DOBŠINSKÁ ĽADOVÁ JASKYŇA ICE CAVE – 136 YEARS FROM ITS DISCOVERY

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Abstract: Ice Cave named Dobšinská ľadová jaskyňa is occurred in the east part of Slovakia, in the southern part of National Park called Slovenský raj (Slovak Paradise) in the karst plateau named Duča. The Ice Cave was discovered by E. Ruffiny in 1870. The Ice Cave is developed in Steinalm Limestones (Middle Triassic). It is a part of cave system of Stratenská jaskyňa Cave. Its length is 1483 m and from them 753 m is covered by ice. The underground glacier has own volume 110 thousand m^3 with maximum thickness 26.5 m. The Ice Cave was created by underground flow Paleo Hnilec in late Tertiary. The main underground spaces belong to fourth cave developing level. We can to assume, that glaciated parts were developed through collapsing and disjunction the Ice Cave from Stratenská jaskyňa Cave in Mindel and beginning of the ice filling creation we can dating to Riss (250 –140 thousand years) at least. An accretion of the underground glacier is active from the top and from the bottom the underground glacier is defrosting, by this way the ice volume is changed by degrees. In period of years 1998 – 2002 an expansive geological, geomorphologic and speleological research was realized in the Ice Cave and on the base of the research we obtain new view and opinion about genesis and development of the extraordinary interesting natural phenomenon. The Dobšinská ľadová jaskyňa Ice Cave together with Stratenská jaskyňa Cave were inscribed in to the Register of World Cultural and Natural Heritage of UNESCO in year 2000.

Key words: Dobšinská ľadová jaskyňa, Stratenská jaskyňa, climatic conditions, underground glacier

Ice Cave named Dobšinská ľadová jaskyňa is occurred in the east part of Slovakia (Fig. 1) in karst territory Slovenský raj (Slovak Paradise) in karst plateau named Duča. The entrance is in level 969 m above sea level with its orientation to north-west. Currency of karst plateaux with abundant distribution of surface and underground karst phenomenon, less monoclinal kart combs is characteristic for relief of Slovenský raj.

Known cave system of Stratenská jaskyňa Cave is in plateau Duča and its part is also Ice Cave named Dobšinská ľadová jaskyňa (Fig. 2). The system was created by two underground allochthonous flows. They were brook Tiesňavy and river Hnilec. In the system were classified five genetic levels and two horizons. The fourth genetic level is the most important and developed level (Tulis – Novotný, 1989).

Fig. 1. Position of Slovenský raj in the frame of Slovakia

The ice cave named Dobšinská ľadová jaskyňa was discovered by E. Ruffiny on June 15th, 1870. The first Cave plan was created in 1871 (Fig. 3).

The Cave is developed in Middle Triassic Steinalm limestones, which are heavily bedded and intensively disjunctive, collapsed by tectonic. The limestones are bedded into large anticlinale and by this way they are created stabile cave ceiling with domal structure. Tectonic discontinuity is mainly in this ways: NW-SE/35°-86° to NE; N-S up to NE-SW with slope to SE and NW; E-W (Novotný – Tulis, 1999, 2001).

The Cave has two parts and they are different developed mainly in the fourth genetic level (Fig. 4). South part is covered by ice and north part is without ice. The north part is represented by fluvial and by gravity moulded horizontal passages. Part, which is covered by ice is represented by one huge cavern falling down from entrance into depth of 70 m with volume 140 000 m^3. These spaces have mostly collapsed ceilings according with reliable tectonic breaks, faults and according with rock stratification. Tectonic influence is used in forming of underground spaces also in parts, which aren't covered by ice. Levelled ceilings contain morphological forms of moulding spaces, which aren't covered by ice and on them we can see pendants, some of them are articulated by downright canals in shape of anastomose, which bottom part presents relicts of older

Fig. 2. Cave system of Stratenská jaskyňa Cave

levelled ceilings. In north part of the Cave we can see reach spread water mechanic sediments – river gravels. Rock gravel material comes from non karst territory building by crystalline complex and by its Palaeozoic and Mesozoic cover (Fig. 5). Water chemical deposits and sediments are occurred only in parts, which aren't covered by ice and they are represented by different forms of stalagmites and stalactites, wall and bottom calcareous sinter films and sinter-falls. A lot of gravity sediments are enlarged in the whole Cave, in glacial part under underground glacier. Sediments represent fragments, boulders of limestone sometimes of sizable dimensions (l. c.).

