КАРСТОВЫЕ СИСТЕМЫ СЕВЕРА В МЕНЯЮЩЕЙСЯ СРЕДЕ"
"NORTHERN KARST SYSTEMS IN OUR CHANGING ENVIRONMENT"

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CONDENSATION CORROSION IN A COLD CLIMATE CAVE

Julia M. James
School of Chemistry, University of Sydney, Australia

The role of condensation corrosion in a cold climate cave is discussed using as an example the Grotte Valerie, Nahanni National Park, Northwest Territories, Canada. Observations in the cave in 2006 led to the conclusion that condensation corrosion is taking place during the summer months. A desktop literature survey concluded that the weathering of limestone and speleothems will be slow and intermittent. It is also concluded that experiments to measure condensation corrosion are the best way to establish the rates of corrosion taking place in the cave under present climatic conditions.

Introduction

Condensation is found in caves of all rock types and at all latitudes and altitudes. It has an important role in relict caves as it allows reaction between the cave atmosphere and bedrock and speleothems and provides a water source for living organisms. A review by Dublyansky and Dublyansky (2000) on the role of condensation in karst hydrology and speleogenesis summarizes the 'state of the art' of condensation studies. This paper is used to comment on the role of condensation corrosion in a cold climate cave using as an example the Grotte Valerie, Nahanni National Park, Northwest Territories, Canada. In a cave the process of condensation corrosion can be established by noting whether features characteristic of condensation corrosion are present. These can be found in James (2004). To comment on its impact on cave development and speleothem dissolution it is necessary to resort to a literature desktop survey and adapting the theories and models found there to the conditions found in this cold climate cave.

Discussion

The Grotte Valerie (Figure 1) is found at 61.5 °N. The Nahanni climate is continental: long, cold, dry winters and short, mild, wet summers. Mean annual temperature is – 8 °C (Yonge, 2004). The annual precipitation is between 400 to 600 mm per year with more than half falling as snow (Ford, 2004). Over the period 1951-1980 at a Tungsten mine ~ 200 km NNW of Grotte Valerie, the average monthly precipitation varied from 12 mm in February to 90 mm in July and the average temperature in January was –24 °C and in July 11 °C (Weaver 2006).

The Grotte Valerie (Figure 1) is a multi-entrance relict cave. It has three known entrances all of which are in a south-facing cliff on the First Canyon of the South Nahanni River. Highest is the West entrance at 740 asl. The East entrance is 38 m lower. The cave lies some 300 m above the river. Ford and Williams (2007) have described in detail the cave climate and ice distribution in the cave. The airflow directions shown in Figure 1 are those experienced in the summer of 1973. These airflows are characteristic of the "Chimney Effect" (Wigley and Brown, 1976) and are expected to reverse in winter.

In late July 2006, permission to visit this restricted access cave was granted by Parks Canada. However, we were not able to traverse the cave beyond the Icefall (Figure 1). Despite this, the following observations could be made. The Central Entrance passage was covered for about 8 m with copious algal and lichen growth. In contrast to 1973, there was no ice in this passage. The floor sediments adjacent to the walls were dry and there was a damp channel in the centre of the passage, indicating the ice is seasonal and may have been present earlier in the summer of 2006. The directions of airflows in 2006, through the entrance passages were identical to those recorded in July 1973 (Figure1).

At the junction of the West and Central Entrance passages, both airflow and humidity increased. Beyond this point, condensation and seepage drips from the roof had turned the floor of the main passage into a quagmire of glutinous mud. The bedrock and speleothems were covered with condensation droplets and shinning with thin films of water (Figure 2A). The active stalactites in Figure 2A have eroded on one side and have cave coral growing on the other. Cave coral in association with solution of speleothems is regarded as evidence for condensation corrosion followed by evaporation of the saturated calcite solutions (Hill and Forti, 1997).

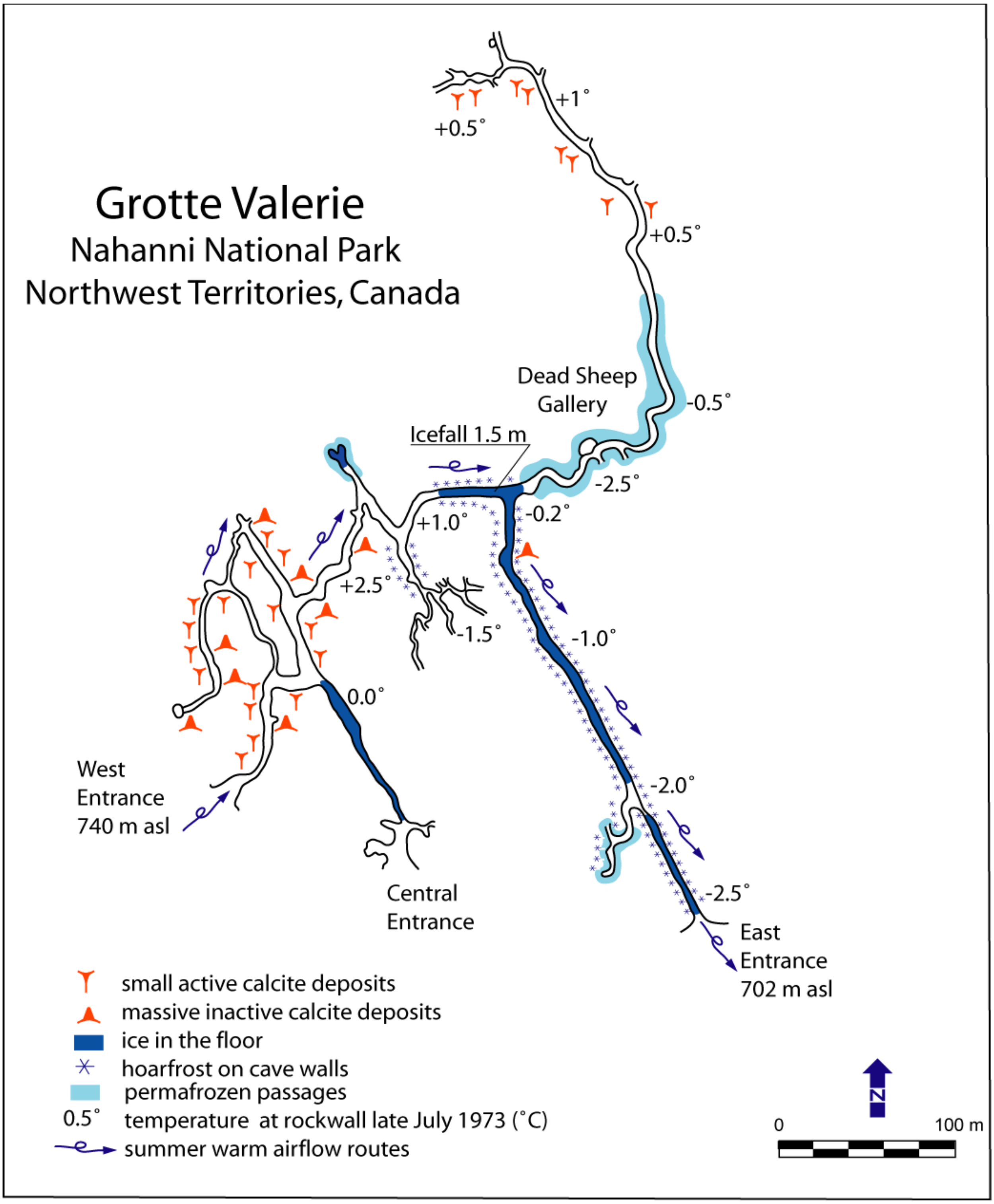
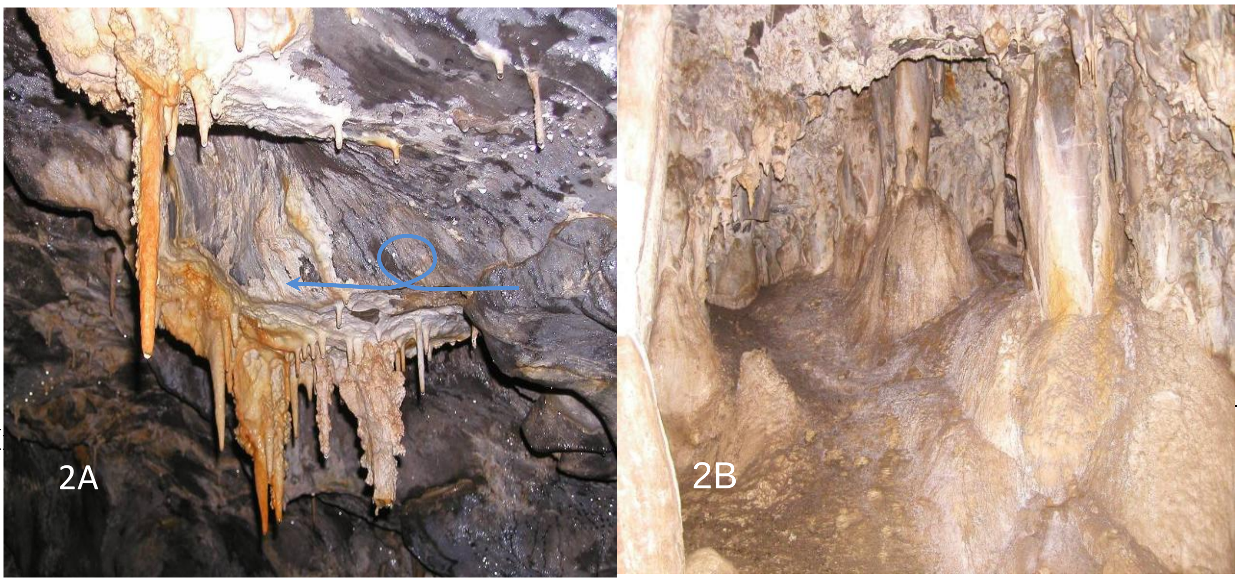


Figure 1: Plan of the Grotte Valerie adapted from Figure 4.28, Brook (1976)

The weathering rinds (Figure 2A) are also a feature of condensation corrosion (Zupan Hajna, 2003). The blue arrow in Figure 2A indicates the direction of the 2006 airflow in the passage. There were massive inactive calcite deposits (Figure 2B) in a number of the dead end passages in this area of the cave. The age of ancient speleothems from the Grotte Valerie has been obtained by uranium series dating: the youngest sample was 150,000 years B.P. and the oldest > 350,000 years B.P. (Table 6.4, Brook, 1976).



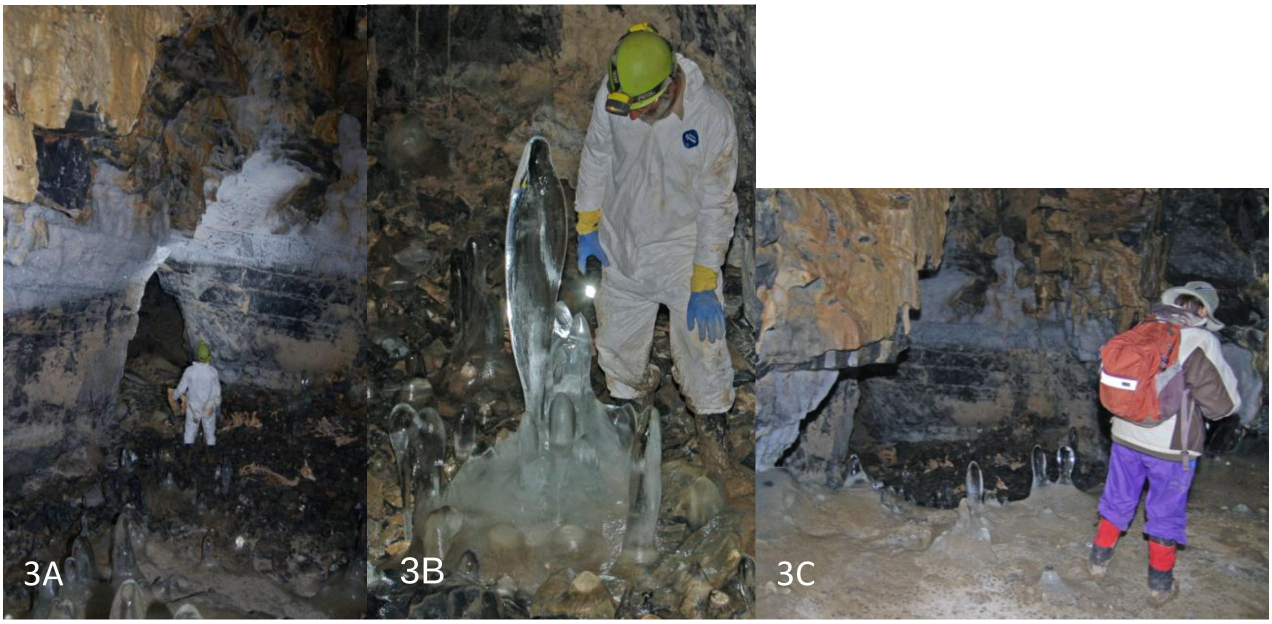


Figure3: 3A – Pit at start of Dead Sheep Gallery, 3B – Ice stalagmites, 3B – At the Icefall

In 2006, ice was first encountered in the cave ~ 5 m from the Icefall (Figure 1). The passage was floored with massive dirty ice on which there was a scattering of small ice stalagmites. The roof and upper walls were glistening with condensation films and droplets. The lower sections of the walls were undercut and banded with hoarfrost. Hoarfrost arises from the sublimation of water vapor in air to ice without the intermediate phase of water. The process undercutting the walls is by hoarfrost/ice wedging and the resulting blocks are lined up below the hoarfrost band. Below the Icefall, the passage widens to form a pit (Figures 3A and 3C). Hoarfrost surrounding the pit has a sharp lower limit that was at the same altitude as the lower limit of the hoarfrost above the Icefall. The hoarfrost had formed attractive patterns on the back wall of the pit (Figure 3A). When the turbulent warm wet air mixes with the cold air in the pit and it is carried up the wall depositing hoarfrost. Figure 3C when compared to Figure 8.18 (lower right) in Ford & Williams (2007) shows a similar distribution of hoarfrost on the back wall of the pit. Above the hoarfrost level were corroded flowstones that glistened with condensation (Figure 3A). Below the hoarfrost, the flowstone was almost completely been removed by ice wedging.

The pit is the start of Dead Sheep Gallery. It is the lowest part of the cave forming a classic cold trap fed by the invasion of cold air in winter when the airflows in the cave are reversed. The permafrozen conditions in the Gallery have led to the freezing out of the water vapor so effectively that the passage is dry and dusty and without ice. Features of condensation corrosion are expected to be absent in the Gallery because in permafrozen passages there is no water to act as the corroding agent. A north trending passage at the end of the Gallery had temperatures above freezing, no floor ice and active speleothems in 1973.

The ice stalagmites in the pit (Figure 3B and 3C) and on the edge of the Icefall have bulbous bodies of clear ice on thinner stems of cloudy white ice. The white ice is formed by rapid freezing in extreme cold and the clear ice forms by slow freezing when the temperatures are just below 0 ºC. In 2006, there were no icicles or stalactites to provide water for these ice stalagmites so the water source may be condensation. The prominent three ice stalagmites present in Figure 3C were absent in Figure 8.18 (lower right) in Ford & Williams (2007).

Whether condensation waters are aggressive to limestone and calcite speleothems can be calculated using WATEQ4F a geochemical modeling program (Ball and Nordstrom 1991). To do this for the Grotte Valerie, it is necessary to assume that the condensed waters are in equilibrium with atmospheric carbon dioxide and take the temperature of the condensation waters as that recorded at the cave walls in 1973. The negative calcite saturation indices that are obtained using these conditions show that the waters are aggressive. Dreybolt et al. (2005) have shown by experiment that short residence times of the condensation waters on speleothems and limestone are adequate for them to become saturated with respect to calcite.

