

**ON THE PROBLEMS OF THE ICE FILLING
IN THE DOBŠINA ICE CAVE**

**O PROBLEMATIKI LEDU V DOBŠINSKI
LEDENI JAMI**

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Izvleček

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Marcel Lalkovič: O problematiki ledu v Dobšinski ledeni jami

Z vprašanjem spreminjanja ledenih oblik v Dobšinski ledeni jami se je v letih 1981 - 1990 ukvarjal Slovaški muzej varstva narave in jamarstva iz Liptovskega Mikulaša. Pojavili sta se dve skupini problemov: naraščanje ali nazadovanje ledu na opazovalnih točkah, razporejenih po jami oziroma prostorsko spremljanje teh sprememb v posameznih delih jame in preučevanje kinetičnih sprememb talnega ledu. Sedanje stanje poznavanja je rezultat meritev, osredotočenih na statične pojave vzdolž turističnih poti v nekaterih delih jame. V določenih delih jame se je talni led zdebil. Največje spremembe so bile zabeležene v Veliki dvorani. Opazujemo tudi kinetične pojave v ledenem polju, ki se pomika proti spodnjim delom jame.

Ključne besede: speleologija, speleoklima, ledena jama, Slovaška, Dobšinska ledena jama

Abstract

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Marcel Lalkovič: On the problems of the ice filling in the Dobšina Ice Cave

In the years 1981 - 1990 problems concerning the changes of ice forms in the Dobšina Ice Cave were investigated through the Slovak Museum of Nature Protection and Caving from Liptovský Mikuláš. There were two main problems: increase and decrease of ice filling in the observation points scattered in the cave or space pursuing of these changes and investigating of kinetic manifestations of the floor ice. Actual knowledge is the result of observations focused on static manifestations along the touristic pathways. There is an increase of the floor ice. The greatest changes have been recorded in the Great Hall. Kinetic manifestations are observed in the ice field moving towards the lower parts of the cave.

Key words: speleology, speloclimatology, ice cave, Slovakia, Dobšina Ice Cave

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The Dobšiná Ice Cave is from the point of view of its opening for public one of the oldest caves in Slovakia. Thank to its unique ice decoration it has been attractive for scientists since its opening in 1870. This scientific interest remains up today. Ice decoration in the cave is presented in various forms and as the floor ice in all parts open for public. The amount and character of ice formations have made it one of the most frequently visited Slovak caves. The cave has been systematically studying by many experts for a longer time. The aim of these studies is to help preserving the present state of ice decoration and filling.

Problems of ice filling changes have been studied by present Slovak Museum of Nature Protection and Speleology in Liptovský Mikuláš during the period 1981 - 1990. The necessity of similar program resulted from the conclusions of scientific conference held in Slovakia in 1970 on the occasion of 100 years anniversary of the discovery of the cave.

Problems of changes of ice filling are twofold. The *first* group of problems includes studies of ice filling increase and decrease at the measuring points distributed in cave and areal observations of the changes in its selected parts. The observing points have been located with respect to character of cave spaces and ice filling into Malá sieň (The Small Hall) - points 1 and 2 , Vel'ká sieň (The Large Hall) - points 3, 6, 9 and 15, into Vel'ká opona (The Large Curtain) surroundings and Ruffiny corridor. Areal studies have been carried out in Malá and Vel'ká sieň and in the space near Vel'ká opona. Later, the measurements have been extended also on Vstupné schodište (the Entrance Stairway) and the passage between Vel'ká and Malá sieň on current excursion route. Some orientation measurements have been done with the same purpose.

The *second* group of problems connected with the study of ice filling changes comprises observations of kinetic manifestations of the ice filling. The studies were based on periodic measurements of observing points located on the floor of those cave's parts covered with ice (Malá and Vel'ká sieň, Vel'ká opona surroundings) and in the ice wall of Ruffiny corridor. The measurements were aimed at determination of horizontal and vertical components of the displacement. Later observations of the excursion pavement deformations in Malá sieň, at Vel'ká opona and in Ruffiny corridor have been connected with the previously achieved knowledge.