In glacial part the ice is the main filling. Underground glacier creates one body and glaciation is year-round and permanent (Fig. 6). Volume of the glacier is 110 000 m^3, the maximum of thickness of the ice is 26.5 m (Fig. 7; Novotný – Tulis, 1995, 1996). Process of glaciation is close to balance. The ice in upper parts is increasing and in bottom parts it is gradually is melting or the ice sublimates into space. The way inhibits marked seasonal oscillations of formation or decre-

Fig. 3. Dobšinská ľadová jaskyňa – the first Cave plan by E. Ruffiny

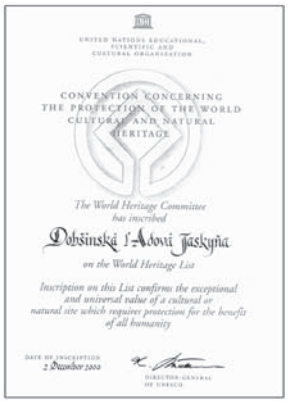

Fig. 4a. Dobšinská ľadová jaskyňa Ice cave (map)

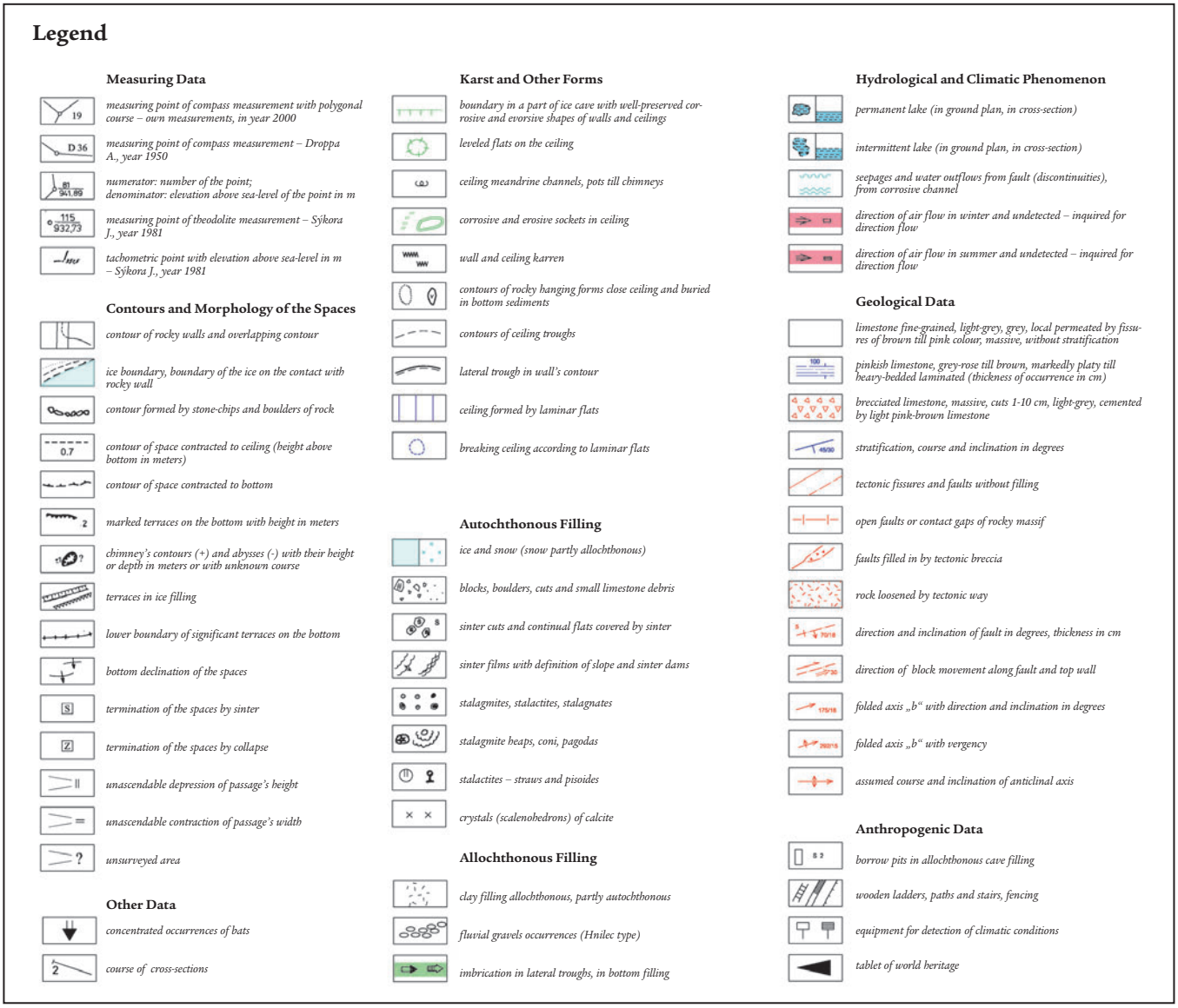

Fig. 4b. Dobšinská ľadová jaskyňa Ice cave (legend)

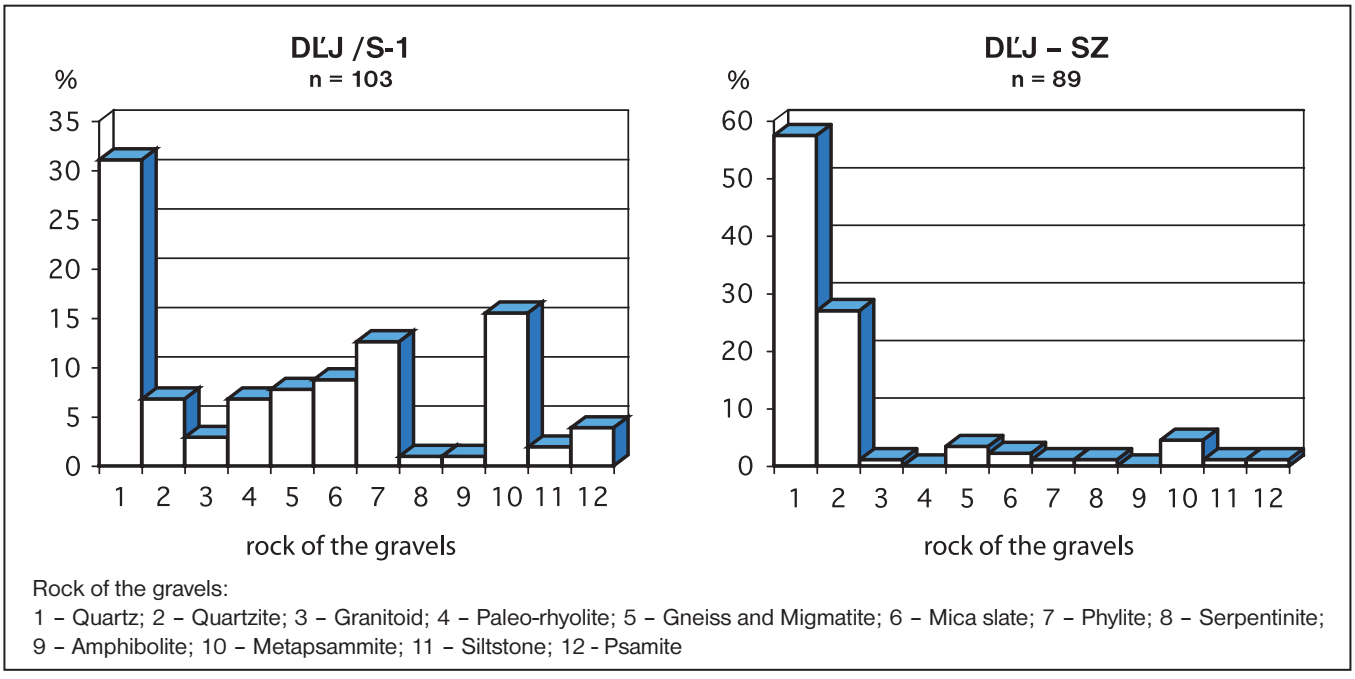

Fig. 5. Histograms of rock composition gravels of Paleo – Hnilec river in the Cave and in the front part of the Cave