An important conclusion reached by Dreybrodt et al. (2005) was that whether the cave air temperatures vary seasonally or diurnally, the amplitude of its variations is the driving force for condensation. Historically it had been assumed that the heat liberated by condensation (44 kj mol^{-1} at 25 °C) on cave walls would be slow to dissipate because bedrock transmits heat slowly suppressing the tendency for further condensation. De Frietas and Schmekal (2006) working in the Glowworm Cave, Waitomo, New Zealand, measured condensation and evaporation continuously with electronic sensors. Both experimentally and by modeling, they endorsed the conclusion reached by Dreybrodt et al. (2005) that the temperature of the rock surface in a cave reaches a constant value. Thus, as condensation and evaporation are essentially a function of cave air temperatures it allows those taken at the cave wall in 1973 to be used in the calculations above.

Condensation in the Grotte Valerie will only take place in the short summers and the amount is limited by the low rainfall. The moisture capacity of cave air (Palmer 2007) is a critical factor when assessing the available condensation. Figure 4 shows the amount of condensation generated by cooling a cubic metre of warm saturated air by 10 °C at the Grotte Valerie walls. It is low and will be reduced if the relative humidity of the cave air is below saturation as is expected in high latitude and alpine caves where the mean annual temperatures are close to or below freezing. A lower temperature differential between cave air and that of the walls will further reduce the amount of condensation generated.

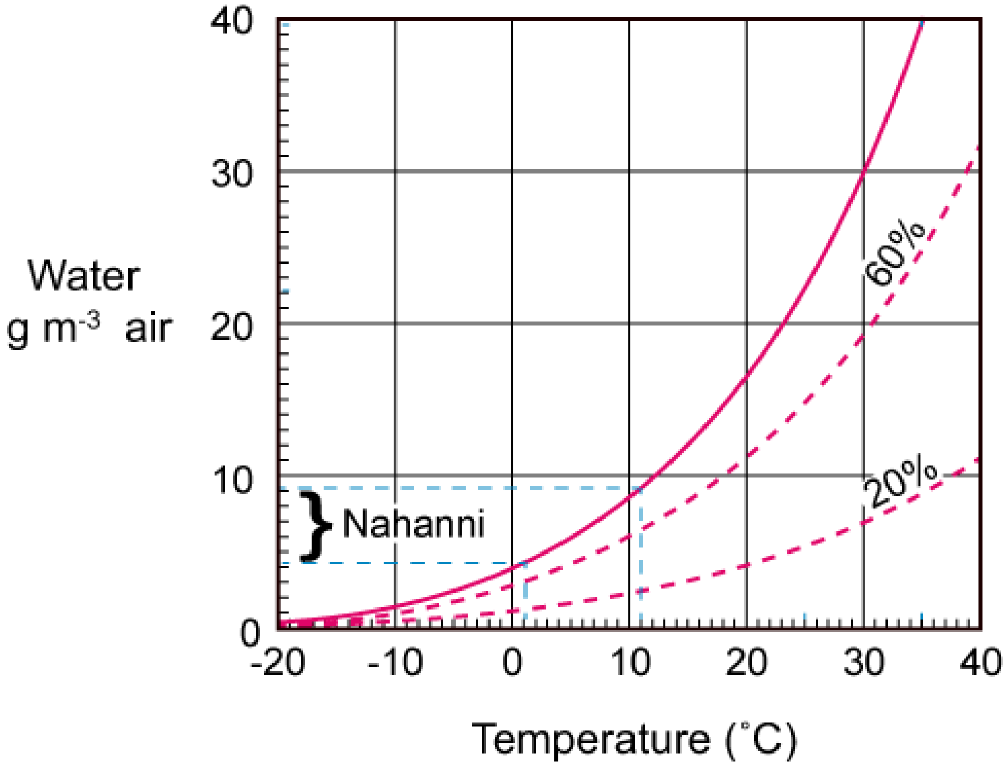


Figure 4: The moisture capacity of cave air with respect to temperature and relative humidity adapted from Palmer (2007)

Using a cave air temperature of 300 K (27 °C) Dreybolt et al. (2005) calculated that for a diurnal continuum with a temperature amplitude of 10 °C the retreat of bedrock would be about 3 µm a^{-1}. Seasonal variations with the same amplitude cause a retreat of bedrock by 0.3 µm a^{-1}. Both general theory and modeling indicate that the short summer season and a cave air temperature close to freezing, condensation corrosion in the Grotte Valerie will be extremely slow. To confirm this, site-specific condensation corrosion experiments are needed in this remote limestone cave. Carrara marble tablets as described by Avramidis et al. (2001) could be used to measure corrosion rates if left for several summer seasons. More soluble gypsum tablets as used by Tarhule-Lips and Ford (1998) may give significant results in a shorter time. In other caves, site specific tablet methods have given corrosion rates higher those derived from models .

Conclusion

It is predicted that under the present Nahanni climate and the Grotte Valerie cave climate, condensation corrosion would be extremely slow. Significant cave development and speleothem dissolution would be correspondingly slow. This can only be confirmed by experiment. In addition, Ford and Williams (2007) have stated condensation corrosion is episodic and periods of locally fast corrosion can be succeeded by times of very slow corrosion and stop altogether. Condensation corrosion in the Grotte Valerie would have ceased as temperatures in the Nahanni dropped below freezing during ice ages. The changes in ice distribution in Grotte Valerie between 1973 and 2006 could have resulted from seasonal variations in the Nahanni climate or climate change or both.

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ICE CAVES USE – HISTORICAL OVERVIEW, AN EXAMPLE OF SLOVENIA

Andrej Kranjc

Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia

In Slovenia there are more than 10 000 caves registered, among them altogether about 650 (6.5 % of all the caves) ice and snow caves and 102 caves (slightly more than 1 %) which are real ice caves. This means that there is ice in them over the year round. In this paper high-mountain caves (above the tree line, this is above 1 600 –1 800 m a.s.l.) containing permanent snow and ice are not taken into consideration. Due to their mostly remote location far away from man's activities they did not draw a special attention until recently(Štirn, 1954). In this study are included only lower lying ice caves, which are exceptions considering their microclimate or speleoclimate. Most of them lie between 800 – 1 200 m a.s.l., while historical data show that such caves were at 400 m even some centuries ago (Kranjc 2009).

Because of their characteristics, cool atmosphere and ice accumulation during the warm period of the year, ice caves attracted a man to use them since very early already. The oldest use was to extract the ice to get drinking water. One of the characteristics of the karst surface is the lack of water. The highest ridges of the Slovenian Alps are surrounded by high (1 200 – 1 800 m) limestone plateaus. There are good pastures (natural or arranged by man) but problem is water. The example is Velika planina plateau north of Ljubljana being a traditional alpine pasture frequented and used by human since Neolithic times on, proved by the archaeology (Cevc 1997). There are two quite large caves at the bottom of a few ten meters deep collapse doline Velika and Mala Veternica, at 1 600 m a.s.l. Due to their feature snow accumulated in them and it slowly changed into ice. Not long ago shepherds still had a habit following their ancestors to gather snow and ice from the bottom of caves and carrying it in baskets to the surface and use it as drinking water for people and cattle. Not long ago shepherds still used wooden shoes (clogs) into which special nails called *lednik* (ice nail) were driven into the sole to prevent slipping (Cevc 1997).

The other use of cave ice and ice caves as a whole is to exploit the main properties of ice and ice caves – the cool, the coldness. People used it either *in situ*, that is the cold of ice and cave atmosphere in a cave itself or they took out the ice and use it for the same purpose. As for the first there are many mentions and remarks in the Slovene cave register and papers of such a use of not only ice caves but cold caves in general. The cave Jazbina (300 years ago it was mentioned as an ice cave but it is no more) was used by the owner of nearby inn for storing beer. A cave in the low karst south-east of Ljubljana was used to mature cheese. At the bottom of a collapse doline Rožek where the snow and ice remained long in the summer the owner of a nearby manor house kept wine. On the plateau Menina Mt. the keeper of a mountain hut kept the meet in a collapse doline – ice cave – Jespa still few tens of years ago. Before the invention of the air condition system people often used "cold" caves with appropriate form and place to organize balls and public festivities, as in the cave of Vilenica on Kras (a show cave in the 17th century already). The cave Podpeška jama (big entrance hall with open connection to underground "cold" stream) was recently arranged (sand floor and electricity) by the inhabitants of a nearby village to have balls in fresh cave during the hot weather outside.

The other mode to use cave ice for cooling is to bring it out and carry to the final user, usually noble or wealthy person, either for private or for business use. Of course it was before the invention of making ice artificially and invention of a refrigerator. Several examples of caves where the ice was extracted are known. The earliest written mention is by Valvasor (1689) citing the cave Ledenica (Ice cave) pri Planinci in the karst hills not far to the south of Ljubljana:

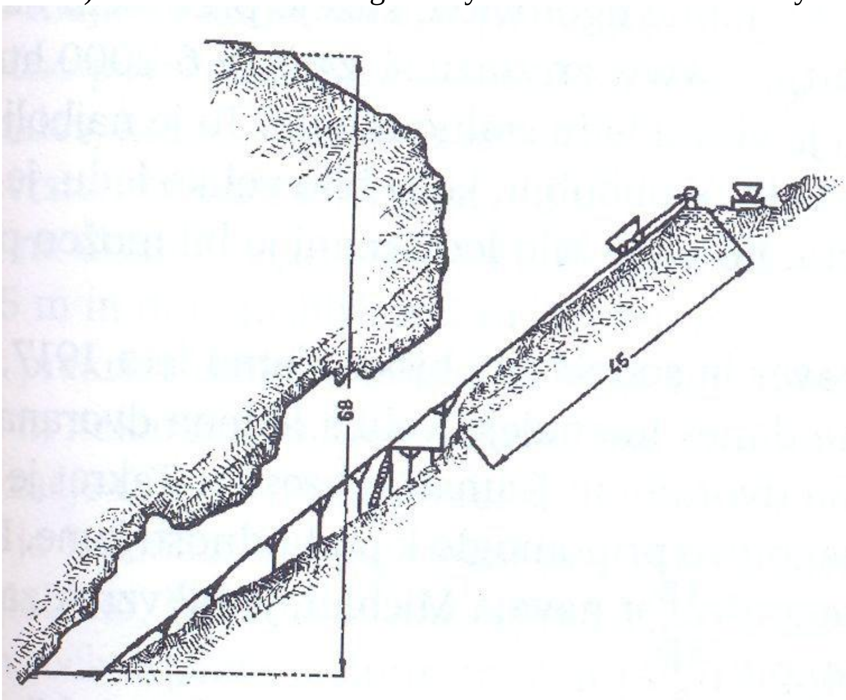
"In Igger Boden above S. Johannis bey Tomischle there is another cave in which man can find ice through the whole summer. Once actual sovereign his Emperor's Majesty has been served with this ice, when at Ljubljana all the ice pits have been already empty. They brought the ice from this cave." (Valvasor, 1689).

The other example is of the above mentioned cave Jazbina:

"During the summer the Count and the Lord of Gallenberg used this ice daily to cool his wine. In the month of August six years ago I personally climbed down the cave and found the ice in all the holes." (Valvasor, 1689).

In some cases the extraction of ice reached the extent of an industrial production. The best known example is Velika Ledenica (Great Ice Cave) v Paradani on the plateau of Trnovski Gozd, not far from the Adriatic port of Trieste. The ice extraction started somewhere in the middle of the 19th century. From this and some other ice caves in the vicinity the ice was transported to Gorica, to nearby towns in Friuli, and to Trieste harbour from where it was transported in special barrels by ships to Alexandria and even to Bombay (Aichholzer 1878). In Alexandria the price for 50 kg of ice was 5 – 6 guldens (day labourer earned little less than 1 gulden per day). During summer drought it was used for local water supply (Habič 1992).

During the 1st World War special speleological army detachment made the research of the cave with the aim to use the ice for water supply of the front. In mild winters (1873 for example) the ice was sent to Vienna and Budapest too. The data for 1867 show the extraction of 16.000 quintales (*quintale* = Austrian Zentner, 100 kg) of ice from the caves of Trnovski gozd plateau (Gams 2003, 102). The owner of the cave usually gave it at leasing for 250 – 500 guldens per year. Extraction was simple: the workers cut the ice into pieces of 10-20 kg, by some authors to 55 kg each and carried them in baskets by wooden ladders to the surface from where it was transported by horse driven wagons down to the valley. In 1950-ies a company exploited ice by the mean of 100 m long cableway with small wagon of 200 – 250 kg of capacity. From the wagon it was loaded directly on the truck on the road. During three months of 1952 they extracted 120 t of ice. It was used by transport of fruits to Austria and Britain. Extraction of ice from Velika Ledenica v Paradani finally stopped in 1962 (Nagode 2002). It is interesting that analyses show that cave ice is denser and has higher melting temperature than ice from the surface (Aichholzer 1878). Such statement was given by Valvasor in 1689 already.



Cross section of the upper part of the ice cave Velika Ledenica v Paradani with the cableway for transport of the ice (Nagode 2002, p. 107).

From the published works there is evidence that such was a practice also in other regions. Petruzzi (1849/50) reports that the ice was used for commercial purposes from two ice caves on Kočevski Rog plateau (South-eastern Slovenia) too: those were Ledena jama v Rogu and Ledena jama pri Kunču (Schwalbe 1887).

The extraction and selling of ice seemed to be such a profitable business that people on the plateau of Kras used to extract and to produce the ice even on the surface. On Kras they used ponds to water cattle, made in the bottom of dolines tightened by clay. During the winter the demand for the water was lower and the ponds were frozen; they extracted the ice from them and sell it. But such a production of the ice was not enough to answer the demand. To increase the production they diverted water from periodical streams over flat surface to freeze quickly and to extract it easier. During the winter there was not great demand for the ice, so people constructed special “ice pits” where it was possible to store the ice during the whole summer. For ice pits they used small dolines or small collapse dolines. Very illustrative example is the village of Senožeče, where a local brewery which needed ice, operated from 1820-1926 (Savnik 1968). Nearby is one of the best preserved ice pit, 17 m deep.

When the ice and cold of ice caves were no more needed or they were no more rentable regarding the new techniques, they got new value: show caves. Because of their singularity even among the caves, this attracted tourists for long time already, people started early to visit them. It is difficult to decide either Valvasor visited ice cave under Lačna gora (Županova jama nowadays) from tourist or from scholar impulse at the end of the 17th century. He reported that the vicar and people from the nearby village often visit it – a sort of a local tourism. In 1927 a part of Županova jama was opened for tourists. In Slovenia there are two other ice caves which figure as show caves. Above the town of Kočevje Ledena jama na Stojni was arranged for a visit by a landlord at the end of the 19th century already. It was meant as a curiosity to be shown to landlord's noble guests during the hunt in the forests of the high karst plateau Velika gora and is neglected nowadays.

Of lesser economic interest but important for other ways of using ice caves is the interest for them shown by scholars, speleologists, and scientists. Valvasor's visit to Ledena jama pod Lačno goro was mentioned already. B. Hacquet visited the same cave little less than hundred years later and he found in it a common ice. But he says that the ice in this cave is just made of five- or six angles crystals. Why just this type of crystallization he could not find out. By his opinion there must undoubtedly be some salt particles in the water. (Hacquet 1778). By the way, Hacquet was interested in ice crystals in general, as shows his article on frostwork on a windowpane (Hacquet 1790). For his main work "Eishöhlen und Windröhren" (Ice caves and wind tubes) Fugger used the examples, observations, and data from ice caves of Kranjska (Carniola) (Fugger 1894). The same can be said for Schwalbe's "Über Eishöhlen" (About ice caves) and "Über die locale Verbreitung der Eishöhlen" (About local distribution of ice caves) (Schwalbe 1882; 1884). It is interesting that Schwalbe (1882a) is mentioning Kungur ice cave too, the example taken from a Russian author. According to new observations and theories on microclimate and ice formation in ice caves, the research of microclimatic conditions is carrying on in ice caves of Slovenia too. A good example is a detailed research with the help of modern techniques in the frame of a doctoral thesis lead by a student of the Karstology programme at the University of Nova Gorica.

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CRYOFLUVIAL KARST IN SIBERIA – THE LENA PILLARS

Paul W. Williams
School of Environment, University of Auckland

The Lena River is one of the great rivers of the world. It flows south to north across 20 degrees of latitude and discharges into the Arctic Ocean, at 73º N. The area of its basin is 2.49 million square kilometres, which makes it the third largest river basin in Asia and eighth largest in the world.