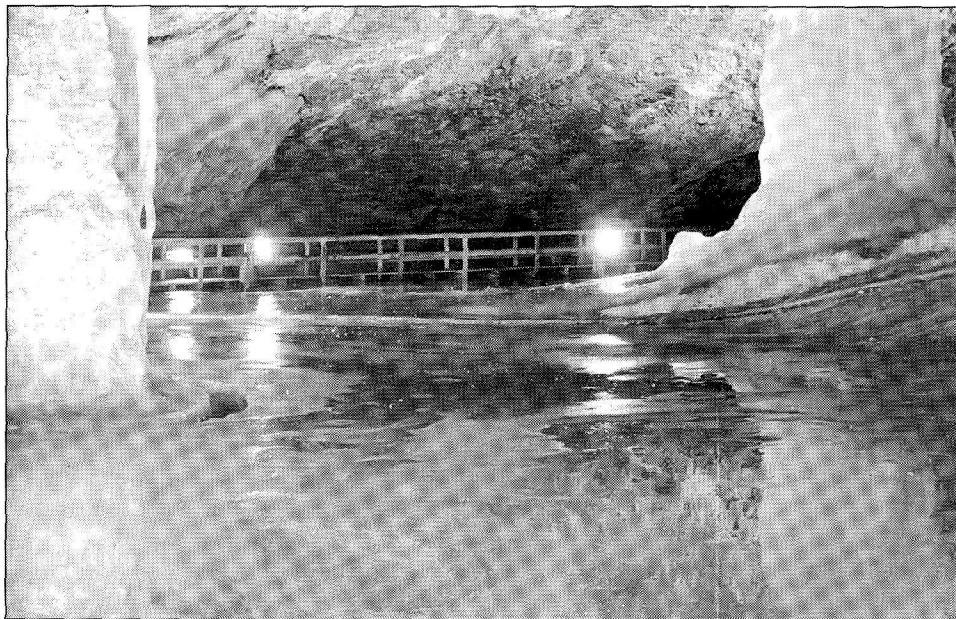
It should be noted that there was no methodology before that would allow

us to predict effective solutions or adequate results. Therefore, in the beginning it was necessary to verify some components used by particular measurements experimentally (observing points, consoles, etc.). Only longer observations in the cave's environment allowed for modifications of measuring procedures or corrections of their extent and character. Another handicap resulted from the character of the environment in the cave. Utilization of some methods was simply excluded due to shape of cave's space. It has led to original constructions and their experimental verification. The ice filling acted as a negative factor as well. Some observing points have been covered with ice in course of measurements or have lost their functionality for another reasons.

Despite the above mentioned problems the ten years observation period has provided valuable data on our tasks. It helped us to know the course of some processes and answered many, previously only accidentally expressed assumption. Unfortunately, the extent of this paper does not allow more complex presentation of this topic.

METHODS AND ACCURACY OF MEASUREMENTS

In order to understand the processes taking place in the environment of the cave as well as possible, the ice filling changes have been observed by



The Large Hall (Photo M. Eliaš)

means of the following methods :

a) geodetic - method of in front intersect

The position of observing points was measured with the aim to determine the horizontal component of their displacement. Position of the points was calculated from particular number of combinations. The method was supplemented by elevations measurements (method of geometric levelling) that were oriented onto determination of vertical component of displacement

b) geodetic - method of numerical tachymetry

This method was used to reveal volume changes of the floor ice. In case of volume changes of ice in vertical direction it was supplemented by lengths measurements aimed at determination of differences used then by calculation of volume changes.

c) geodetic - method of measurements of small lengths at observing points with specially constructed equipment with the aim to determine ice increase or decrease at measured points

d) photogrammetric - methods of single - snap photogrammetry and ground stereophoto-grammetry

The methods have been used by evaluation of shape and volume changes of selected part of ice field and ice formations.

Specific conditions in the cave had influence on the accuracy of measurements. Therefore, the accuracy of position of particular points is characterized by average error of ± 5 mm. Geometric levelling was affected by mean error of determination of the observing point elevation $m_z = \pm 0.6$ mm. The magnitude of ice increase and decrease at particular observing points is characterized, with respect to technical parameters of used equipment by mean error $m_x = \pm 1.0$ mm.

RESULTS

The observation results can be divided into several groups. The first includes increase and decrease of the floor ice as determined by measurements on observing points (Malá sieň, Vel'ká sieň, Vel'ká opona surroundings)

It comprises also volume changes evaluated by numerical tachymetry.

Second group of results is created by volume changes of the vertical ice walls (Vstupné schodište, passage between Malá and Vel'ká sieň) and changes on the observation points in vertical ice wall of Ruffiny corridor.