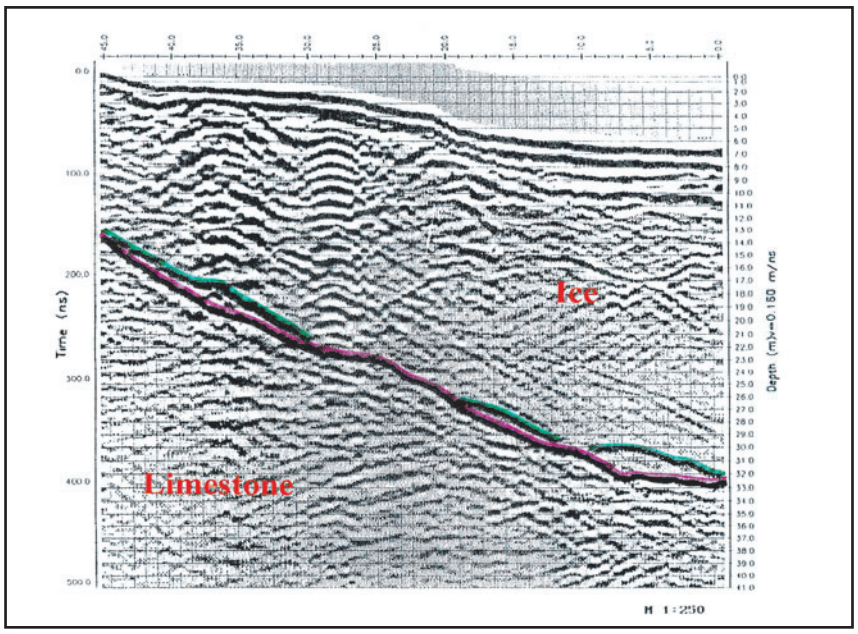

Fig. 6. GeoRadar profile through Dom named Veľká sieň in cave Dobšinská ľadová jaskyňa (Dobšinská Ice Cave)