The city of Yakutsk in the middle of the basin has one of the world's most extreme continental climates with an annual temperature range of almost 100º C (-60º to +40º C). Permafrost is continuous and at least 300 m deep, except beneath the course of the river where there is a narrow permafrost-free corridor. Precipitation is small (~ 250 mm) and mainly falls as rain in summer.

This region has numerous cryohydrological and permafrost phenomena, including: permafrost cliffs along rivers; glaciers formed by freezing of perennial spring waters; salt ice build-ups (nadedi) where rock salt is deposited from the freezing of salt water springs; pingos and patterned ground; and thermokarst lakes.

The Lena River at Yakutsk varies from 5-10 km wide and to 10 m or so deep, and its floodplain is about 35 km wide. The river flows at about 105 m asl in this region. It is incised into a broad rolling plateau with summits around 200 - 400 m. Gently dipping Cambrian dolomitic limestones underlie much of country. Where the river swings against the edge of the plateau, its cliffed margin is lined by 100 m high rocky pillars that extend in a discontinuous belt for 40 km or so and also extend up tributary valleys (Buotama and Sinyaya). These are the Lena Pillars.

The age and origin of these pillars is uncertain. It is presumed that they are karstic in origin, because they are formed of carbonate rock. But is this possible in a periglacial environment with little liquid runoff? This presentation examines the origin of the Lena Pillars and concludes that several conditions are important for their development:

(1) The pillars are strongly controlled by major vertical joints, some of these are ancient tectonic features, but some are recent and formed by unloading of the cliff face parallel to the river.

(2) The joints that isolate individual pillars have sometimes been widened by dissolution of the carbonate rock (mainly in the Pliocene rather than in the colder, drier Pleistocene?). This permitted water penetration from the surface and, in turn, facilitated cryogenic processes (freeze-thaw action).

(3) Cryogenic processes widen gullies between pillars leading to their isolation. Pillar faces show almost no evidence of contemporary dissolution (karst) processes. Thus the pillars are essentially cryogenically produced landforms.

(4) Fluvial processes are also critical. This is because cliff-foot ice-shattered debris slides downslope to the valley floor where it is transported away by the river. Without fluvial action the pillars would be buried in their own cryogenic debris. This is why the pillars are riverside landforms. Pillars are best developed in slopes undercut by a river, typically on the outside bends of meanders where river flow is swiftest and so most able to carry away loose rocks.

EFFECTS OF GLACIATIONS ON KARST AQUIFERS AND LANDFORMS IN CANADA.

Derek Ford
Emeritus Professor of Geography and Geology, McMaster University,
Hamilton, ON L8S 4K1, Canada

Limestone, dolomite and gypsum outcrop over an area of ~1,200,000 km^2 in Canada. Under the Prairie provinces an area of more than 500,000 km^2 of salt overlain by clastic rocks is also potentially accessible to interstratal dissolution. Most of the country was repeatedly glaciated by continental ice sheets or alpine glaciers during the Quaternary.

The interrelationships between glaciers and components of the karst system developing in these rocks are complex and varied. Nine differing effects of glacier action upon karst are recognised here: 1) erasure by glacier scour, which chiefly impacts upon karren and upper epikarst layers; 2) dissection of cave systems and lesser conduits in aquifers by valley glaciers, principally in alpine areas; 3) infilling of dolines and poljes with glacial detritus; 4) injection of glacial detritus deep into an aquifer, rendering it partly or wholly inert; 5) shielding of soluble bedrock from post-glacial dissolution by glacial deposits that are rich in soluble rock fragments; 6) sealing of limestone pavements and epikarst by melt-out tills beneath frozen-down (cold-based) ice; 7) acceleration of karst development by superimposing glacial aquifers upon karst aquifers or focusing into glacier-margin karst terrains; 8) steepening groundwater hydraulic gradients by glacial entrenchment of valleys; 9) inducing inter-stratal dissolution by means of deep injection of melt waters during glacial recession and the accompanying crustal isostatic rebound; 10) initiating groundwater flow with karst dissolution where permafrost thaws beneath an insulating cover of glacier ice. Varying efficiencies and combinations of these differing effects can produce great variety in karst regions.

KARST, PERMAFROST AND GLACIATIONS IN CANADA

Derek Ford
Emeritus Professor of Geography and Geology, McMaster University,
Hamilton, ON L8S 4K1, Canada

Permafrost is developed throughout the northern half of Canada, displaying three zones of increasing severity: (1) in the southern parts of the region ‘sporadic permafrost’ that is generally confined to silty, frost-susceptible soils: (2) ‘widespread but discontinuous’ permafrost that may extend deep into bedrocks throughout the central lowland regions between Lats. 60-68^o N and further south in the mountain ranges to east and west: (3) continuous permafrost up to 500 m in depth north of Lat. 68^o N in the coastal lowlands of the mainland and throughout the arctic islands, extending down to Lat. 62^o N or below in high mountain areas. A latitudinal model shows progressive limitation of ground water circulation and karst dissolution in carbonate rocks beginning at ~Lat. 62^o N that greatly restricts development north of 68-70^o N. Karst activity in sulphate rocks begins to be impeded around Lat. 68^o and is severely restricted north of 75^o. There is probably deep dissolution of salt beds occuring in diapirs and other structures to ~80^o N.

The ‘Nahanni North Karst’ in limestone and dolomite at elevations between 300 and 1600 m above sea level (asl) at Lat. 62^o N in the southern Mackenzie Mountains best exemplifies the interplay of karst and permafrost processes in the mountainous ‘widespread’ zone. Much groundwater may be obstructed by ground ice build up for periods up to decades before the ice seal is broken. This region is now experiencing rapid warming, with some 40 landslides from permafrost melt in glacial silts or on shale slopes above the karst being recorded in the past twenty years.

Around Lats. 64-67° N in the lowlands between Great Bear Lake and the Mackenzie River in the ‘widespread’ zone there are very extensive tracts of doline, polje and turlough topography on gentle dolomite plateaus between 300 and 600 m asl, plus some large lakes (400 km^2) that drain underground without impediment; it is evident that ground water is able to circulate freely where there are significant stream sinks or where lakes and ponds maintain talik leaking conditions beneath them. Further west in the northern Mackenzie Mountains patterned ground phenomena prevail on carbonate rocks in the continuous permafrost zone above ~1000 m asl but there can be significant local penetration by groundwater to create some striking springhead (reculée) cirques.

In the arctic islands the very extensive tracts of limestone and dolomite display dissolution with frost shatter in the seasonally active thermal zone, plus a few taliks beneath ponds. Some dolines have been reported in gypsum on Devon Island (75° N) and short sinking stream systems (100 – 500 m) on salt diapirs further north.

ECOLOGY OF CYANOBACTERIAE AND ALGAE IN PEVCHESKAYA ESTRADA CAVE (PINEGA, ARCHANGELSKY REGION)

Sh.R. Abdulun
Bashkirian State University, Ufa, Russia

The results of cyanobacteriae and algae investigation from different habitats in Pevcheskaya estrada cave (Pinega, Archangelsky region) are presented. 31 species and infraspecific taxa from Cyanoprokaryota, Bacillariophyta and Chlorophyta were identified. Green algae were found to dominate. Highest species number, average species number in one sample, sum of abundance number and average abundance number in one sample were found in ground, as well in situated near Golubinsky proval cave. It is found, that resemblance between cyanobacteriae and algae species composition of Pevcheskaya estrada and Golubinsky proval caves is higher, than with Kueshta cave (Bashkortostan Republic). Possible, it is connected with influence of cave location.

CRIOMINERAL FORMATIONS FROM SOME CAVES OF IRKUTSK REGION

E.P. Bazarova
Institute of earth crust, Irkutsk, Russia

Criomineral formations from three caves of Irkutsk region are distinguished. In the mineralogical relation collected powder material was submitted by calcite and ikaite. Impurities are submitted by quartz, biotite, graphite, feldspars and organic material.

RUSKEALA GEOPARK PROJECT

I.V. Borisov, Y.S. Lyahnitsky, O.A. Minninkov, T.A. Musatova, I.Y. Khlebalin, A.A.Yushko.
Russian geographical society, Saint-Peterburg

The Ruskeala marble quarries represent a mining history of Sweden, Russia, Finland, and Karelia. The first exploitation of marble was conducted in the end of the 17th century by Swedes. In the mid 18th-19th centuries, Ruskeala marble was widely used for decoration of architectural constructions in Saint-Petersburg.

The Ruskeala quarries are partly flooded, and now they look like water-filled steep-walled depressions. The walls of the main quarry are penetrated with whole systems of underground horizons – adits and drifts, connected by vertical pits.

In 1998, according to the Karelia's Council of Ministers Decree, the area of the Ruskeala main quarry was assigned the official status of the mining history monument of regional significance. However, practice has shown that without a rational usage of such a geosite, its official status as a protected area cannot provide its conservation. Creation of nature-protecting excursion-tourist centers on the basis of geosites is one of perspective directions in this respect.

At present, the area of the main quarry, named "Ruskeala Mountain Park" is leased to a private person. It was equipped and used for excursions. A foot-path is made around the main quarry as well as through a short adit. However during excursions, insufficient attention is paid to geology and underground mine workings.

Currently, a team of researchers, led by Yu. Lyahnitsky, is conducting exploration of underground cavities. They explore the "Ruskeala Gap" - a unique object that represents a giant sun-ken many-tier mine working. The gap is located near the main quarry, and it should be included into the protective area and into the touristic path.

ZOOBENTHOS OF PRIPINEZHYA CAVE SYSTEMS (ARKHANGELSK REGION). - VARIETY OF FAUNA AND ECOLOGICAL COMPLEXES SPECIES.

E.S. Chertoprud*, M.V. Chertoprud*, P.P. Borisov, E.V. Shavrina*****
*Moscow State University
**Institute of fish culturing and oceanology, Moscow
***State reserve "Pinezhsky"

Here describes the faunal composition and ecological complexes of zoobenthos inhabiting the waters of cave systems Olympiyskaya, Museynaya, Chrustal'naya (nature reserve «Jelesnye Vorota») and Golubinskiy proval, Kitej (Pinejskiy conservancy area). Samples were collected in January 2011 (20 samples – macrobenthos; 20 samples – meiobenthos).

In the collected samples revealed 17 species of invertebrates belonging to four classes: Nematoda, Oligochaeta, Crustacea and most diversely represented, Insecta. Among the identified taxa troglobiont is one species of Amphipoda – Pallasea sp. n. (new species for science); troglophils – two species – Copepoda: Megacyclops viridis and Olygochaeta: Enchytraeidae indet.; trogloxene presented exclusively by insects and their larvae are most numerous – 14 species. The basic principles of the fauna formation in the studied caves are discussed. Found in the caves Golubinskiy proval and Kitej the new species Pallasea sp. n. is the most northern finding of troglobiont organisms in Eurasia. This fact is important both for the analysis of biogeography of freshwater amphipods, and in model evaluation of the distribution of the cave faunas relicts in general.

EXAMPLES OF MODELING OF KARST PROCESSES

A.Ya. Gaev, Yu.A. Kilin, I.N. Alferov, N.S. Alferova
Public Institute of karstology and speleology, Russian geographical society
Orienburg State University

ABOUT METHODOLOGY AND METHODS OF HYDROGEOLOGICAL RESEARCHES OF KARST PROCESSES

A.Ya. Gaev, Yu.A. Kilin, I. I. Minkevich , N.S. Alferova, I.N. Alferov
Public Institute of karstology and speleology, Russian geographical society
Orienburg State University

SEASONAL CRYOGENIC CAVE DEPOSITS OF NORTHERN CASPIAN REGION

I.V. Golovachev
Russian geographical society, Astrakhan

In the article description of the seasonal snowy- ice deposits, characteristic for the karst of the North Caspian region is given.

Keywords: karst, cryogenic deposits, cryogenic mineral formations, cave Baskunchakskaya, Baskunchak lake, elevation Bish-chokho, Inder lake, northern of the Caspian region.

THE OVERVIEW OF KARST TOPOGRAPHY IN THE NORTHERN PART OF SIBERIA ACCORDING REMOTE SENSING DATA

D.V. Dobrynin*, A.A. Semikolennykh **
Moscow State University
*- R&D Centre Scanex, **- soils faculty

MICROFUNGI IN SOME CAVES OF SWEDEN: LUMMELUNDA CAVE (GOTLAND ISLAND), ICEKRYSTALL AND HOPPLET CAVES (VADVE UPLAND).

A.E., Ivanova, A.A. Semikolennykh
Soil Science Faculty, Moscow State University
Moscow, Russia

Introduction. Some recent microbiological researches (Cunningham et al., 1995, Koilaj et al., 1999, Khizhnyak et al., 2003, Semikolennykh et al., 2004) demonstrate the important role of micro fungi in the functioning of subsurface ecosystems and different geochemical processes. Microfungi as one of the trophic level in cave ecosystem which could consume an organic matter of different origin: primary biomass of chemosynthetic prokaryotes, organic detritus, dispersed organic compositions in bedrocks. Visiting caves by human could create the additional flows of untypical organic substances as well as fungal diversity associated with human and anthropogenic artifacts. That is why the characteristics of cave fungal communities could be used as the indicator of recreation traffic and anthropogenic load on natural cave ecosystems. In the early papers authors (Khizhnyak et al., 2003) described an increasing of total fungal biomass in often visiting caves and exchange of aborigine fungal populations on new dominants such as representatives of genera *Penicillium* and *Mucor*, and also general decreasing of fungal biodiversity in caves with hard visiting traffic (Shapiro and Pringle, 2010)...

Aim of our investigation was to deduce the features of cave mycobiota in cold climate of Sweden and its sensitive to anthropogenic load.

Objects. We studied Lummelunda Cave (Gotland Island, 18,405619 E.lon., 57,735134 N.lat) at the South and the caves of Vadve Upland karst massive (Icekrystall Cave: 18,3597665 E.lon., 68,5316167 N.lat; Hopplet Cave: 18,2871916 E.lon., 68,5540111 N.lat.) at the North of Sweden. The Lummelunda Cave is separated into two functional parts: preserved and visiting. The samples pattern is represented in the table 1.

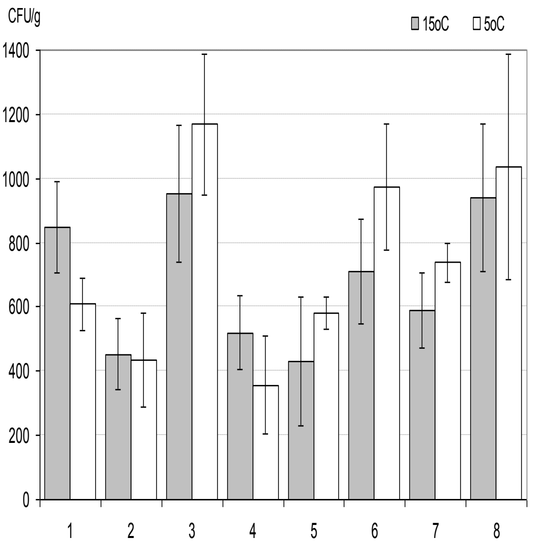
Methods. The isolation of microfungi from samples was performed by dilution plate technique (CBS course…, 1998) on Czapek agar in combination with different temperature of incubation - 15°C and 5°C. The composition and structure of microfungal assemblages were characterized by using ecological indices, such as occurrence rate and relative species abundance.

Results. There was no clean difference between the account of microfungi cultivated into 5 and 15 °C (fig.1). There was a tendency of exceeding the account of fungi which grew at +5 in comparison with the account of fungi isolated at +15°C, this tendency was shown everywhere in north Vadve Upland ecosystem especially in upper soil horizons. Usually it was similar account of growing fungal colonies from cave samples of both temperatures. Prevailing of mesophiles was discovered only into visiting part of more southern Lammelunda Cave.

Table 1. The location of samples.