Third, and from the viewpoint of this contribution the last group includes kinetic manifestations of ice filling and related deformations of the excursion pavement.

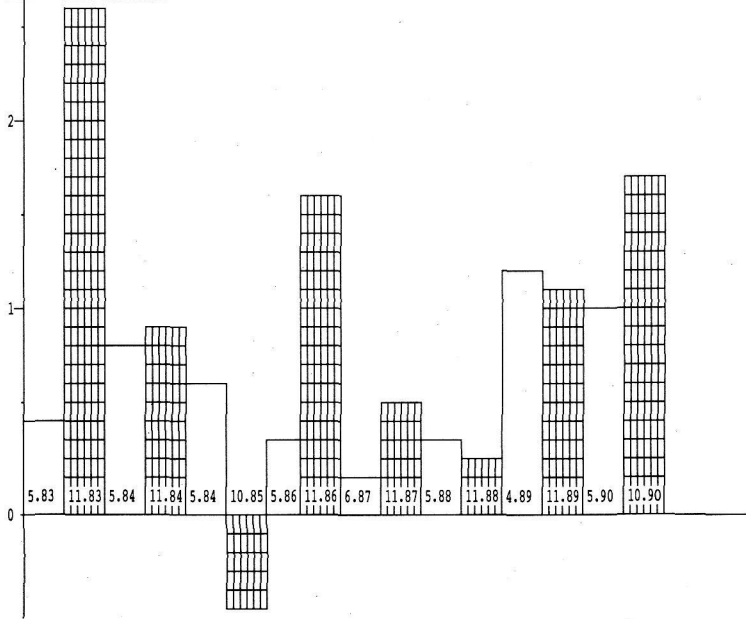
a) Ice filling increases and decreases

Quantitatively the largest increases on the observation points have been recorded in marginal part of Malá and Vel'ká sieň. Surroundings of Vel'ká opona seemed to be a promising area as well. The intense draining of water resulted into covering of the observing point with ice in 1984 already.

