ACTIVITIES ON PRESERVATION AND RESTORATION OF KUNGUR ICE CAVE GLACIATION IN 2004-2005

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Absract

There were very large variations in temperature regime and ice in Kungur Ice Cave during last 300 years. Sublimation, congelation and methamorphic ice deposits for last 20 years became smaller in volume. Reasons are natural and anthropogenic factors. These factors were explored during time of restoration of ice deposits of a cave which partially has been lost after construction of input tunnel in 1937. Restoration had place in 1950-1960 under management of V.S. Lukin. The theory of glaciation of Kungur Ice Cave has been created by him. This theory might be also applied to other caves in different regions. At the beginning of millennium organization, which had exploited the cave fully neglected the question of ice preservation. Therefore Kungur lab of Mining institute RAS decided to keep these processes under it own control. There were done many works which included: freeing up of the ways of warm air access to places of sublimation crystals growth, organizing of winter cave ventilation and making of sluices system in input and output tunnels. As a result during last 3 years we could see a tendency to moving zones of constant glaciation further into the cave and to enlarging area of growing sublimation ice crystals in Brilliantovy, Polarny, Sclep, Krestoviy, Zapadniy Halls and in galleries between them. In gallery between Sclep and Zapadniy Halls icing on the floor has significantly grown up. All these works don't resolve absolutely all questions about permanent ice in cave therefore in the future they should be prolonged.

Работы по сохранению и восстановлению оледенения в Кунгурской пещере в 2004-2005 гг.

В течение последних 300 лет в Кунгурской Ледяной пещере произошли очень серьезные изменения в температурном режиме и состоянии льда. Сублимационные, конжеляционные и метаморфические ледяные отложения в течение последних 20 лет сильно уменьшились в объеме. Причины - естественные и антропогенные факторы. Эти факторы исследовались в течение периода восстановления ледяных отложений в пещере, которые частично были утеряны после строительства входного туннеля в 1937 г. Восстановление имело место в 1950-1960 гг. под руководством В.С. Лукина. Им была создана теория оледенения Кунгурской Ледяной пещеры. Эта теория может быть также применена к другим пещерам в различных регионах. В начале этого тысячелетия организация, которая эксплуатировала пещеру, полностью пренебрегла вопросами сохранения льда в ней. Поэтому Кунгурская лаборатория Горного института РАН решила держать эти процессы под собственным контролем. Было проведено много работ, которые включили: освобождение путей доступа теплого воздуха к местам роста кристаллов возвышения был, была организована зимняя вентиляция пещеры и создание системы шлюзов во входном и выходном туннелях. В результате в течение последних 3 лет мы могли видеть тенденцию к перемещению зон постоянного оледенения далее в пещеру и к увеличению области растущих сублимационных кристаллов льда в Бриллиантовом, Полярном, Склепе, Крестовом и Западном гротах и галереях между ними. В галерее между гротами Склеп и Западный наледи на полу знаменательно выросли. Все эти работы не решают абсолютно все вопросы о постоянном льде в пещере, поэтому в будущем они должны быть продлены.

The first record about glaciation in Kungur Cave was made by V.N. Genin in 1722-1734. He wrote about «long hoarfrost hanging down from the ceiling in queer forms at half arshin», «great icy pyramids», «tributary galleries filled by ice and so impassable» (Gennin, 1937). In many reports (Altberg, 1931, Golovkov, 1939, Karakash, 1905, Kittary, 1848, Fedorov, 1883) some kinds of ice crystals in the cave are described. In 1940-1950 G.A. Maksimovich paid large attention to ice of Kungur Cave, he has described its origin, made a classification, studied their chemical composition (Maksimovich, Panarina 1966) and compounded first instructions on study of cave ice (Maksimovich, 1963). V.S. Lukin in 1960 gave a theory of Kungur Ice Cave glaciation, explaining the reasons of its formation (Lukin, 1963). The fullest description of ice in Kungur Cave was given by E.P. Dorofeev (Dorofeev, 1969). Following the glaciologists, he had pointed out three genotypes of ice: congelation, sublimation and sedimentary-metamorphic. The largest part of cave ice (98 %) was made by congelation ice, sublimation and sedimentary-metamorphic ice, as his data shows, makes only 2 %. Their distribution in Kungur Cave is shown in Fig. 1.