№ sample	Sampling site
Lammelunda Cave, Gotland Island	
1	visiting part with recreation, ground
1+ (2отп)	visiting part with recreation, dead bodies of insects
2	wild part, ground
2+ (9отп)	wild part, dead bodies of insects
Vadve Upland, northern part, Hopplet Cave	
3	top peat-like day-light soil horizon (0-5 cm)
4	ground on cave ceiling
5	ground on cave floor
Vadve Upland, southern, Icekristall Cave	
6	top peat-like day-light soil horizon (0-4 cm)
7	mineral soil horizon (4-10 cm)
8	ground on cave floor

The species weald was higher in southern Lammelunda Cave than in the caves of northern Vadve Upland (fig.2). Total biodiversity was higher twofold in preserved part than in visiting part of the cave. Shapiro and Pringle (2010) discovered the decrease of fungal biodiversity into the often visiting caves in comparison with the rarely visiting caves. Thus, we also found a reduction of mould diversity in result of anthropogenic recreation by example of caves from cold climate. Moreover, a variety of mesophilic fungi in comparison with the psychrophilic species was greater only in visited parts of the caves (fig.2), in other variants of caves and upper soils the diversity of mesophilles and psichrophilles was similar.



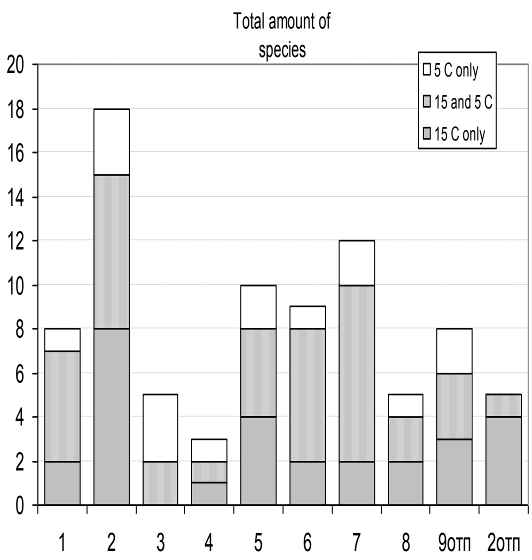


Fig. 1. (left) The amount of fungal colony forming units (CFU) per a gram of dry sample. Samples numbers are in table 1.

Fig. 2. (right) The microfungal species richness into different temperature conditions. Samples numbers are in table 1.

In the northern caves of Vadve Upland it was found that generally the fungal biodiversity in the caves is similar to the surface soils. *Geomyces pannorum* is the main dominant in the majority of habitats both in caves and soils (tabl.2 and Fig. 3). This species is typical in tundra soils, cold and humid oligotrophic mineral horizons (Parinkina, 1989; Domsch et al., 1993), it is viable in long-term (up to 3 million years) permafrost layers and crioconservation soils of Arctica and Antarctica (Kochkina et al., 2001), so it is indicator of cold and humidity habitats.

Species *Penicilluim solitum, P. citrinum* had a high rate of abundance and occurrence also. Other molds of genera *Doratomyces*, *Mortierella*, *Paecilomyces*, *Trichoderma* were identified as typical only in the mesophylic populations of all investigated habitats.

By comparison, the reserved (wild) and visiting parts of Lammelunda cave, we showed that the same dominants were in both habitats. But occurrences of other species were different. Only few typical species (frequency of occurrence was in range 30-60%) were isolated from visiting part with recreation. On the contrary, mainly rare species (frequency of occurrence <30%) were found in the wild part. Also *P.viridicatum* was frequent in visiting part, it was common as overgrown on surfaces of discrete organic substrates on clay in low temperatures of Pinega region caves near by 64 northern latitude (Ivanova, pers. comm.).

Table 2. The dominate microfungi. Samples numbers are in table 1.

Sample*	Dominant species, frequency of occurrence >60%	Typical species, frequency of occurrence 30-60%
1	Geomyces pannorum	Ulocladium chartarum, Penicillium solitum, Penicillium viridicatum, Acremonium strictum
2	Geomyces pannorum	Acremonium strictum
3	Geomyces pannorum, Penicillium solitum	
4	Penicillium solitum	Paecilomyces carneus
5	Geomyces pannorum, Penicillium solitum, Penicillium citrinum	Chaetomium funicola, Fusarium verticilloides, Penicillium glabrum
6	Penicillium solitum, Penicillium citrinum, Penicillium glabrum, Mucor plumbeus	Geomyces pannorum, Fusarium sporotrichioides
7	Geomyces pannorum, Penicillium solitum, Penicillium citrinum, Penicillium glabrum, Mucor plumbeus, Fusarium sporotrichioides, Ulocladium chartarum	Alternaria alternata
8	Geomyces pannorum, Penicillium solitum	

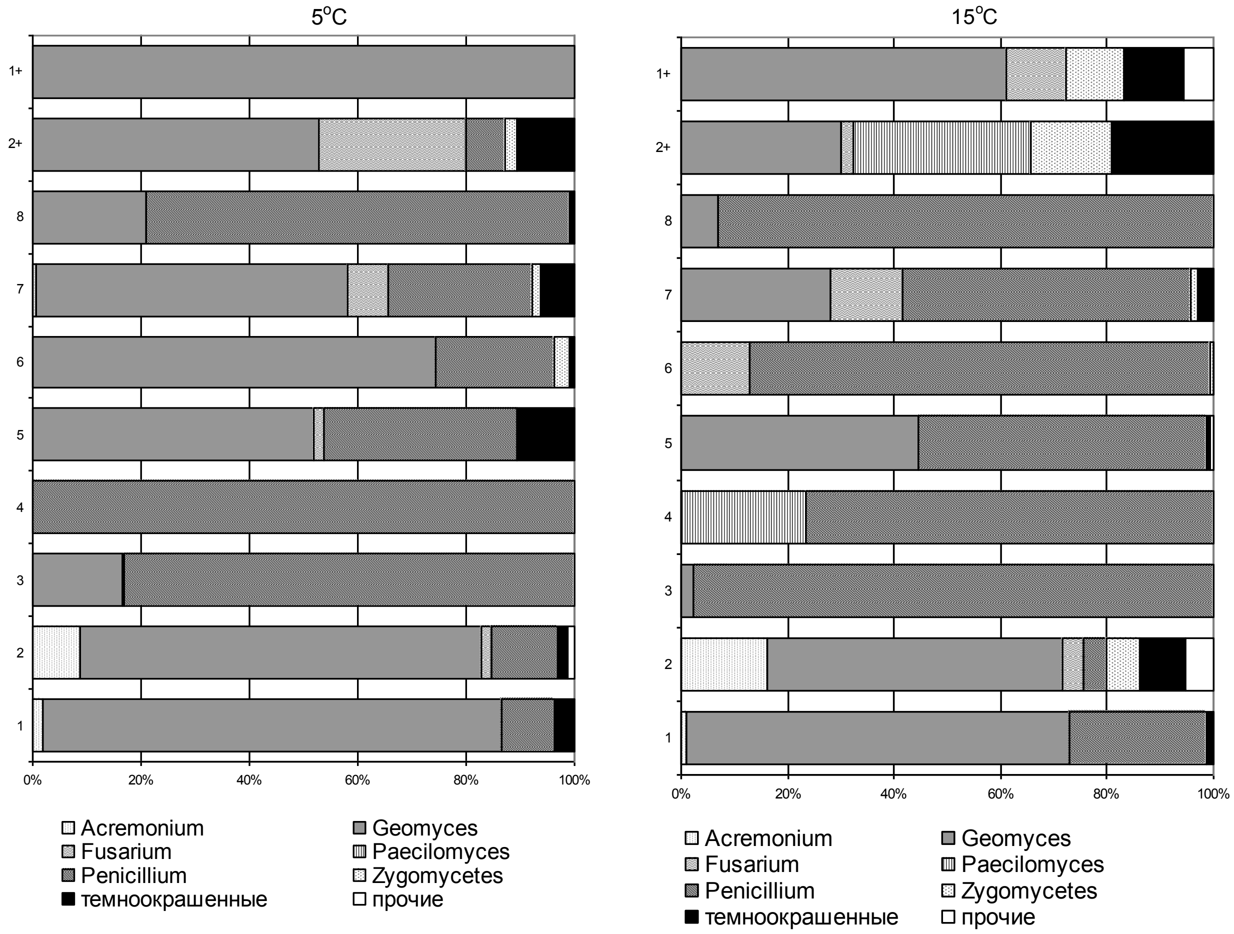


Fig. 3. The composition of microfungal associations structure by species abundance (medium for 3 temporal replications). Samples numbers are in table 1.

Thus we found a greater fungal diversity in south Lammelunda cave than in north Vadve Upland caves of Sweden. We believe that subsurface conditions of caves in cold climate of Sweden contribute to preserve the diversity of mesophilic organisms. It was also found that the anthropogenic recreation results in the introduction of mainly mesophilic microfungal populations. At the same time the abundance of moulds increases sharply as a result of recreation. And the diversity of species reduced due to occupation of a few dominant fungi that displaced a lot of rare species.

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INTERACTION BETWEEN A KARST AND A FROZEN GROUND (ON AN EXAMPLE OF CAVES OF SOUTHEAST BELOMORSKO-KULOISKOE A PLATEAU)

S.A. Iglovsky

Institute of ecological problems of North ASC Ural branch the Russian Academy of Science, laboratory of the complex analysis of space and terrestrial data for the ecological purposes, Arkhangelsk, Russia

Summary. It has been established that cave-karst ice southeast Belomorsko-Kuloiskoe plateau presented by crystals, stalactites, stalagmites, stalagnates, ice cover, underground icing, by vein icy bodies, traffic jams, ice-cement, which by nature of food can be divided into sublimation, congelation and snow-water species. The formation of ice in the caves of the area is influenced by the morphology of the caves, their hydrodynamics and microclimate, the activity of karst processes, water. The greatest development of the ice noted in entered areas of the caves, in the zone of negative temperatures up to 200 m. Great is the role of the cave of ice, as in increase of stability of karst massif, but also in the development of nival corrosion. Ice-cements in terms of fractured rocks, prolong the time of existence of the caves, being a mechanism maintaining their stability.

On character of «supply» it is possible to allocate atmogenic (sublimation), congelation or hydrogenic (most widespread) and snow-water cave-karstic ices. Typical forms of an ice in caves are ice crystals, integumentary ices, icing (stalactites, stalagmites, stalagnates, cascades, ensembles – heterogeneous ice «corralling» stalagmites), ices-cements, segregation crystals. It is possible to carry to heterogeneous ices, integumentary icing in which thickness there are the jacks of the ice which has arisen from fallen down with arch sublimation of crystals. The variety of kinds of cave-karstic ices is caused by various influences of water and air streams on a karstic file. Their arrangement is connected with local influence on a site of a karstic file of cooled air, and also from a mode of humidity and temperature. It is reflected in formation of this or that kind of a cave-karstic ice.

The sulphatic karst of southeast Belomorsko-Kuloiskoe a plateau is highly active, that is caused by speed of chemical carrying out of substances from a file up to 684 $т/км^2$; and raised density of karstic forms - 100 - 500 on 1 km^2, in zones poorly developed friable quaternary a cover - up to 2800 on 1 km^2 [1, 3]. Formation of cave-karstic ices is obliged to continental congelations of the Moscow and Valdai age which caused reorganization of a relief previous karstic generation. The core superficial carsting area is connected with approach and degradation Last-Valdai (Ostaschkov) age congelations. The karst contains the generated cavities of a wide age range (average - late Pleistocene - Holocene). The drain of glacial waters has caused formation of karstic forms and caves. Caves are incorporated in gyps-anhydrite deposits Sacmar, bottom Perm age. Formation of cave-karstic ices is subordinated latitudinal ash values and defined by an arrangement carstic massive in northern zone (64 n.l.), that is characteristic and for other regions [1, 2, 5]. On plains border distribution of cave-karstic ices coincides with breadth 50-60 n.l. It can be indirectly connected with their distribution near to southern limit of permafrost. In southeast Belomorsko-Kuloiskoe a plateau they settle down approximately in

100-150 km to the south from permafrost limit. Sporadic finds of permafrost in vicinities of s. Pinega are noted. Basically they are dated for peatlands.

The greatest age of cave-karstic ices is noted for caves of Kuznetsk Ala-Tau and makes more than 500 years. The maximal age of cave ices of area has been established for icing in a caves «Yubileinaya» «Anniversary» (Sotka-26) and Olympic. According to exogenic group of joint-stock geology company «AGD» it makes 200 years, (definition was spent by a radiocarbon method, on the rests of wood freezing in an ice) [1, 3, 4, 7]. The ice such icing differs lamination, a high level metamorphism. It, as a rule, opaque, with inclusion bubble of air. Horizontal layers of sandy-argillaceous structure of fragments of icing testifies to long-term character of development.

Now volumes of underground cave-karstic ices of area were considerably reduced in comparison with observed 15 years ago. Similar processes are marked and in caves of Urals Mountains [1, 2]. Rhythmic processes in a congelation of caves are shown in the form of dynamics of displacement of borders of cooling of rocks in cavities up to zero value of temperature, them freezing, dynamics of chemistry and morphology of an ice. The sizes and the form of a cavity define possible volume of accumulation of an ice in a cave there are long-term rhythmic processes in a congelation of the caves, caused by filling of all volume of a cavity with an ice. It was characteristic for a cave the Ice Wave and of some Kulogor caves in 80th years which for the first time have been described in the middle of 70th years as opened, however inputs in which in 80th years of the last century have been closed by an ice and have opened only in the end of XX century.

At freezing of karstic rocks even at a significant openness of an input in a cave, probably, operates as «temperature indemnification», and presence of negative temperature anomalies. The last, can be connected with an arrangement of several inputs at different high-altitude levels that provides safety of various kinds of an ice and formation of karstic type cryotextures which is presented by a network of cracks in the karstic rocks filled by an ice. In caves, with significant difference between freshet level of waters, occurs thermodenudation the arches and thermoabrasion an ice up to a level of the maximal rising of water.

The role of cave ices, both in increase of stability of a karstic file, and in development nival corrosion is great. Ices-cements in conditions cracking rocks prolong time of existence of caves, being the mechanism of maintenance of stability of their modern condition [1, 2, 3, 4.6, 7]. Interaction of karstic and cryogenic processes is shown in increase in speed of development karstic failure- subsidence processes due to dissolution karstic rocks (table 1). Are possible destroying on entering in caves. Inside of caves landslidely-fallen the phenomena are connected both with gravitation, and with thawing long-term icing, stalagnates. Now within the limits of area increase of activity failure- subsidence and landslidely-fallen activation is marked. The intensive phenomena are dated for zones of karstic broad gullies and river valleys. In table 1 regional classification of interaction of karstic and cryogenic processes is presented. Having the general cryogenic genetic group, accumulation of a cold in karstic massive has specific forms of display in the form of various cave-karstic ices. The last have great value for safety of caves in zones of crushing of rocks of karstic broad gullies. The landslide phenomena are connected with thawing long-term underground ices in breeds on a surface and in caves, opening or collapsing cave inputs.

Table 1. Interaction of karstic and cryogenic processes.

Factors of power-carry caused occurrence of process	**Genetic group**	**Types of processes**	**Forms of display**	**Place of display**
Freezing and thawing of rocks	Cryogenic	Thermokarst	Zapadini (bottoms)	Water-separate spaces
		Cryogenic cracking	Polygonal formations	Bogs massive
		Degradation of permafrost	Thawing of islands permafrost, strengthening of activity of cryogenic processes	Peripheral parts of bogs and «islands» in them, slopes of large karstic forms
Accumulation of a cold in karstic massive		Formation of inclusions and deposits of a cave-karstic ice	Cave-karstic seasonal and long-term ices: sublimation crystals, icing, an integumentary ice, permafrost	Karstic cavities (entering 100-200 meter zone)
		Freezing of the landslide and fallen formations	Freezing of the landslide and fallen formations	Karstic circuses, a broad gully (about karstic cavities)
		Formation of a snowing. Firnisation	Snow fuses, jacks, firn tongues	Opened speed up superficial karstic forms (slopes, the bottoms)

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PROTECTION AND SOUND MANAGEMENT OF CAVES OF THE URALS

Kadebskaya O.I.
Mining institute, Perm, Russia

A large variety of the surface and underground karstic structures encounters at the Ural region. The karstic features are most intensively developed in the Paleozoic sediments. At the eastern edge of the East-European platform and adjoining area of the Pre-Ural foreland basin, the dissolution processes are active in the interlayered gypsum, anhydrite, limestone, and dolomite beds of the Irenian horizon (P_1ir), and less in limestone and dolomite rocks of the Fillippovian horizon of the Kungurian Stage, as well as in the Artinskian (P_1ar) limestone strata. Salt and sulphate Irenian deposits are predominantly encountered at the northern and central parts of the Pre-Ural basin. At the area of the West-Uralian Folding Zone and Central Uralian Uplift, the karstic features develop in the Devonian, Carboniferous, and Permian carbonates of a total thickness of up to 2000 m. More intensive the karstic processes are on the western slope of the South Ural.