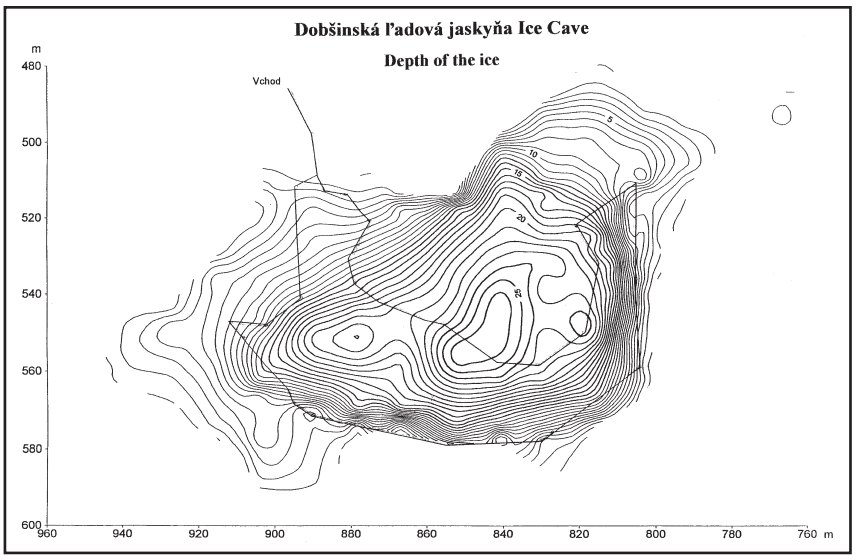

Fig. 7. Depth of the ice

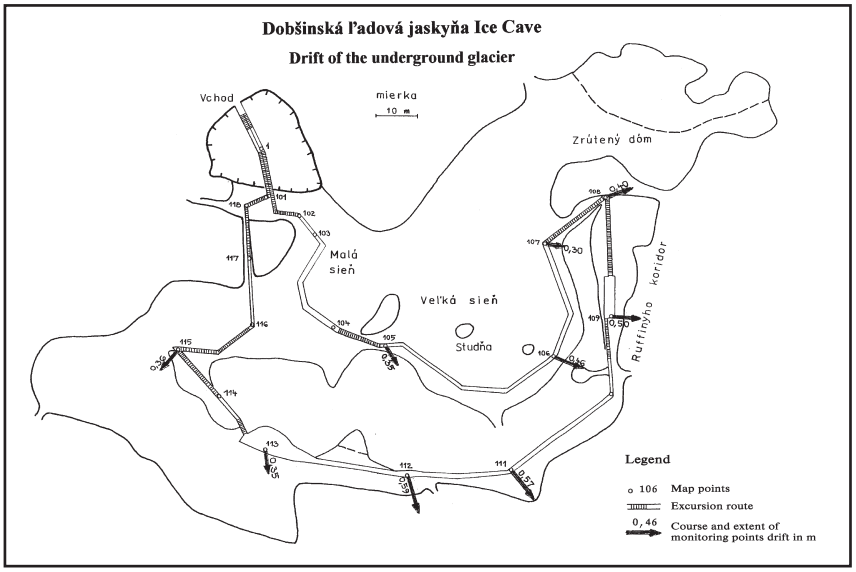

Fig. 8. Drift of the underground glacier

ase of ice. The glacier is "flowing down" through inclined bottom (Tulis, 1997), and it is deforming (Fig. 8).

The area of glaciation spaces is increasing from discovery of the Cave (Tulis – Novotný, 2003).

The ice in the Cave is creating mainly during spring season so water interfuses from melting snow and from precipitation through limestone's overlying rock into cave with minus temper grade of air. Ice destruction is beginning in the second half of summer season under the thumb of penetrating water into the Cave.

Underground glacier generated under peculiar geological-geomorphologic, hydro-geological and climatic conditions.

Underground waters are supported only from atmospheric precipitation (Novotný – Tulis, 2001). Water inflows into underground to parts, which aren't covered by ice, are mostly diffused and they are represented by drip from ceiling and from walls. The drip has different, but mostly low intensity from tectonic faults and open fissures. Whereas karst massif above cave spaces has thickness less than 20 to 50 m and it is karsificated, intensity of surface precipitation is very quickly demonstratives in underground and level of underground lakes balances and it is depends on external precipitation determined flows into these lakes. Some lakes are decrescent to lakes with area up to 1 m^2 or they are completely drying-out in time of low precipitation, but mainly during winter season. Water from drip is source for creating of cave chemogenic sediments – speleothems.

Characteristic of waters: Temperature of water in lakelet (in spaces Kvapľová sieň and Biely dóm) is close to air temperature in the Cave: 2.9 °C a 3.5 °C (outdoor temperature 0 °C).

Waters in underground spaces have hardness about (9-10°/N) and mineralization 340 – 370 $mg.l^{-1}$; type of water: basic strong calcium – hydrogen carbonate type (A2).

Climatic conditions in glaciated part of the Cave were under study practically from times of its discovering. Observed variations of air temperature were in range –3.5 to +0.5 °C according with long--term observations. Super cooling of the rock massive was observed into depth 0.5 and 1 m (Dropa, 1960; Halaš, 1985).