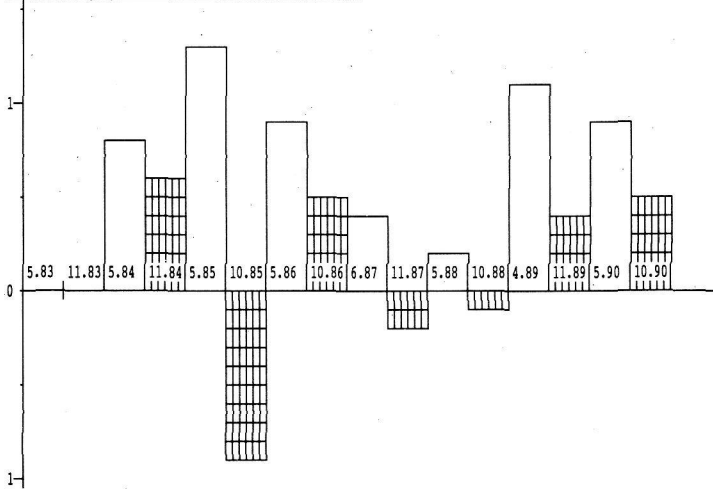
Decrease of ice

a) Entrance Stairway

DIE GRÖSSE DES EISABNAHMEN
a / die Eintrittsstiegen



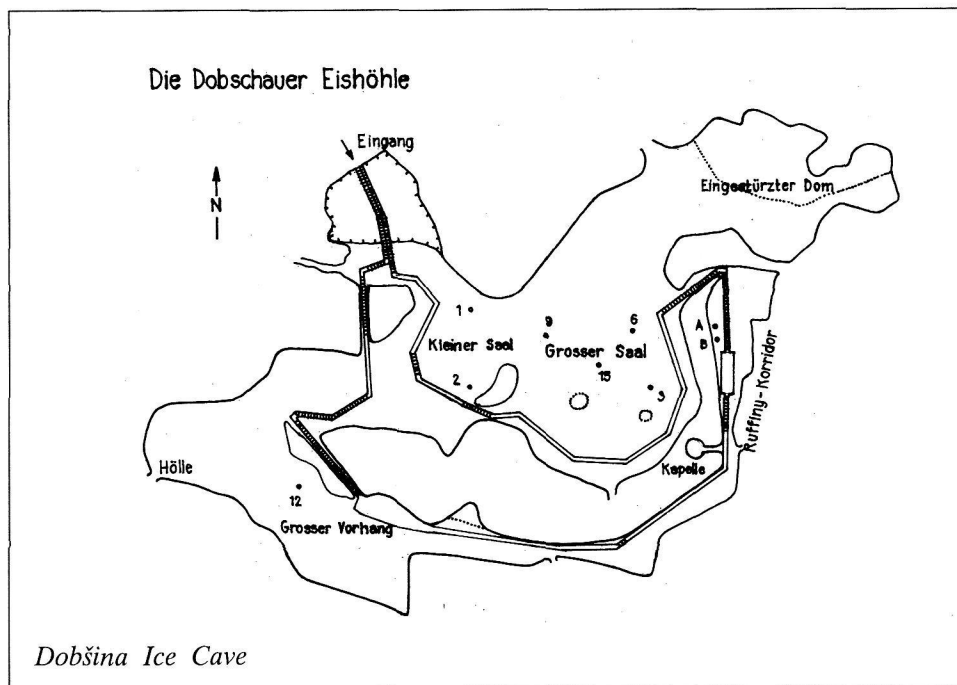
b / der Übergang zwischen Kleinen - und Grossen Saal



b) Passage between Large and Small Hall

Punkt	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Die Angaben in mm										
1-Kleiner Saal	0	12	3	19	10	32	115	vereisigt		
2-Kleiner Saal	0	-9	10	-8	-4	-5	-6	7	beschädigt	
3-Grosser Saal	8	0	-14	24	7	7	-27	60		
9-Grosser Saal	50	111	26	64	vereisigt					
15-Grosser Saal	27	30	-22	-13	7	13	-36	12		
6-Grosser Saal	-13	12	beschädigt							
12-Grosser Vorhang	-	83	95	vereisigt						
A-Ruffiny-Korridor	-	-8	-9	-6	-5	-4	-3	-4	-7	-1
B-Ruffiny-Korridor	-	-7	-4	-2	-5	-5	-6	1	-6	-7
+ die Eiszunahmen - die Eisabnahmen										

Increase and decrease of ice at observation points



Consequently, it was not possible to evaluate the increase of the floor ice. Decreases of ice filling have been reported only in passage between Malá and Vel'ká sieň. Such tendency is connected with volume changes of vertical ice walls proved by measurements at these places (Table 1).

The floor ice has been increasing during the observed period as a result of human technical interventions. This fact is documented by increases determined by numerical tachymetry in Malá and Vel'ká sieň and Vel'ká opona surroundings. The largest uplift of the floor ice is in Vel'ká sieň and the largest re-groupment has been recorded in surroundings of Vel'ká opona. It is the lowest part where the water flowing from higher parts gradually freezes and creates new ice layers.

b) Volume changes of vertical ice walls

Decreases of ice filling prove that the profile of corridor in the entrance part of the cave is being permanently wider. The decrease in Vstupné schodište is approximately 12 cubic meters for the period of eight years, while in passage between Malá and Vel'ká sieň it has reached the value of 4 cubic meters approximately. Supposed this process is not stabilized, its negative consequences can become evident after some time in forms that are only hardly predictable yet.

Neither Ruffiny corridor is without problems. Small changes represented by decreases of ice filling have been observed there, too. This tendency is confirmed also by decreases of ice on the observing points. The decrease of ice wall for the given period (1982 - 1990) was 41 - 47 mm with annual decreases within 1 - 9 mm.

The course of volume changes with respect to particular seasons is interesting as well. Measured data indicate that the course of volume changes (decreases) in the beginning and end of season (with respect to their magnitude) follows a sinusoid. Frequency or the extremes of the curve are situated within the range of two to four years. Volume changes measured in the beginning of season have greater phase shift. Volume changes at the end of season are characterized by higher values.