Over 3200 caves of total length of about 244 km are known at the Ural region today (see Table). The longest of them are: Dihvja (10100 m), Sumgan (9860 m), Kinderlinskaya (9113 m), Kizelovskaya (Vihasherskaya, 7600 m), Kungurian Ice Cave (5700 m), Ordinskaya (4900 m). The deepest caves of the Ural region are Kinderlinskaya (elevation difference 215 m), Shulgan-Tash (165 m), Kutukskaya-4 (155 m), Sumgan (134 m), Tjomnaya (132 m).

Table. Caves distribution at the Ural and Pre-Ural region (Caves of Volga, Ural and Pre-Ural region, 2010)

Region	Total caves number	Total length, m	Longest cave, m / deepest cave (m)
Republic Komi	129	2450	Medvezhja (480)
Tumen region	10	370	Lulinskaya (140/18)
Perm kray	761	75960	Dihvja (10100) / Tjomnaya (132)
Sverdlovsk region	463	18200	Severnaya (2250) / shaft Sadykovskaya (88)
Republic Bashkortostan	983	103000	Sumgan (9860) / Kinderlinskaya (215)
Tcheljabinsk region	765	35000	Sukhaya Alia (2130) / Shumikha (108)
Orenburg region	34	3009	Podarok (700)
Republic Tatarstan	32	3268	Yurjevskaya (1005)
Astrakhan region	37	2663	Baskuntchakskaya (1480)
Total	3214	243920	Dihvja (10100) / Kinderlinskaya (215)

Karstification affects the underground and surface hydrologic regime. Cave development starts with formation of the fracture and karstic water pathways, which later transform to the network of cave conduits.

At the Ural region, the most complicated and interesting model object for hydrogeological study is Ordinskaya Cave. Here is a good opportunity to get very new data about development of the karstic features providing permanent control of the karst aquifer regime in zone of the siphon circulation. The same observations can be conducted in hydro speleo system Shulgan-Tash, which is a continuation of the cave named after Ozhiganov.

A particularity of underground hydrosphere of the karst areas, having well developed conduits network, is a high quantity of water stored in karstic rocks, especially in carbonates.

Large springs appear at the karstic water discharge areas. Such bright unique objects, as “Krasniy Kljuch”, the largest karstic spring of the Ural region (Bashkortostan republic), and mineralized karts spring “Kurgazak”, can become the natural heritage sites of the region.

Another particularity of the areas of well developed caves network is interconnection of the surface and underground hydrospheres. Terrestrial rivers and underground karstic conduits create a common hydrologic-hydrogeological system.

Formation of the karstic structures is controlled by the tectonic history of the region and the climate changes. During the process of speleogenesis, the geological processes (weathering, gravitational, suffusion, erosion, glacial, etc.) expand deeper beneath the Earth surface.

Uniqueness of investigation of the caves and cave’s deposits is contained in feasibility of usage of the obtained data for characterization and modeling of the continental climate and its changes. The most intensive development of the karstic processes was from the Middle Jurassic to Lower Oligocene in relatively stable tectonic conditions and wet tropical and sub-tropical climate. These ancient karstic features are matched now only like sinkholes in the erosional depressions filled with later deposits. The same buried sinkholes, related to the river valleys, remained after the second upper Paleocene karstification stage. Formation of the modern karstic landscape started in Pliocene and continues at present. A zone of development of the karst structures at this stage (caves, ponor, vaucluse) is related to the present river valleys.

Cave’s mineralogy has not been studied well until now. Often, the caves are used as a source of mineral resources. Cave’s minerals are not classified so far. Secondary deposits of the Ural’s caves are presented by all the basic genetic types (Maksimovich, 1963).

Gravitational deposits are presented by the fallen and collapse subtypes. At the entrance parts, the deposits of the thermo-gravitational subtype encounter. Hydro-mechanical deposits develop in all the karstic voids, but beds of significant thickness occur only in the large caves. Deposits are from Holocene to late Pleistocene in age. Locally, the voids are filled with paleo-karstic material.

Hydro-chemical deposits occur rarely. Carbonate crystals, crusts, stalactites and stalagmites, which development is related to the overlying carbonate beds, predominate. There are encountered the gypsum crystals (more often ephemers), rosette-shaped concretions, and gypsum crystal crusts.

From this point of view, the most interesting objects are Kinderlinskaya, Kizelovskaya Viasherskaya, and Sukhoy Log (Perm kray) caves.

Frost weathering is most intensive in the ice caves. Glacial deposits are presented by all the genetic types and have a versatile morphology. In the zone of the downward vertical circulation, the stalactites, stalagmites, curtains, ice falls, and ice shields dominate. In zone of horizontal circulation, the crusts, veins, frazils, and, in zone of atmogenic circulation, ice cryctals and crusts occur. The specific forms of underground ice are the ice plugs, ice shields and ice-cements. The most significant quantity of the ice encounters at the pre-entrance parts of up to 200 m in length. The most famous cave with ice features is the Kungur Ice Cave. Here is observed over 120 genetic types of the ice features. Just the annual and perennial ice is the general landmark of the cave excursion tour. Beside the Kungur cave, the ice encounters in the Askinskaya, Kinderlinskaya, Ylacyn, Ice Lipovaya, Marihinskaya, Medeo, and other caves.

History of formation and development of the Pleistocene landscape as habitat of the primitive human is one of the current term of investigation of the Paleolithic age. Into the strata of cave deposits, there is observed a high concentration of the archaeological artifacts, plant's pollen and spores, animal fossils, which can be used as evidence of the environment changes that took place through the Quaternary.

Cave's paleolithic settlements are the significant part of the historic and natural heritage of the Ural region. Many of them are well known due to the scientifically interesting and valuable paleontological and archaeological findings. In this regard, the Medvezhja, Unjinskaya, Kizelovskaya, Mahnevskaya, Ignatjevskaya, Staromuradymovskaya, Vogulskaya, and Shulgan-Tash caves can be considered as the unique objects.

The most unique are the caves having the deposits of Pleistocene age. These caves are located at the area of 4 administrative subdivisions of the Perm kray, 3 subdivisions of the Cheliabinsk region, and 6 subdivisions of the Republic Bashkortostan. The majority of the caves, as it is proved by rich findings of the osseous remains, were populated by animals. In some caves, the tracks of the prehistoric human staying were discovered. Malaya Makhnevskaya cave is the only cave at the Ural region, which have the remains of animal species of the last interglaciation age. This age (110-130 thousand year) at the Ural region is referred to as "streletskiy interglaciation age", and at Eastern Europe as "Mikulinskiy interglaciation age". This is the northern occurrence of fossils of the Himalayan bear and porcupine. This Himalayan bear is defined as new subspecies named a perm black bear or Ursus thibetanus permjak (Baryshnikov, 2001). At present, this site is entirely destroyed by the commercial "black paleontologists".

Because of activity of the "black paleontologists", presently, 84 from 130 known in the Perm kray caves have lost the pleistocene deposits, which could be used for studying of the climate and landscape changes in the region, entirely or partially.

Caves are the habitat of the modern specific species, staying permanently (troglobionts) or temporally (troglophiles). Speleogenesis is accompanied by the penetration of the hydrosphere, atmosphere, and biosphere into the earth crust, and changing and complicating of the boundaries of the objects. The consequences of these processes are the concentration of the groundwater flow, formation of the water abundant zones and reservoirs of underground atmosphere that creates conditions for the adaptation and habitat of the species in the underground environment. An isolation from external influence and relatively stable internal climate of the caves lead to appearance and preservation of large quantity of the endemic species.

From the karts species of the Ural and Pr-Ural region, only Crangonyx Chlebnikowi is the specialized stygobiont, having distinct morphological forms adapted to the karstic habitat. This is a relic of the Turgay fauna, which is a voiceless witness of the climate cataclysms and great migration of fauna and flora, comprised large areas of the Earth surface. These are eyeless and translucent amphipods. The color of crangonix is explained by the whitish tissue transilluminated through the transparent crust (Pankov, 2010). Separate crangonix subspecies inhabit the Kungur Ice, Mechkinskaya, Babinogorskaya, and Ordinskaya caves. Crangonixs settled into the caves at the beginning of the earlier pleistocene glaciation approximately about 400-500 thousand years ago. Ancestors of the troglobiont *Crangonyx chlebnikowi* remained on the surface and did not survive due to severe pleistocene climate changes. There are not encountered amphipod species analogous to this crangonix in the surface water streams of the Ural and Pre-Ural region.

The largest at the Ural region bats settlement (of about 4 thousand) existed in the Smolinskaya cave (Sverdlovsk region). Unfortunately, despite of the status of natural heritage, uncontrolled human visiting destroyed the environmental conditions of the habitat of these animals. Today only single examples can be met in this cave.

Peculiar vegetation is also an attribute of the karstic landscape. Karstic processes and specific environments (dry soil, high summer temperatures, bedrock outcrops) contribute to preservation of the local extrazonal vegetation areas, such as the Kungur forest steppe in Perm kray (the northern area of kovyl steppes of Eurasia) and Yuzhniy Kraka steppe (Bashkortostan republic). Ice Mountain (Kungur) is an area, where a number of unique plants, included in the Red Book (list of threatened and endangered species) of Perm kray or in the Red Book of Russia (*Stipa pennata* and *Cephalanthera rubra)*, grow. Today, forest steppe ecosystems at the Middle Ural are under threat of disappearance and protecting the existed areas of steppe vegetation is an essential problem.

The Kungur Ice Cave was a first cave used for touring purposes in Russia. Since 1914 this cave is regularly visited by tourist. It is a research laboratory of the Mining Institute UB RAS and is also used for field curses for students of the Perm State University. The excursions in the Shulgan-Tash cave were resumed in 1992, and a length of the excursion rout is today above 370 m. Underwater part of Ordinskaya cave is used for training the speleo-divers.

Today only 5% of 3200 caves, located at the Ural region, have a status of protected natural heritage objects. The lowest quantity of protected karstic objects are in Bashkortostan republic, where only 32 of 983 caves are recognized as the natural heritage and some caves are located in the national parks or at other protected areas (Abdrachmanov et al, 2002).

The protected heritage objects status restricts the business operation at the area, but does not affect the uncontrolled visiting. The caves, often visited by informal tourists, are in really bad condition. Local authorities and enthusiasts attempted many times to establish a cave protection.

Dumping with trash is another problem associated with preservation of the caves, even located in remote and hard accessible places. The worst conditions are noted in the Kinderlinskaya (Bashkortostan) and Sukhoy Log (Perm kray) caves.

Since the 90th's, paleolithic heritage objects of Ural region have been threatened by the illegal commercial excavations. Unique for Russia, sites, where the remnants of ancient animals (not studied entirely) were found, are almost destroyed. It is noted, that the fossil bones from these sites were sold at the geological fairs in Germany and America and encountered in European geological museums.

Despite the fact that speleological objects of Ural region are unique and related to natural, historical, and archaeological heritage, no cave has today a status of the federal heritage object, excluding only the caves located at the conservation areas.

The grand caves of the world (Carlsbad, Mammoth, Sarawak) are included in the World Heritage List. There are about 250 countries in the world, and in 58 of them the world heritage objects, which are of interest for speleology and spelestology, are recognized (Maksimovich and Mescheriakova, 2010). Unfortunately, the Russian objects are not presented in that list, though, undoubtedly, they exist in the country and at Ural region too. In 2004, the International Union for Conservation of Nature and karst and caves conservation executive committee included the Kungur Ice Cave in the list of the karstic objects nominated for natural World Heritage sites of UNESCO. Undoubtedly, Ordinskaya cave, which is the longest among the world caves developed in sulphates, and Shulgan-Tash (Kapova cave), which is a unique site of the Paleolithic culture at South Ural, might be included in this list.

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CRYOMINERAGENIC PROCESSES ON AN EXAMPLE OF CAVES OF THE URALS

O.I. Kadebskaya, T.A. Kalinina
Mining institute, Perm, Russia

Cryomineragenic processes are quite common. Unfortunately, up to the present time there is no general classification of their conditions, types etc., supporting our discussion on cryomineral origin.

The conditions where cryomineragenic processes occur in the largest scale (no matter if marine or continental) seem to be the regions with currently existing ice cover, where cryochemical processes are related to surface glaciers and the regions where the cryochemical processes are connected with underground ice. The latter covers the regions with perennial permafrost and also the regions, located more to the south, where underground ice forms in underground cavities – caves.

History of investigation of cryomineral formations of caves is very short. There are some special works concerning mainly glaciers and naled ice, where investigation of their chemical contents gave some important data on their chemical components and also cryochemical processes connected with them Alexeyev (1987), Alexeyev, Ivanov (1976), Ivanov (1981, 1983), Shumskiy (1955), Bukowska-Jania, Pulina (1984, 1990), Bukowska-Jania (1998), Clark, Lauriol (1992), Courty, Marlin, Dever, Tremblay, Vachier (1994), Drozdowski (1982), Fairchild, Bradby, Spiro (1993), Fairchild, Bradby, Spiro (1994), Fairchild, Killawee, Sharp, Spiro, Hubbard, Lorrain, Tison (1999), Fairchild, Killawee, Spiro, Tison (1996), Faure, Hoefs, Jones, Curtis, Pride (1988), Ford, Fuller, Drake (1970), Galuskin, Bukowska-Jania (1999), Gokhman (1997), Grasby (2003), Griselin, Marlin (1998), Hallet (1979), Jazuel, Sauchez (1982), Killawee, Fairchild, Tison, Janssens, Lorrain (1998), Souchez, Lemmens (1985), Vogt, T., Corte A.E. (1996), et.al.

Various similarities and differences in the mechanism of the cryomineragenic processes can be observed in all the mentioned cases. As a rule, precipitation of salts from the solution appears to be a part of the circulation system of such substances as calcium carbonate.

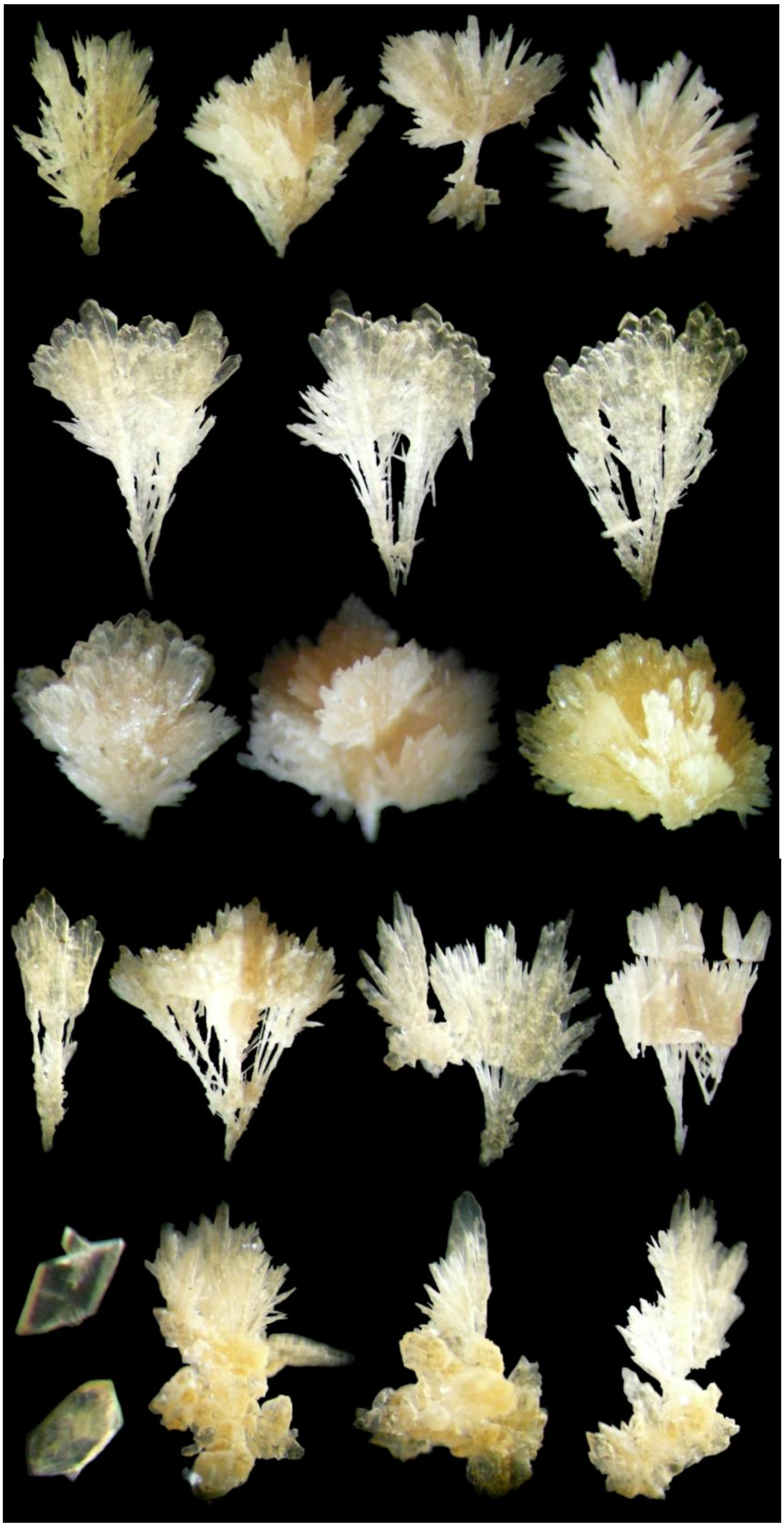
It is not possible to characterize all the mentioned conditions, but in all cases formation of a large amount of cryomineral powder take place (different in each case). The particles of cryomineral powder are usually dispersed in the whole mass of the rocks (e.g. in debris), however, after melting of ice bodies its can accumulate in various forms and sizes.