During last years the problems of cave glaciation changes were studied by B.R. Mavlyudov and O.I. Kadebskaya (Mavlyudov, Kadebskaya, 2003a, b).

The maximum of cave glaciation was fixed by I.I. Lepekhin in 1770, when perennial ice was met in the area of Meteornyj Hall (Lepekhin, 1772). Until the beginning of XX century cave glaciation was regulated by natural processes. Since 1914, when the cave began its life as an

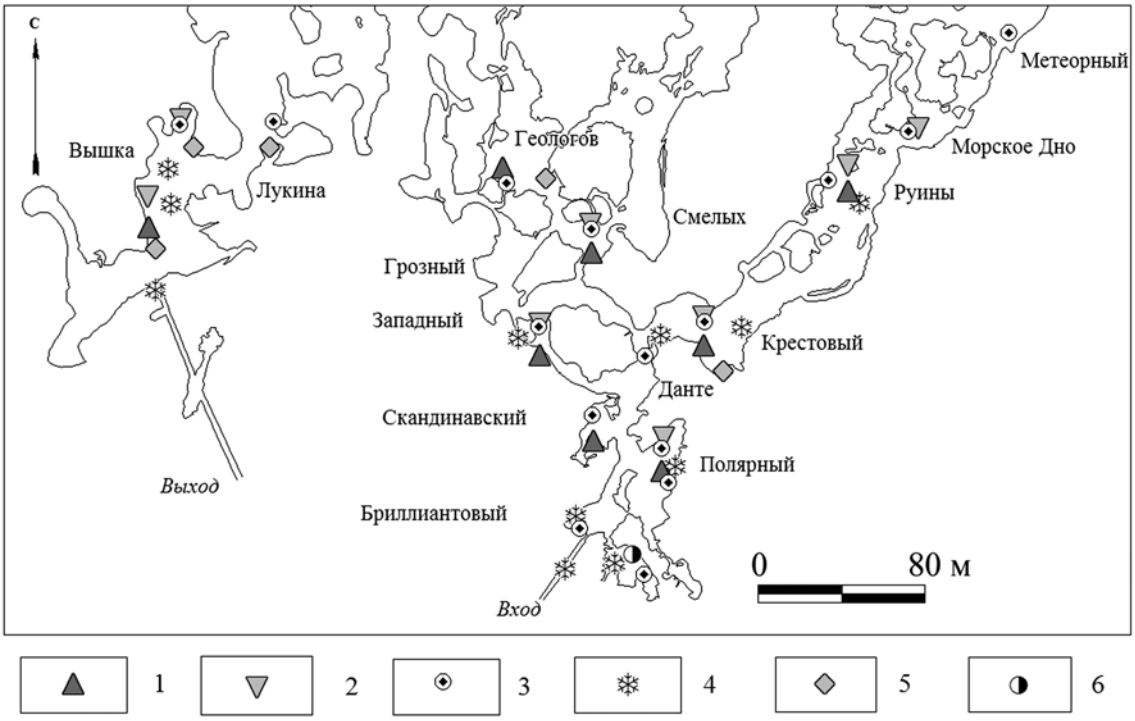

Fig. 1. Distribution of different kinds of ice in Kungur Ice Cave (Dorofeev , 1969).
1 - stalagmites, 2 - stalactites, 3 – icings, 4 – sublimation crystals, 5 - lake ice, 6 - firn snow

excursion object (show cave), the glaciation regime was disturbed by installation of an entrance door. The accumulation of cold began to depend on the time it was opened for winter ventilation. More changes to normal air circulation brought the entrance tunnel, made in 1937. Before that winter ventilation took place through the old natural entrance. The airflow came through a sinuous passage with many tributaries into the Brilliantovyj Hall from the east.

From the north (from gallery Telachij Hodok) a warmer and wet air came due to a steady horizontal turnover. Some of this warm air also got into the Polarnyj Hall. When warm and wet air met the main cold airflow a sublimation of water vapor occurred and crystals grew on the vault, looking like large crystals of underground hoarfrost, which were always a great attraction of Kungur Ice Cave (Fig. 2). The regulation the air exchange between surface and the cave was underestimated at this time. The strong flow of frosty air coming through the tunnel in winter hindered the growth of sublimation ice crystals in Brilliantovyj Hall. Common cave glaciation was reduced, decreasing its aesthetic value.