Volume changes in the passage between Malá and Vel'ká sieň showed similar course. The shape of curve expressing volume changes variations at the beginning and end of season is rather similar. Season beginning is characterized by higher values of decreases than its end. Frequency is within the range of two to four years as well. Lower value of the phase shift is typical for the volume changes at the end of season. Its higher value is connected with changes recorded in the season beginning again.

c) Kinetic changes

As it follows from the evaluation of observing points position, their displacement is pronounced in direction Malá sieň - Vel'ká sieň and only partially in direction Malá sieň - Vel'ká opona. The values of the displacement reach up to 37 mm in the x axis direction and up to 31 mm in the y axis

direction during the period of three years. The data are relevant to points situated in Malá and Vel'ká sieň. Movement velocity of particular points in horizontal component of displacement varies. In case of points in Malá Sieň (points 1 and 2) it is 10.7 - 14.9 mm/year. Movement velocity of points in Vel'ká sieň (points 3, 9 and 15) is characterized by values between 5.4 and 18.1 mm/year. The greatest changes have been observed in central part of Vel'ká sieň (points 3 and 15) which correspond to volume changes of the floor ice in this part of the cave.

Vertical components of measured displacements vary between 1.5 and 78.5 mm. Maximum has been reached in passage between Malá and Vel'ká sieň (point 2). The downward tendency has been observed during the given period by all observing points although there were some uplifts in particular periods. However, the uplifts were recorded at points located at places with pronounced horizontal bedding of the floor ice.

Ruffiny corridor is characterized by lower horizontal component of displacement velocities of the observing points. The reason is that the observing points are set in vertical ice wall. Vertical displacement is 6.7 mm/year on average. Also these points are typical for downward movement during the observed period.

Changes expressed either as depressions or deformations of the excursion pavement in the area of Malá sieň are the evidence of destruction typical for the entrance parts of the cave. Measurements carried out during the period of five years showed that there has been a marked drop of the left and right sides of the pavement. The drops recorded by 26.5 m long pavement were 49 mm on average at the left side and 28 mm at the right side. Such results are partially connected with some unwise human activities (drainage channels). At the same time they give evidences of kinetic manifestations of the ice field taking place in the direction Malá sieň - Vel'ká opona.

Pavements depressions have been found out also in Vel'ká opona surroundings and on stairway at Kaplnka in Ruffiny corridor. Near Vel'ká opona they are more pronounced only in the front part (in the direction of excursions) and are connected with the state of bedrock underlying the bearing constructions. The depressions of the right side of stairs at Kaplnka result from situation indicated by changes on observing points A and B and volume changes of the wall ice of Ruffiny corridor in its near surrounding.

CONCLUSIONS

It is neither possible to give the detailed description of ice filling changes in this paper nor analyze the reasons of the changes. However, it seems that it is necessary to re-evaluate some of human interventions in the environment of the cave. It is not only problem of draining channels that should be solved with higher consideration than before.

The consequences of digging the new entrance corridor through the ice field in the vicinity of Malá sieň in 1974 became evident just during the observed period. They were confirmed by other works, too. And, it is the status that must be carefully analyzed if also the future generations are to find in the cave that what made it well known among their present visitors.

O PROBLEMATIKI LEDU V DOBŠINSKI LEDENI JAMI

Povzetek

Z vprašanjem spreminjanja ledenih oblik v Dobšinski ledeni jami se je v letih 1981 - 1990 ukvarjal Slovaški muzej varstva narave in jamarstva (Slovenské muzeum ochrany prírody a jaskyniarstva) iz Liptovskega Mikulaša. To delo je bilo rezultat znanstvenega srečanja leta 1970, ki je bilo ob stoletnici odkritja jame. Glede vprašanja, ki bi ga bilo treba rešiti, sta se pojavili dve skupini problemov. V prvo sodi opazovanje naraščanja ali nazadovanja ledu na opazovalnih točkah, razporejenih po jami, oziroma prostorsko spremljanje teh sprememb v posameznih delih jame. V drugo skupino sodi preučevanje kinetičnih sprememb talnega ledu. Sedanje stanje poznavanja problema je rezultat meritev, osredotočenih na statične pojave vzdolž turističnih poti v nekaterih delih jame.

Na osnovi preučevanja lahko sklenemo, da se je, zaradi določenih tehničnih ukrepov, talni led zdebelil. Največje spremembe debeline ledu so bile zabeležene v Veliki dvorani. To potrjuje tudi odebelitev ledu na določenih posameznih opazovalnih točkah. Na drugi strani pa lahko opazujemo kinetične pojave v ledenem polju, ki se pomika proti spodnjim delom jame (Velika in Mala dvorana). Vrtenje opazovalnih točk v Ruffinijevem rovu je posledica pritiska ledene stene.