Dispersed masses of cryomineral material, mostly carbonate one, significantly enrich cave sediments determining many of their lithologic features and epigenetic transformations. For example, cryochemical material, dispersed in broken parts of rocks covering mountain slopes and then dissolved, forms hard crust or breccia as a result of its evaporation in summer time.

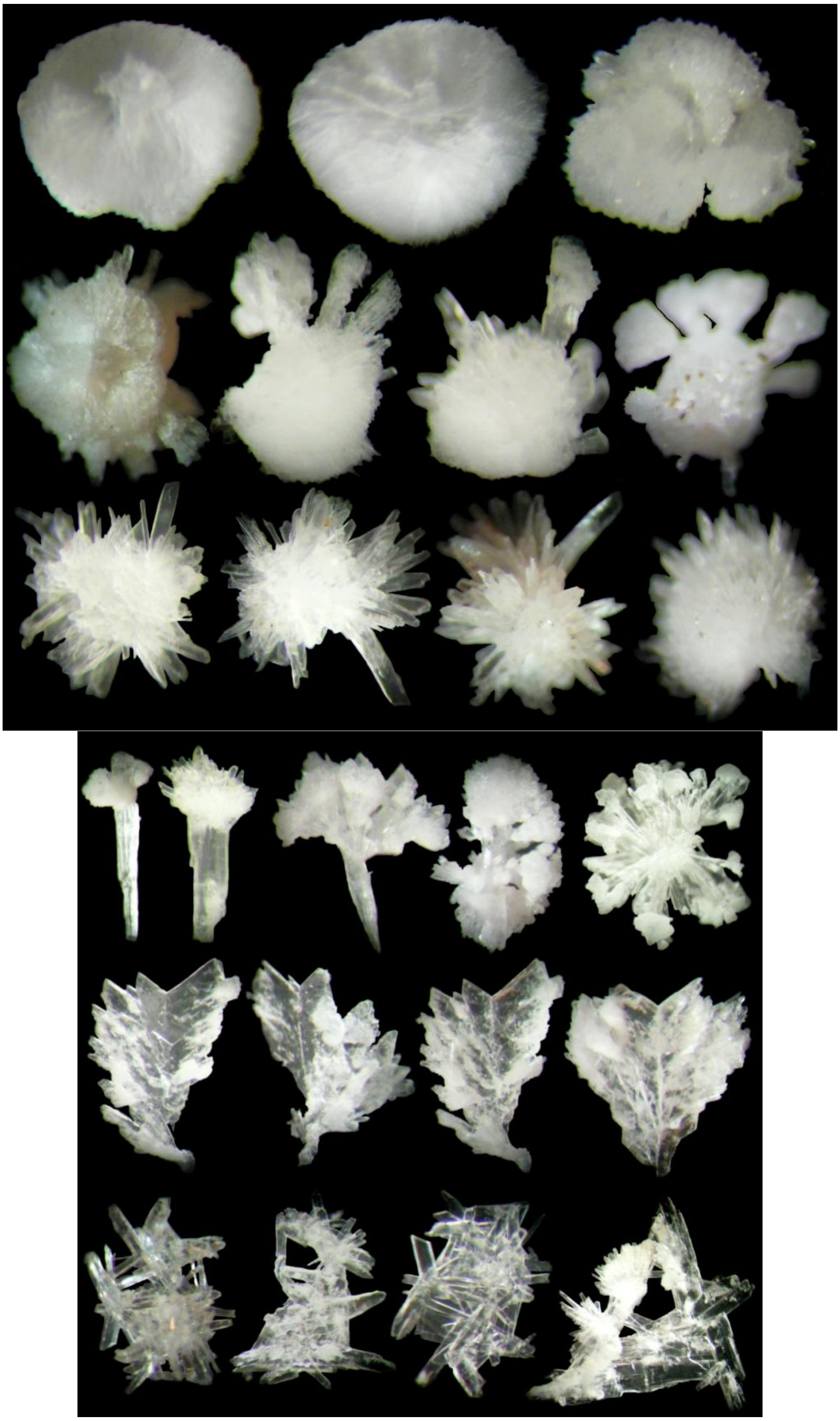
“Cryochemical factories” were especially active in production of dispersed carbonate material in Pleistocene. Cementation replaced production of dispersed enriching carbonate material in deglaciation periods that resulted in formation of various types of carbonate sediments. Carbonate contents in Pleistocene loess is also mostly of primary-cryochemical origin.

Cryomineral enrichment of sediments in moraines, outwash plains and other areas connected with land-ice are also very good examples of such process. After melting of ice sheet large amounts of carbonates were washed into loose fluvioglacial sediments not only enriched them, but also influenced in some cases their lithological character (e.g. carbonate moraines).

Mineralogy and morphology of cryomaterial from gypsum and limestone caves is various. Gypsum is a dominating material (over 95 % of cryomineral mass) in gypsum caves. It occurs mainly in the form of split crystals, often twin crystals, and spherolites. Calcite and celestite occur less frequently, but they also occur in split forms. Numerous phases of calcium carbonate are the most common in limestone caves.



The separated pine-skeletal dendrites in different stages of regeneration (at the left), zonal aggregates and separated crystals with new formed on them split crystals. Pervyj Grotto, Kungur Ice Cave

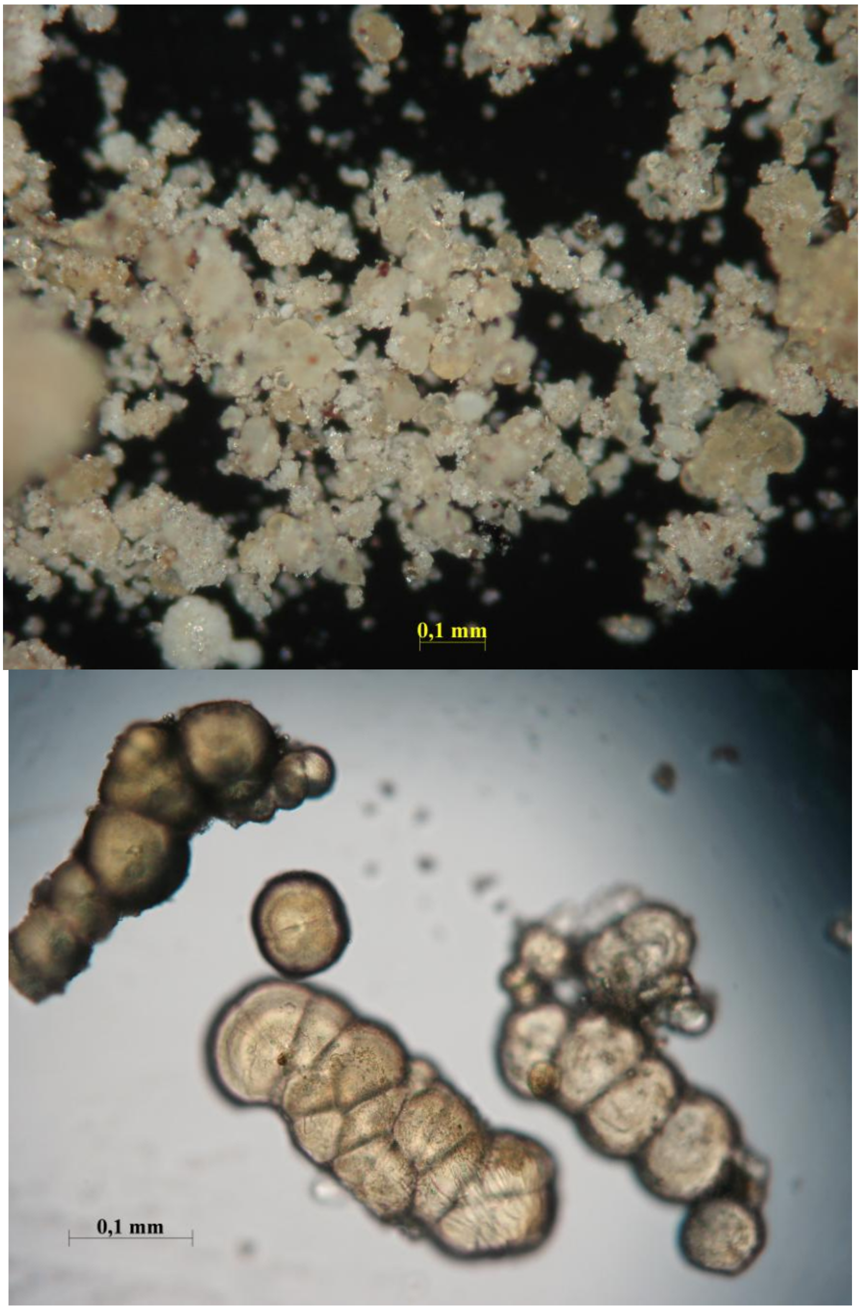


Regenerated (in different degree) spherolites, sometimes with the signs of 2 stages of splitting (at the left). Split crystals of gypsum and flat aggregates (twins and joints).
Scandinavskyj Grotto, Kungur Ice Cave

Unfortunately, it is impossible to find features definitely determining cryogenic origin of minerals at this stage of research. It is necessary to examine bigger number of samples, possibly to carry on their statistic analysis, to study their morphology and make an attempt to find "isotopic support" for the morphological features, etc. Currently, the investigation can be based only on results of underground observations, few experimental data and also on the number of morphological features always accompanying cryocrystals.

Importance of "speleocryomineralogical" researches

- Age of cryomineral formations is also very interesting for investigation. Their dating could distinctly show the growth of underground ice, so the cryominerals could serve as age markers much more stable than ice which can melt, recrystalise, etc.
- Aerosol material, including particles transported by air from outside, is preserved in cryomaterial growing layer by layer in underground naled ice. It can also be the source of information about pelaeoclimatic conditions of the past.



Recrystallisation of carbonate cryogenic powder, Mariinskaya Cave, Perm Region

Cave material varies greatly in its content and morphology, reflecting, not only different formation mechanisms, but also varied factors of unbalanced conditions of the solution and changing environmental conditions in the cave.

Detailed mineralogical investigations, applying the latest research methods, including isotopic analysis, will undoubtedly explain unknown effects and consequences accompanying cold mineral

Successive stages of mineral crystallisation, tempo of the process, cryomorphic transformation of crystals in the surrounding ice (recrystallisation in changing environmental conditions), inclusions in cryocrystals (for example, water or other minerals), phase transformation of the mineral matter, its aggregation, structure of crystals (growth zones etc.) and many other problems also are very interesting.

INVERTEBRATES FROM CAVES OF PINEGA AREA: BRIEF REVIEW

S.A. Kapralov
Niziy Novgorod State University

Available data about invertebrates from caves and some karst habitats of White Sea-Kuloi plateau were summarized. Notholca caudata (Rotatoria, Brachionidae), Mysis relicta (Mysidacea, Mysidae), Pallasea quadrispinosa (Amphipoda, Pallaseidae), Ephemeroptera indet., Culicidae gen. sp., Helomyza serrata (Diptera, Helomyzidae) were recorded in caves. In addition, 12 mite species (Mesostigmata) and 18 springtails (Collembola) were adduced for sinkholes & other cold karst habitats of Pinega area. Cave fauna of the region is very poor, but only special studies can give the representative pattern of hypogaeic life in the North.

INFLUENCE OF KARST PROCESSES ON THE FORMATION OF GROUNDWATER (South-Western Crimea)

E.P. Kayukova
St. Petersburg State University (SPSU), St. Petersburg

Within the second (inner) ridge of Crimean mountains in the midstream of the river Bodrak (surroundings of the village Trudolyubovka) there is a unique geological site existing for nearly 60 years, where St. Petersburg State University conducts geological field training for 2nd year students. Since 1998, during the geological training hydrogeological studies that include surface water and precipitation research, are carried out. Since the training is held in the summer, all the studies are seasonal (June - July).

Within the site, the river Bodrak flows from the south-east to the north-west (the catchment area is 76.5 km^2, average height of the catchment is 430 mm, average altitude of the longitudinal profile is 250 m, underground flow, calculated by morphometric method according to A. Green [4] is 125 mm).

The average annual temperature in the vicinity of the site varies around 11,6° C (at present, there is a trend of temperature increase of 0,37°/10 years). Negative anomalies of mean monthly air temperatures are associated with periods of dominance of the north-east winds.

The study area is divided into the following zones and aquifers: Quaternary aquifer (Q); Lyutetsky aquifer (Pg_{2lt}); Danish aquifer (Pg_{1d}); Hauterivian aquifer ($K_{1(v-h)}$); water bearing zone of Karadag series (J_{2b}). Unweathered sediments of Karadag, Eskiordinskoy and Taurian series form the regional aquitard.

Groundwater developed in the study area mostly belongs to zone of active water exchange. Only fracture-vein water of Karadag volcanic-sedimentary series (northern part of the village Trudolyubovka) belongs to the deeper zone. Groundwater of the Bodrak river basin are formed by precipitation (685 mm is a middle precipitation value of the river catchment), as well as by the transit water and condensation. About half of total precipitation value is spent on evaporation and transpiration. In the warmer months, the groundwater resources are replenished by condensation. Condensing flow is estimated as 2% of the precipitation, it is 11 mm (module of condensation flow is 1.85 $l/sec \cdot km^2$) [1]

From 1998 till present time there is a negative trend in precipitation (with the dynamics of about 1 mm/year) within the studied area. The chemical composition of precipitation corresponds to continental areas (contribution of the marine component is about 20%). The average salinity is 40 mg/l, pH ranges around 7. The predominant component of 30% of precipitation is calcium bicarbonate, other rainwater is of sulfate-bicarbonate calcium (18%), bicarbonate sodium-calcium (15%), sulfate- bicarbonate sodium-calcium (12%) composition.

About 250 kg of chemicals falls annually on the one hectare of the Eastern part of Bakhchisaray region. Contents of all macro components are well correlated with salinity, but the highest correlation rates are between hardness cations and bicarbonates.

Higher mineralized precipitation is associated with north-eastern winds. Winds of NNE direction bring dusty soil rich in iron minerals, eastern winds contain clay particles. Sources of major ions of HCO_3^-, Ca^{2+}, K^+ and of significant part of Mg^{2+} and SO_4^{2-} ions are soil and rocks (often these are particles of carbonate rocks).