After activities on restoration of cave glaciation in middle 1960-ties under V.S. Lukins supervision (Lukin, 1965) during next 20 years the cave kept its ice beauties and attracted many visitors.

Fig. 2. Sublimation ice crystals and icing in Polarnyj Hall

However by 1985 ice mass balance in the cave became negative, in winter the cave stored approximately three times less ice than melted in summer. That most likely was connected to many factors the main of them was the catastrophic flood on the Sylva River in 1979 when the cave was flooded and a part of stored cold in it was driven away. Probably the size of cave glaciation was influenced by the construction of the second entrance into the cave in 1972 that has withdrawn a part of airflow from the old tunnel.

But the greatest negative effect was caused by little attention to winter ventilation of the cave. In some years ventilation was not conducted at all, and the door of the tunnel was opened only for visitors to pass. As a result in the beginning of XXI century cave glaciation considerably reduced (Fig. 3), the border of permanent ice had come closer to the entrance reaching the Dante Hall (Mavlyudov, Kadebskaya, 2003b).

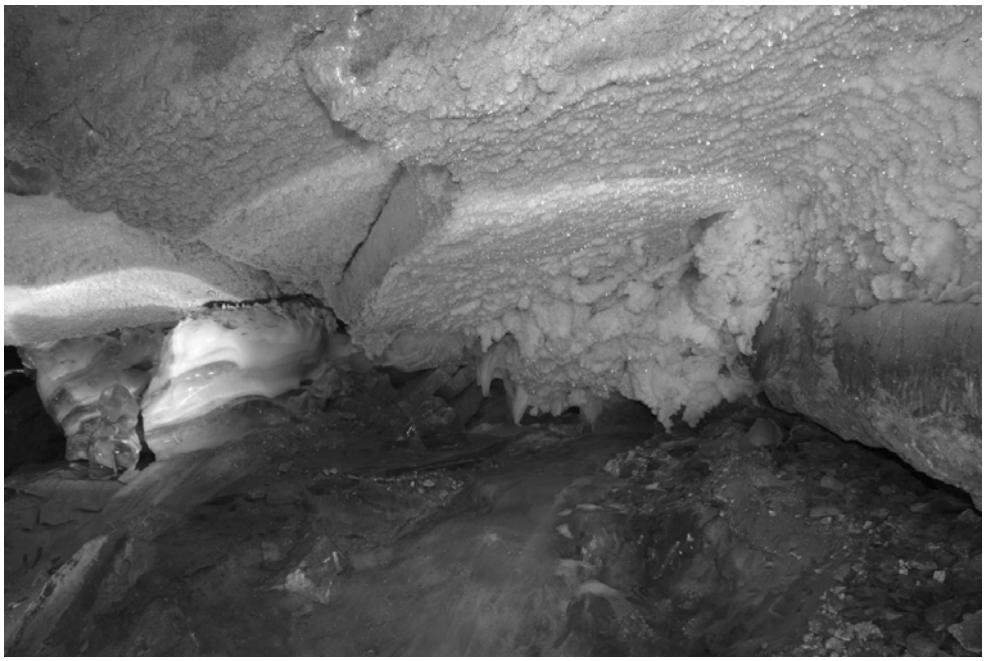

Fig. 3. Arches of Brilliantovyj Hall almost without sublimation ice crystals before restoration activity

To restore cave glaciation a complex of preventive actions took place: the system of winter ventilation was renewed; in winter 2001-2002 an ice strip between Brilliantovyj and Polarnyj Halls was artificially restored, it was renewed in the following winter as well. As a result the area of seasonal glaciation in winter of 2002-2003 moved as far as Morskoye Dno Hall and the quantity of ice flowstone (icings) in the cave has increased. However sublimation crystals in Brilianovyj Hall were not to return (Mavlyudov, Kadebskaya, 2003b).

