the karst corrosion studies by *Zámbó (1986)* supplied valuable data for the evaluation of the CO_2 content of the involved caves.

All these are 'only' fundamental research, but indirectly, or even directly, they promote the development of applied fields, such as speleotherapy.

Miklós GÁDOROS
electrical engineer
Budapest
Kapi út
H–1025

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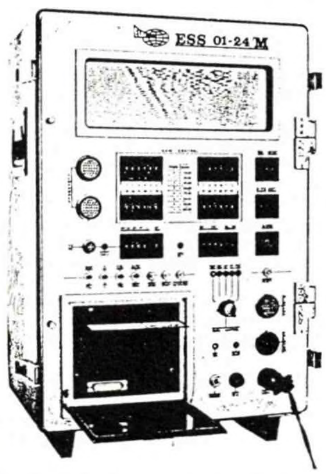

Top: Mineral formations in the Beremend Crystal Cave, Villány Mts. (by T. Hazslinszky)
Bottom: Sátorkő-puszta Cave, Pilis Mts. (by P. Borzsák)