The leading role in the formation of trace-element composition of rainfall in the study area belongs also to continental sources. Due to the wind directions, the there is an ecologically favorable situation in the lower layer of the atmosphere of the study (anthropogenic contribution to the chemical composition of precipitation is negligible).

Karst processes in the study area are associated with carbonate deposits of the Paleogene (they form the cuesta scarps of the Second ridge), as well as with the Cretaceous deposits composing the top of mesas.

Karst of the Inner ridge is developing mainly due to water absorption of transit streams and their tributaries. This leads to the formation of fairly numerous, but smaller (length is about 300 m) Ponor caves in Danish and nummulite limestone [2, 3].

In the inner ridge, the underground karsting is nearly absent, due to the deepening of river valleys below the base of the Cretaceous and Paleogene limestone. Small forms (funnels, ditches), sometimes of anthropogenic origin [2], appear.

According to A.B. Klimchuk, manifestations of karst foothills of Crimea have hypogene nature. It means that they are associated with the regime of the ascending groundwater discharge and with water exchange between aquifers. The share of the karst rocks in Paleogene sections is 45%, in Cretaceous sections it is 18%. [5].

Carbonate deposits have a significant impact on the formation of both chemical composition and quantity of natural waters. In the study area there are permanent springs, their outputs are confined to carbonate rocks (Afeniz spring). There are also springs discharging along the fracturing zone of flysh rocks those who carried on unloading zone cracked flysch rocks. However, their chemical composition indicates that they form in the upper carbonate rocks (spring in the north- western slope of Patil mountain, a spring near Maly Kermen mountain). The formation of calcareous tuff is observed near the spring.

The condensing flow from Cretaceous limestone ($K_{1(v-h)}$) is estimated as 1,8% of the precipitation. The condensing flow is counted up on summer minimum flow of Patil springs (in hot period).

Water formed in carbonate rocks, are hard and alkaline (pH 7-7.5), of calcium bicarbonate composition with salinity of 0.6 - 0.7 mg/liter.

Ag	Al	As	B	Ba	Cd	Co	Cr	Cu
0,0047–0,0048	0,14–0,19	0,00015–0,0002	0,028–0,080	0,70–0,75	0,00002–0,00017	0,0002–0,00026	0,0020–0,0044	0,0038–0,0041

Fe	Li	Mn	Mo	Ni	P	Pb	Rb	Sb
0,15–0,38	0,0050–0,0077	0,003–0,0065	0,00011–0,00032	0,0009–0,0042	0,012–0,033	0,00073–0,0034	0,00043–0,0007	0,0001–0,0002

Se	Si	Sn	Sr	Ti	Th	U	V	Zn
<0,001–0,001	5,8–11	<0,001–0,0036	0,27–0,36	0,002–0,0041	<0,0001	0,0022	0,0005–0,0006	0,019–0,145

A water associated with karst deposits has good drinking quality.

ECOLOGICAL EDUCATION AT THE EXCURSION ACTIVITY OF THE LLC "STALAGMIT-TOUR" COMPANY (KUNGUR, PERM REGION)

N.N. Kozlova, D.V. Naumkin
"Stalagmit – Tour" Company, Kungur

LITHOTROPHIC MICROBIOTA CAVES OF KINDERLINSKAYA (SOUTH URALS) AND BASKUNCHAKSKAYA (CASPIAN LOWLAND)

L. Y. Kuzmina, Sh. R. Abdullin, A. S. Ryabova
Baskirian State University, Ufa

The lithotrophic microbiota of carbonate Kinderlinskaya (South Urals) and gypsum Baskunchakskaya (Caspian Lowland) caves and factors, which influence at the communities structure of these microorganisms, are investigated. Intensity development of sulfur bacteria proceed in grounds of Kinderlinskaya (near (I, II) and remote (IV) zones) and Baskunchakskaya (remote parts) caves. The activity of these bacteria led to sulfur acid weathering. Sulfur compounds oxidation processes in bottom sediments of Kinderlinskaya cave are reduced in tens and hundreds, than in lying near grounds. But sulfur reduction processes, which influence with higher water-exchange (seepage, ground flooding) and ground high anthropogenic pollution by organic matter, are proceeded intensity. Acidophilic iron bacteria are presented in grounds of both speleosystems. The role of lithotrophic microbiota is discussed in geochemical status of caves.

STUDY AND CONSERVATION OF THE KAPOVA CAVE AND ITS PALAEOLITHIC PAINTING

Yu.S. Lyakhnitsky, A.A. Yushko, O.A. Minnikov, O.Ya. Chervyatsova
Russian Geographical Society, Saint-Petersburg

A group of speleologists from VSEGEI and RGO has performed comprehensive studies, monitoring of dynamic parameters, and fixation of Palaeolithic drawings of the Kapova (Shulgantash) Cave from 1995. During this period, the microclimate of the upper stage of the cave was improved, a design for drainage of halls with drawings was elaborated, and about 190 drawings were discovered and frozen, 140 of them have been discovered for the first time. The Kapova Cave Palaeolithic painting is characterized by special features that prove the presence of an ancient centre of the world's culture in the Southern Urals.

PROTECTING AND REGULATING THE USE OF RUSSIA'S CAVES AS GEOLOGICAL HERITAGE SITES

Yu.S. Lyakhnitsky
Russian Geographical Society, Saint-Petersburg

The paper describes the activities of the Commission for Karst Science and Speleology at RGO concerning the conservation and comprehensive study of caves and preparation projects of their restricted employment for excursions. Case studies of successful arrangement of the caves and the present-day negative status of other caves are given. The conclusion is made about the

prospects for implementing the concept of the regulated use of the caves for their conservation and education work with young people.

PSEUDOKARST AND NON – KARST CAVES – A DISCUSSION AND EXAMPLES FROM RUSSIA

Yu.S. Lyakhnitsky, I.Yu. Khlebalin
All-Russian Geological Research Institute (VSEGEI), Russian Geographical Society (RGS), St. Petersburg, Russia

The problem of classification of karst and similar processes was mainly solved in Russia as long ago as 1947 at a conference in Molotov (Perm). At present, these ideas are being worked out in more detail. V.N Dublyansky (2004) proposed the following concept. Karst evolves only in readily soluble sedimentary and more rarely metamorphic rocks (limestone, gypsum, anhydrite, salt, marble). Pseudokarst is subdivided into intrusikarst, volcanokarst, clastokarst, suffosiokarst, thermokarst, and glaciokarst. Analyzing these ideas, it is necessary to make following remarks.

Intrusikarst evolves in intrusive and effusive crystalline rocks under corrosive and erosion influence of flowing waters.

It is almost impossible to distinguish the clastokarst and suffosiokarst, because they evolve in different sedimentary fragmental rocks (loess, clay, sandstone, breccias, conglomerate). They are characterized by predomination of erosive and suffosion processes resulted from water flow activity, which breaks links between particles and evacuates them from the massif.

Thermokarst evolves in frozen ground mainly as a result of melting the permafrost. These are specific round lakes and other phenomena.

Glaciokarst forms in glaciers during their melting and under the influence of flowing water. The authors found cavities in various rocks and even in peat. Of importance are the processes, which lead to the formation of the cavities rather than rocks lithology. Otherwise man-made cavities, cavities resulted from underground fires, etc. could be assigned to the pseudokarsts, but they have nothing in common with the karst objects and have absolutely different morphology.

Volcanokarst is the generation of cavities (gas bubbles, lava tunnels) caused by volcanogenic processes, but in the authors' opinion they cannot be assigned to the pseudokarsts.

Gravity and landslide cavities form a special group and also cannot be assigned to the pseudokarsts, because the mechanism of their formation is not associated with the influence of flowing waters.

So the authors propose to define the pseudokarsts as a result of processes, which take place in poorly soluble sedimentary and other rocks, in frozen ground and ice under the influence of flowing waters.

Gravity and volcanic cavities cannot be considered as pseudokarst, since they have absolutely another nature and morphology, which are not associated with the influence of flowing water. These are two particular groups of natural cavities. Pseudokarsts are only those formations, which are close in their genetic and morphological features to the karst, but the main factor of the karst process, corrosion, gives way in them to erosion and suffosion.

The pseudokarst is rather widespread in Russia, and it has been studied for a long time.) Caves, cones, depressions, and holes were described in conglomerate of the Yuryuzan-Sylvino depression of the Pre-Uralian trough. Pseudokarst is recorded in the Pre-Uralian area of Bashkiria, almost in 50 % of its territory. They are evolved best of all in clay, siltstone, and sandstone in the basin of the Ik, Dema, Syunya rivers. The construction of a reservoir in this region on the Agardy River resulted in the activation of the pseudokarst and complete dewatering of the pond. In the Kirov Oblast there is a series of lakes up to 10 m deep, whose formation is associated with pseudokarst processes. V.N. Dublyansky and R.A. Tsykin (1992) compiled a cadastre of caves in conglomerate and sandstone in the former USSA. The Kama-Middle Volga, the Caucasus, the Lena-Enisei and the Sayan are the areas, where pseudokarst caves are the most widespread. 120 cavities are included into the cadastre. In the Mana region there are 18 caves in conglomerate. In a coastal band in the south of the Far East there are also caves, grottos, niches, and arcs.

In the Urals there are pseudokarst caves located in various rocks. Such caves as Pesochnaya Glubina (36 long/6 m deep), Peschany Grot (28 m), Jules Verne (15 m) are located in sandstone; Kvartsitnaya (150/28), Shuidinskaya 1 and 2, Zyuratkulskaya 1 and 2, Zigalginskaya 1 and 2 in quartzite; Itkulskie caves in schist, gneiss, and amphibolite; Savelievy Groty in miaskite; Kisegachskaya in granite; Pugachevskaya (10 m) in serpentinite, Kolybelnaya (50/13) and Churochnaya (10 m) in conglomerate. According to their data, about 2 % of caves are pseudokarst ones. A very interesting case of a transitional process from the karst to the pseudokarst is the Oreshnaya cave in the East Sayan. This is the largest world's cave in Ordovician limestone-dolomite conglomerate. It is the most intricate 3-D labyrinth apparently formed under phreatic conditions of about 58,000 m long with amplitude of 240 m.

One of well-pronounced excursion pseudokarst (clastokarst) caves is the "Svyataya" cave in a suburb of St. Petersburg on a tributary of the Oredezh River, not far from the Nabokov's estate. To a less extent the pseudokarst processes are manifested in old mine workings in Sablino and Staraya Ladoga, where sandstone is subjected to the erosion by underground waters.

First experiments on the organization of the reliable protection of geological inheritance objects are associated with the caves of Sablino. Excursions with geological and ecological concepts allow constant effective protection of the caves and to carry out educational and pedagogical work with young people. Artificial caves, two waterfalls, and abundant Cambrian and Ordovician outcrops with fossils, beautiful minerals and mineral springs are demonstrated there. The Sablino nature monument is not a geopark, but in fact it has all parameters of a geopark. The authors believe that the creation of a network of such well-protected nature monuments used for regulated excursions can promote the development of a system of Russia's geological heritage protection, including pseudokarst caves.

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CAVES GLACIATION; PROSPECT OF RESEARCHES

B.R. Mavlyudov
Institute of geography RAS

It is shown that cave glaciation have good prospects of researches in future. They will be connected with such directions: climate, paleoclimate and paleogeography; caves glaciology; caves cryology; cryogenic mineralogy of caves; biology of caves; archeology of caves; methodological range; caves conservation; excursion and educational activity, use of knowledge about caves glaciation.

INFLUENCE OF LYTHOLOGY OF GYPSUMS ON STRUCTURAL PLAN OF PODILLIA CAVES LABYRINTHS

V. V. Pokalyuk*, A. N. Doroshenko, C. I. Tereschenko***
*Institute of environmental geochemistry NAN, Ukraine
**Institute of inorganic chemistry NAN, Ukraine

Morphology, structure, localization and distribution features of the so-called “dome folding” within the gypsum mass of the upper torton of the Dnister Podillia region have been studied. The initial sedimentary crystallization genesis of the “domes” from salt-generating brine by columnar growth of gypsum crystals (megaspherolites) was vindicated. Connection of the “domes’” morphology with intensity and manifestation of karstic processes during formation of caves has been analysed. The dome-shaped forms grow upwards with the structures’ diameter increasing from several centimeters to 5-8 meters towards the top of the gypsum mass. Symmetry axis within separate structures are always subvertical (symmetry of a dome-shaped hemispheroid). Larger structures located upwardly enclose smaller ones located below. The ensemble of the adjoining dome structures composes a mosaic of convex polygonal cells. The formation mechanism of the above-described structures is similar to that of ordinary crystallization spherulites while the size of the first ones is 10 – 100 times larger (up to 10 m in diameter). These huge structures grew at the bottom of a shallow basin with the depth exceeding the convexity of the hemisheroids, i.e. over 2 m (presumably to 5-10 m).

FEATURES OF FLORS AND VEGETATION OF KARS LANDSCAPES OF THE PINEGA STATE NATURE RESERVE (ARCHANGELSK REGION)

L.W.Puchnina
Natural reservation “Pinezhsky”

A large part of the territory of the Pinega state nature reserve (PSR) represents complex combination of karst landscapes. On a degree of karst participation in formation of a morphological structure of landscapes according to the classification of V. N. Andreychuk (1992) there are: karstogenus, karsted (subtype karst-glacial), glacial with elements of karst, bed-denudated with elements of karst landscapes.

The glacial with elements of karst landscape is most prevalent, it is developed on the sites of poor denudated surface of glacial equalization in the central and the south- western parts PSR. The karst forms are represented by single sinkholes and swales. The territory is characterized by the greatest swampness (more than 15 %). Peaty-glei and oligotrophic peaty soils dominate in the edaphic cover, and podzol soils dominate on drained sites of the landscape. The karst-glacial landscape has been developed on middle- karsted sites between two rivers with predominance of clastokarst forms in the northwestern, western and south-eastern parts of the reserve. Large sinkholes and karst basins, as a rule, well drained prevail here. A drainage of the territory is strengthened by a developed net of superficial narrows and hollows. The karstogenus (KG) landscape is represented strongly karsted sites adjoining to the valley river Sotka and the lake Eraskino and by karst narrows. Highest density of the karst forms, croppings of gypsum rocks, availability of specific soils – roughhumus sulpharendzins are characteristic for the landscape. The bed –denudated with elements of karst landscape (BD) is met on covered over redstone and limestone sites of the raised bed –denudated plain flatness in the north-eastern part of the reserve. Two subtypes are marked inside a landscape: dissected bed –denudated – (BD1) and poorly dissected bed –denudated – (BD2). The subtype BD1 differs by a high drainage of the territory and availability of rich sod-podsolic soils.

The wide development of karst processes has stipulated richness and originality of flora and vegetation of the PSR. The total number of vascular plants of the reserve is 509 species, which are included into 238 genuses and 67 families. The flora of the Archangelsk region includes 1104 species (Shmidt,1989). Thus, 46,1 % of the flora of the Archangelsk region is marked on the area of 0,1 % of its the territory. Boreal species make the main body of the flora of the reserve, the large role in its formation belongs to the boreal Ural-Siberian species. The conifers Picea obovata and Larix sibirica concern to them. Their satellites are Salix pyrolifolia, Atragene sibirica, Spirea media, Lonicera pallasii, Paeone anomala, Crepis sibirica etc. Plenty of 27,4 % rare and relict species are represented in the flora of the PSR. Relict species concern to such floristic elements, as arctic, hypoarctic, broad-leaved-forest, endemic and taiga (Simacheva, 1986). Overwhelming majority of relicts belougs to KG and, in a smaller measure, to KGl and BD1 landscapes; in LEK and BD2 landscapes the number of relict species is insignificant. A group of arct-alpine (*Dryas octopetala*, *Pinguicula alpina*, *Thalictrum alpinum*, *Saxifraga aizoides* etc.) and hypoarctic (*Cystopteris dickieana*, *Astragalus frigidus*, *Arctous alpina*) relicts find optimum conditions for its existence on gypsum taluss and uncovered declines of the karst rivers and narrows. South-taiga and broad-leaved- forest relict species such as, *Cypripedium calceolus, Paeonia anomala, Corydalis soliida, Stellaria nemorum* are met on eutrophic locatious of the river Sotka plain also on bottoms of karst narrows. As a whole, in KG landscape there are 80 % of species of the flora of different geographic connections, in the LEK landscape there are less than 50 % of species, the majority of them one is tipical for the northern taiga.