In 2004-2005 these activities were continued. In Stari Vhod (Old Entrance) old doors were dismantled and new doors with iron bars installed (area 2 m^2). Also the entrance was freed from solid sedimentary-metamorphic ice (volume 4,9 m^3). In winter of 2004 ice and rock blocks in the old entrance were removed, a tunnel 10 m long, 1 m high and 0.7 m wide appeared. For restoration of sublimation crystals growth in Brilliantovyj Hall a pile of ice and rock blocks in the central part of the Hall was removed (area of 22 m^2 and 1 m deep). For improvement of wet air circulation gallery Telyachij Hodok was cleared up from ice to cross-section of 1,3 m^2. As a result sublimation crystals on walls and sealing grow more intensively (Fig. 4).

In spring of 2005 a new door was installed in the middle part of the entrance tunnel in order to store tourist groups, old doors were also changed. Similar works were conducted in the exit tunnel as well. Here old wooden airlock walls were exchanged for brick ones. These changes provide better regulation of summer and winter cave ventilation. During four years in winter hard snow and ice blocks were brought into the cave from the surface in order to putty holes in walls and sealing of nearest Halls and galleries between them. This action creates regulation of air currents directions and so improves cooling of cavity.

In March of 2002 there occur a collapse on the Ledyanaya Gora (Ice Hill). Taking into account the map of the cave we can say that this collapse was above the southern part of Krestovyj Hall. Each spring after this collapse water flows intensively into the cave through cracks. Through artificial channels it flows along western wall of Krestovyj Hall and freezes entering the zone of negative temperature. Due to this now the volume of naled ice (icing) increased.

For today activities on preservation and restoration of Kungur Ice Cave glaciation are not finished. A system of remote monitoring of main microclimatic parameters was designed; it will become functional in first half of 2006. In future old lighting equipment should be changed for new equipment with smaller heat rejection, seasonal ventilation of the cave will be kept under control and also the inflow of wet air from dipper part of cave into nearest Halls will be improved.

References

Altberg V.Ya. (1931) Observations in Kungur Ice Cave in 1929-1930. Part II. *News of Govenment Hydrological Institute*, 32, 77-92. Leningrad, (in Russian).

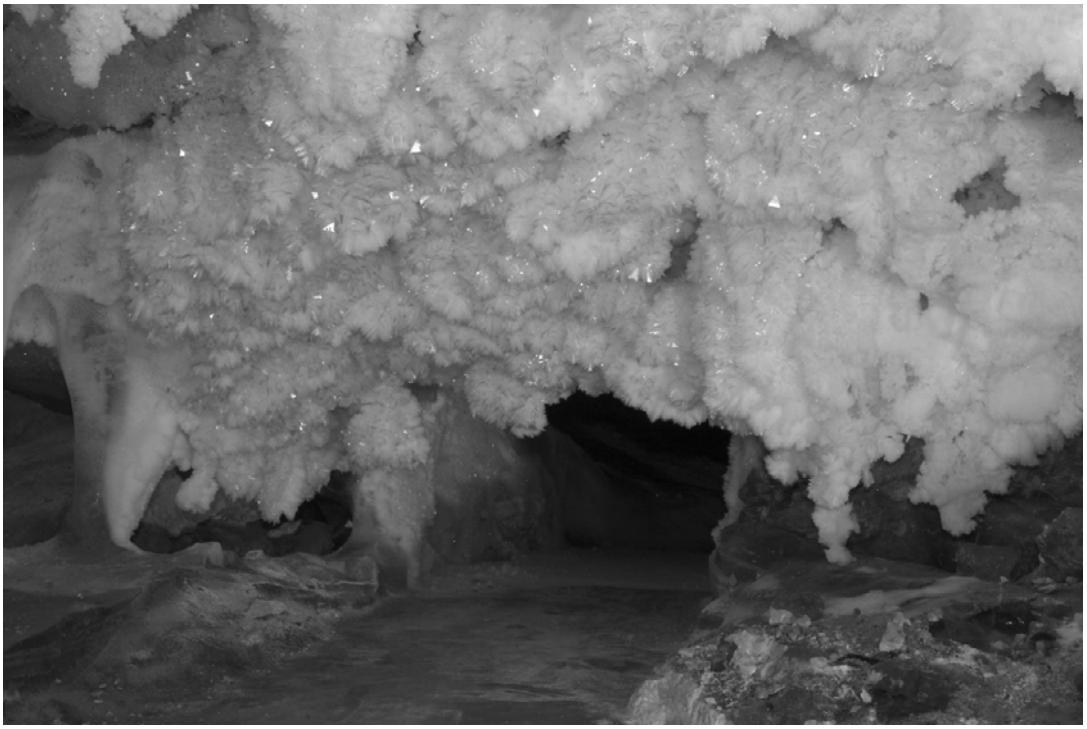

Fig. 3. Sublimation crystals at the entrance in Telyachij Hodok after ice excavation