Tab. 1. Results of microclimatic measuring in non iced parts of the Cave

Stand	Date	Temperature			Air flowing	
		Of Air	Of Water	Of Floor (In the depth. 5 cm)	Course	Velocity
		[°C]			[m.s^{-1}]	
Pred jaskyňou	3. III. 2001 5. V. 2001 6. VIII. 2001	0 – 0.2 13.1 – 15.9 8.7 – 14.5				
Zrútený dóm	3. III. 2001 5. V. 2001 6. VIII. 2001	-1.2 0 0.5		 -0.8	Do prepadliska Duča Do Zrúteného dómu Do Zrúteného dómu	1.49 0.92 0.2
Biely dóm, bod 93	3. III. 2001 5. V. 2001 6. VIII. 2001	3.6 2.7 2.4		 1.1	Do Ľadovej pivnice Z Ľadovej pivnice Z Ľadovej pivnice	0.42 0.75 0.46
Biely dóm, bod 100	3. III. 2001 6. VIII. 2001	3.6 3.0	3.5 2.7	 1.1		
Ploché bludište, bod 82	3. III. 2001 5. V. 2001 6. VIII. 2001	3.4 2.6 2.8		 1.1	Do Bieleho dómu Z Bieleho dómu Z Bieleho dómu	1.31 0.27 0.39
Severná chodba, bod 28	3. III. 2001 5. V. 2001 6. VIII. 2001	4.2 4.3 3.1		 1.1	Bez prúdenia Bez prúdenia Bez prúdenia	0 0 0
Severná chodba, bod 32	3. III. 2001 5. V. 2001 6. VIII. 2001	4.2 3.9 3.6		 2.5	Na západ do závalu Zo závaliska ?	1.62 0.16 0.08
Kvapľová sieň, bod 39	3. III. 2001 5. V. 2001 6. VIII. 2001	4.4 3.9 2.4		 1.7	Na sever do suťoviska Bez prúdenia Bez prúdenia	0.07 0 0
Kvapľová sieň, bod 43	3. III. 2001 5. V. 2001 6. VIII. 2001	4.1 3.8 2.8		 1.5	Na sever do sute Bez prúdenia Bez prúdenia	0.45 0 0
Kvapľová sieň, bod 46	3. III. 2001 5. V. 2001 6. VIII. 2001	3.6 3.6 2.5		 1.4	Na sever do puklín Na sever do puklín Na sever do puklín	1.55 0.70 0.2
Kvapľová sieň, bod 59	3.III. 2001 5. V. 2001 6. VIII. 2001	3.2 3.8 2.6		 1.1	Bez prúdenia Bez prúdenia Bez prúdenia	0 0 0
Priepasť dvojitý ponor, ústie	3. III. 2001 5. V. 2001 6. VIII. 2001	3.4 3.3 2.7		 1.2	Z priepasti Z priepasti Z priepasti	1.19 0.36 0.18
Vstupná chodba, bod 9	3. III. 2001 5. V. 2001 6. VIII. 2001	0.2 2.0 1.8		 -0.1	Do Kvapľovej siene Z Kvapľovej siene Z Kvapľovej siene	0.81 0.60 0.22
Vstupný labyrint, bod 5	3. III. 2001 5. V. 2001 6. VIII. 2001	-0.8 0.6 -0.1			Do Zrúteného dómu	
Kvapľová sieň, bod 69	3. III. 2001 6. VIII. 2001	3.3 1.7	2.9 0.7	 0.7		
Kvapľová sieň, bod 78	6. VIII. 2001	1.6	1.2	1.0		

Accumulation of coolness the rock massive during winter season guarantees stabilization of ice filling during summer season also.

Results of climatic observation for non glaciated part of the Cave are presented in Table. Very interesting is fact, that the highest temperature 4.4 °C was measured during winter season in part Kvapľová sieň and the lowest temperature 1.8 – 2.7 °C in August in part named Biely dóm. During summer season temperature of bottom sediments was about 1 °C lower than air tem-

perature. In spite of above mentioned facts air flowed in summer from sink hole named Duča into underground part Zrútený dóm; from Ľadová pivnica through Biely dóm, Kvapľová sieň and Vstupná chodba into glaciated parts of the Cave. During winter season flow of the air has reverse direction. We can say that the Cave is dynamic cave.

Stratenská jaskyňa Cave and Dobšinská ľadová jaskyňa Ice Cave created one underground system, which was created by the river Hnilec and the brook Tiesňavy in old Pleistocene and in Tertiary period. Initially an integrated cave was mainly by denudation separated into two independent individually developing caves.

Forming of the third high terrace (Mindel) of river Hnilec together with undercutting of slopes and with following destruction and pre-forming of some cave spaces in part of nowadays sink hole called Duča and thereby also to permanent interruption of connection these caves, it was one from the processes of denudation. By this way appropriate climatic conditions were created for genesis of the Cave with ice filling (Tulis – Novotný, 1989). This process passed then in Mindel period, but it is possible that it was passed in Riss period (Novotný, 1995).

In conclusion we can say that process of allocation the integrated cave is possible to date into end of Glacial period of Mindel (before 400 thousands years) till Riss period during which time beginning of ice filling creation we can to date at least to Riss period (250 000 – 140 000 years; Novotný – Tulis, 1996).

Above we mentioned that the underground glacier is growing up from top and from bottom it is melting. Thus within specific period the whole mass of the ice is changed. It was question for several authors. A. Droppa (1960) according with count flakes of growth determined the ice age to 5000 – 7500 years. According with our own observations (Tulis – Novotný, 2003) we can say that the ice mass in the Cave is permuted during 2700 to 3000 years. However the data have not exact substitution.

The Dobšinská ľadová jaskyňa Ice Cave together with Stratenská jaskyňa Cave was in 2000 registered to List of World Cultural and Natural Heritage of UNESCO.

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