Dorofeev E.P. (1969) Ice crystals of Kungur Cave. *Peshery* (The Caves), 7(8), 30-38. Perm University, Perm (in Russian).

Dorofeev E.P. (1978) Change of a temperature regime of Kungur Cave in the period of its exploitation and actions on preservation of ice formations. *Research of karst caves with the purposes of usage them as excursion objects*. 117-118. Tbilisi (in Russian).

Dorofeev E.P. (1988) Evolution of Kungur Cave glaciation. *Peshery* (The Caves), 21, 36-41. Perm University, Perm, (in Russian).

Dorofeev E.P. (1989) Types of ice in Kungur Cave. *Minerals and deposits of caves and their practical value.* Abstracts, 23-25. Perm (in Russian).

Dorofeev E.P., Mavlyudov B.R. (1993) Dynamics of Kungur Cave glaciation. *Peshery* (The Caves), 23-24, 131-140. Perm University, Perm (in Russian).

Fedorov E.S. (1883) A note about Kungur Caves. *Data for geology of Russia*, 11, 217-243. Publising house of Sanct-Petersburg Mineralogical Society, Sanct-Petersburg (in Russian).

Gennin V.I. (1937) The description of the Ural and Siberian mining factories (1735), 571-572. Government publishing house «History of factories» (in Russian).

Golovkov M.P. (1939) Research of ice of Kungur Cave. *Scientific notes of Leningrad University*, series geol.-soil sciences, 22(5), 11-35. Leningrad (in Russian).

Karakash N.I. (1905) Ice cave in the Ural. *Data of Emperor Sanct-Petersburg Society of naturalists*, 36(1), 11-16 (in Russian).

Kittary M.Ya. (1848) Ice cave in vicinity of Kungur. *Magazine of the Ministry of Internal Affairs*, 22, 357-381. Sanct-Petersburg (in Russian).

Lepekhin I.I. (1772) *Continuation of the day time notes on different provinces of the Russian country in 1770*, 2, Publishing house of an Academy of Sciences (in Russian).

Lukin V.S. (1963) Activities on recovery of a natural regime of Kungur Ice Cave. Peshery (The Caves), 3, 35-42. Perm University, Perm (in Russian).

Lukin V.S. (1965) Temperature anomalies in caves of Preduralje and critical analysis of the theories of underground cold. *Peshery* (The Caves), 5(6), 164-172. Perm University, Perm (in Russian).

Mavlyudov B.R., Kadebskaya O.I. (2003a) About study of a temperature regime in caves and about necessary accuracy of measurements (on an example of Kungur Ice Cave). *Kungur Ice Cave. 300 years of scientific and tourist activity*, 140-148. Kungur (in Russian).

Mavlyudov B.R., Kadebskaya O.I. (2003b) About degradation of Kungur Ice Cave glaciation and possible ways of its reconstruction. *Kungur Ice Cave. 300 years of scientific and tourist activity*, 148-155. Kungur (in Russian).

Maksimovich G.A. (1963) The instruction on study of caves ice and ice caves. *Methodic of caves study*, 27-35. Perm (in Russian).

Maksimovich G.A., Panarina G.N. (1966) Chemical composition of ice in caves of the Perm region. *Chemical geography and hydrogeochemistry*, 6(7), 33-37. Perm (in Russian).

Sivinskikh P.N. (2005) Activities on preservation and restoration of Kungur ice cave glaciation in 2004-2005. *Glacier Caves and Glacial Karst in High Mountains and Polar Regions*. Ed. B.R. Mavlyudov, 123-126. Institute of geography of the Russian Academy of Sciences, Moscow.