The largest part of the reserv'es teritory is covered by forests (87 %), little more than 10 % of the area a covered by bogs, same small areas are covered by meadows, bushes and societies of light forests. The forest vegetation is represented by fir, pine, larch, and birch stands. In total 101 vegetative associations are fixed on the area of the reserve. In the bound of the LEK and KG landscapes 47 % of vegetative associations are fixed, 38% - in the KGl landscape, 19% -in the BD1 landscape, 13 % - in the BD2 landscape of the total number of associations. The KG and LEK landscapes differ by the composite phytocoenotic structure, that is caused by different factors. The complication of phytocoenotic structure of the KG landscape is determined by strongly expressed karst relief and its specific soils. The complicated phytocoenotic structure of the LEK landscape is conditioned by easing of an edificatoric role of fir-tree in conditions of the strong swamped of the relief. A composite phytocoenotic structure of the LEK landscape is determined by a diversity of fir-tree coenosises, where the greatest number of associations are represented by moss, grass-swamp and sphagnum fir forest and also of oligotrophic and mesotrophic mire societicus. Billberi-moss fir forest with broad participation in grass-undershrub layer of hypoarctic species take the central place. Vegetation of the landscape is tipical for the north- taiga subzone. The richness of vegetative associations of the KG landscape is determined by a diversity of sparse groups on gypsum taluss and meadow associations of the karst narrows and of the plain of the river Sotka. Forests in typological attitude are uniform enough, they are coenosises of grass- undershrub and grass groups of associations, though they are represented by all specios of formations meeting on the territory of the reserve. The majority of vegetative associations has azonal character and is specific for same sites of intensively developed karst. The vegetation of the BD1 landscape is represented mainly by fir forests of grass and moss groups of associations. Grass fir forest of the BD1 landscape differ by the greatest productivity.

MYSTERIOUS PALLASEA (CRUSTACEA: AMPHIPODA) FROM THE CAVES AND GOLUBINSKY COLLAPSE SINK-HOLE AND KITEZH CAVE

D.A. Sidorov* , E.S. Chertoprud, A.A. Semikolennykh**, E.V. Shavrina*****

*Soil-biology institute, Vladivostok, Russia

** Moscow state university

*** Natural reserve “Pinezhsky”

A small collection of an enigmatic amphipods was sampled in 2008 and 2011 in the Golubinsky Gap and Kitezh caves (Pinega Region, Archangel Area). The samples were studied and assigned to a new unknown form of the genus *Pallasea* Bate (Fam. Pallaseidae). *Pallasea* sp. from the Pinega caves possess with absence of the lateral projection of cephalon and dorsal cuticular spines on metasome inherent to the North European *P. quadrispinosa* Sars, 1867. The further complex investigation are necessary for the taxonomic clarification of a new form with the North European *P. quadrispinosa*, *P. laevis* Ekman, 1923 from Novaya Zemlya as well as Baikalian *Pallasea*, including investigation of the biology of this enigmatic species inhabiting the unique karst caves in the northern part of Russia.

FEATURES OF AIR CIRCULATION IN KULOGORSKIE CAVES

S.V.Sorokin, N.A. Franz
Tver State University
Speleoclub “Labirint”, Arkhangelsk

The research suggest that, in Kulogorskaya cave system the upper entrances to the ventilation system are the turf-covered sinkholes having air permeability due to the presence of "corrosive rantklyuft" on the vertical walls of the wells. Larger, in comparison with natural "rantklyuft" cross-section of the artificial top-entry the Well causes the appearance of the local system of air circulation in which the Well in the winter plays the role of the lower entrance.

SURFACE DISSOLUTION AND WEATHERING OF GYPSUM IN A COLD HUMID CLIMATE AND THEIR INFLUENCE ON SOIL FORMATION

I.A. Spiridonova, S.V. Goryachkin
Institute of geography RAS, Moscow

This paper entitled "Surface dissolution and weathering of gypsum in a cold humid climate and their influence on soil formation" by I.A. Spiridonova and S.V. Goryachkin, describes results from a unique long-term field experiment on surface dissolution of gypsum rocks within a karst landscape in the Pinega Region, NW Russia. The experimentally determined dissolution rates (8 g/kg/year and 0.02 g/cm^2 /year) are 3 times lower than the rates of gypsum dissolution observed within a river flow system and underground gypsum denudation by karst waters. We also conclude that the rate of cryogenic disintegration of gypsum is greater than the rate of gypsum dissolution, thereby resulting in the formation of powdery-gravely gypsum soil horizon at a rate of more than 1 cm per 100 years. This disintegration is hindered by the moss layer and litter development which acts to slow down the rate of temperature change.

KARST PHENOMENA OF NATURAL PARK “LENA PILLARS”

E.V. Trofimova
Institute of geography, Moscow, Russia

Natural Park “Lena Pillars” is situated in the latitudinal part of the valley of great Siberian River Lena. Orographically region explored belongs to Prilenskoe Plateau raised at 300-600 m above sea level. Climate of the territory is Sub-arctic extreme continental and dry: average annual temperature of the air is –9,8°C at the annual temperature amplitude to 98°C. Average annual precipitations doesn’t exceed 249 mm. There is the area of continuous permafrost up to 300 -400 m thickness. Lower Cambrian limestones and dolomites with a thickness 400-500 m outcrop represent karst rocks.

In spite of the insignificant quantity of the precipitations falling on the territory of NP Lena Pillars, karst processes are widespread here. The main reason is the role of the permafrost in relation to the water, which is the principal factor of the karstification. On the one hand, in spring and summer periods the evaporative capacity practically is equal to zero in consequence of the low temperatures of the soil in conditions of permafrost. Moreover, in warm part of the year the chilled surface condenses actively the water from the air because of the considerable difference of the temperatures between the air and the soil. On the other hand, the quickly filtration of the precipitations into karst massifs is blocked by permafrost. That is the reason of the accumulation of the water, causing the karst processes, is realized on the surface. Therefore the development of karst relief in the regions with permafrost is in need of in some times less of the precipitations as compared with the ones where the permafrost is absent (Parmuzin, 1954; Trofimova, 2007). Additionally, the infiltration of the summer precipitations along the deep fissures of carbonate rocks, as well as the considerable snow accumulation, causing the warming impact on the cryolithozone, have done much to support the activity of karst process on the territory of NP Lena Pillars. More than that, the factor of carbonate reaction plays a significant role in the development of the processes considered: the displacement of the temperature maximum lower the foot of the seasonal thawing up layer, favoring the formation of intra-permafrost taliks, are the features of the regions with the carbonate karstifying rocks. In closing, the solubility of CO_2 in the water decreases with the increase of temperature: so, if the atmospheric pCO_2 is equal 0,0025, the solubility of CO_2 in the water at the temperature 0^0 C is 8,4 mg/l, at the temperature 10^0C – 5,85 mg/l, at 20^0C – 4,28 mg/l and at 25^0C only 3,73 mg/l (Jakucs, 1979). Thus, cold waters of permafrost's regions, saturated by CO_2, are characterized by the considerable aggressivity in respect to karstifying rocks.

Classic superficial and underground karst of Natural Park "Lena Pillars" is represented by karst sinkholes, ponors, dry channels, disappearances of the rivers, karren, karst pillars, etc.

As for Lena Pillars directly. Lena Pillars, as the form of karst relief, were formed episodically in relation with the incision of the valley of Lena into Prilenskoe Plateau. Generally, the age of Lena Pillars is estimated to 400 000 years (Tolstikhin, Spector, 2004).

On-going development of Lena Pillars is controlled considerably by the following geomorphological processes: frosty and cryohydratational weathering, which are the dominant in the modeling of limestone pillar relief, gravitational-slope, karst and fluvial processes. Karst is related with the unloading cletfs, where the chains of sinkholes are revealed exactly at its bottom. Frequently, these sinkholes have the open ponors, being the doubtless confirmation of the recent karst process.

Type of karst, developing in cold dry climate in conditions of permafrost, has the specific scientific name, fixed in "Terminology of the karst" (1991): frozen ground karst. Karst of Natural Park "Lena Pillars" is the obvious example of such type of the karst, having the outstanding universal value for the world karstology.

THE INFLUENCE OF GYPSUM KARST ON GEOCHEMISTRY OF NORTHERN BOREAL LANDSCAPES

T.Yu. Tuyukina
Institute of Geography, Russian Academy of Sciences, Moscow

Studies in the subzone of northern taiga of European territory of Russia, in the middle flow of r. Pinega, on its right bank (district of Pinezhsky reserve) and on the left bank show up that the territories affected by gypsum karst, in dependence of area of distribution of Quaternary cover on top of gypsum rocks, can be divided into areas of open, covered and mantled karst.

Areas of karst development of these 3 types are associated with landscapes that differ in composition of natural components and features of their geochemistry, both among themselves and from the moraine landscapes.

In landscapes of **opened gypsum karst** Quaternary sediments have low thickness (up to 0,5 meters) and encountered fragmentary, overlapping not more than 50% of the surface. The thickness of the Quaternary deposits in **landscapes of covered gypsum karst** is up to 5 meters, and outcrops of gypsum are fragmentary. In **mantled karst landscapes** the impact of this process occurs only in the formation of subsiding landforms and in the influence on the composition of groundwater, Pre-Quaternary rocks are not encountered here as parent.

In **landscapes of opened karst** the maximum density of karst landforms occurs: from 100 to 1500 forms and more per $km^{2.}$ Karst landforms are funnel-shaped, tubular, crack deepenings, shared with jumpers and residual hills. Soil, formed on hard gypsum, which had previously been given the name "sulforendzina" (S.V. Goryachkin, 1993), predominate in the soil cover. Birch and pine forests are grow in landscapes of this type, but their growing weight of above-ground wood is 8-10 times less than in the typical zonal taiga communities. Tops and slopes of residual hills are characterized by atypical grass-lichen ground cover.

Oligotrophization of plant communities is associated with extreme geochemical poverty of parent rocks in the majority of elements of plants mineral nutrition: gypsum as evaporite at 98-99% consists of $SaSO_4$ X $2H_2O$. As for most soils of the taiga zone, formed on silicate rocks, acid and strongly acid pH in the forest litter horizon is typical for sulforendzinas. Reaction of mineral horizons of sulforendzinas range from acid (in the upper horizon) to weakly acid in the lower part of the profile, it is slightly higher than in soils on silicate rocks. Such pH values occur due to the fact that $CaSO_4$ is a salt of strong acid H_2SO_4 and somewhat weaker base $Ca(OH)_{2,}$ and consequently, the hydrolysis of $CaSO_4$ gives a slightly acid reaction. Humus content in the mineral horizons of sulforendzinas is less than 1.5%, lower than in the podzolic soils (Albeluvisols according WRB) of the moraine landscape.

Concentrations of chemical elements in the thin loamy horizons of soddy soils (Leptic Regosol) and humus-peaty soils (Histi-Leptic Regosol) of opened karst landscapes are generally within the same mathematical order as in the loamy horizons of podzolic soils in the moraine landscapes of the region of research. In this case, the underlying gypsum is the source of the important biophilic elements: calcium and sulfur. Therefore, although the thickness of the soil profile on the residual undenudated silica-silicate deposits is low, these soils are much more favorable for plant growth in comparison with sulforendzinas. This is the reason for the relatively high carbon content of humus in the topsoil and mineral horizons of soddy and humus-peaty soils (up to 7.5 and 18.9% respectively).

In the landscapes of opened karst peat soils (Histosols) of karst depressions enriched by ash elements and have higher nitrogen content unlike peat soils (Histosols) of moraine landscapes. In addition to enrichment by Ca, S and Sr, in karst peat bogs the contents of K, Si, Al, Fe, Cu, Br are also increased, ash content increased by 4-8 times (depending on the horizon of peat). Obviously, the chemical elements entering into the swamp with surface and groundwater in the sulfate form, lose their mobility in a reducing medium due to the transition to sulfides and sorption by peat deposits. In addition, the swamps in karst depressions accumulate loamy silt, demolished from the surrounding territory in the form of mineral dusts and suspensions.

Natural waters of opened karst landscapes characterized by calcium sulfate composition and high mineralization - 1.3-1.7 grams per liter. All surface and underground waters (of cave streams) in comparison with surface and groundwaters of moraine landscapes are also much less acid (have a pH from neutral in oxidation zone to slightly alkaline in conditions of low Eh) and are characterized by high contents of S, Ca and Sr. Along with this, karst waters have decreased contents of Fe, Mn, Al and Cl in comparison with waters of moraine landscapes. Nevertheless, despite the sharp differences in the composition of parent rocks of gypsum karst landscapes and moraine landscapes, thanks to the high solubility of sulfates the contents of some elements (Mg, Na, Cu, Zn, Rb, Pb, Ni) in the karst and "moraine" natural waters are within one order; the differences between the contents of studied elements in waters are less them the differences in composition of soil-forming substrates of two landscapes (gypsum and moraine loams).

Marsh plant communities in karst depressions developing in conditions of more balanced mineral nutrition than communities on residual gypsum hills are more rich in quantities of species in the grass-shrub layer, which include many Ca-phylous plants (legumes, orchids).

In marshy lakes of opened gypsum karst landscapes in the water-saturated muds an intense sulfate reduction occurs, accompanied by precipitation of $CaCO_3$ from a solution in the bottom of the anoxic zones of lakes. (Bacterial sulfate reduction of calcium leads to the removal of sulfur from the solution or in gaseous form (H_2S), either in the form of insoluble sulfides. As a byproduct of sulfate reduction a bicarbonate-ion appear, which is being associated with remaining in solution ion of calcium, precipitates in the form of $CaCO_3$ (Rattan Lal et al., 2002).

Typical taiga species in karst woodlands, usually have an increased ash content and in increased amounts accumulate Ca and Sr. In some habitats an increased concentrations of elements from the group: S, Zn, K, Rb, Al, Mg, Mn, Fe - are also found in plant tissues, which is obviously due to the high availability of these elements to plants in the form of sulfates. A group of elements, which contents are decreased in all habitats of landscapes of opened karst, include the chemical elements dispersed in the gypsum substrate: Mn, Si, Fe, Al, Mg, K Zn, Cl, Rb, Ni.

In landscapes of covered karst the development of karst denudation leads to inclusion of carbonate-containing moraines (lying deeper than 100 cm in moraine landscapes) and gypsum in the root layer. Podzolic soils (Albeluvisols) are situated on the tops of karst elevations in such landscapes, grey-humus soils (Hypercalcaric Leptic Regosols) are appear in conditions of shallow underlying of carbonate and gypsum rocks. At the same time, stratificated podzolized residually calcareous soils (Leptic Regosols) form the main background on the slopes and bottoms of sinkholes with less than 5 meters depth. Areals of sulforendzinas are fragmentary (take areas of n $m^{2)}$.

The close occurrence of carbonate-containing horizons with a neutral and slightly alkaline reaction is reflected by increasing of pH of organic soil horizons in comparison with litters of podzolic soils in moraine landscapes. In addition, although in all horizons of loamy soils of two landscapes the levels of other oxides are similar, the contents of CaO and MgO are increased on covered karst, with the exception of horizons ElB in Leptic Regosols on slopes and bottoms of sinkholes, which (according analytical data) podzolized stronger than automorphic podzolic soils on tops of karst hills due to intense attack of surface runoff. Along with this, levels of strontium in the mineral horizons, with the exception of carbonate-containing and gypsum horizons, are not larger than those typical for podzolic soils. In landscapes of covered karst high concentrations of calcium (up to 4.54%) are characteristic of litters, and litters have high ash content (6,5-23%), which is also a common feature for the opened karst landscape soils. In Hypercalcaric Leptic Regosols an additional biogeochemical and sorption barrier of accumulation take place (horizon AY), where the concentrations of Ca, Mg, K, Mn, Fe, Ni, Cu, Zn, Rb and Y are higher than typical for soils of moraine landscapes (in the opened karst landscapes the similar organic horizons accumulate only Ca, Fe and P).

As in the opened karst landscapes, on covered karst an upward trend of the ash content in plant organs of typical taiga representatives of forest stand, shrub layer and green mosses observed, but a group of elements with increased accumulation on covered karst is usually wider. In more than half samples it consists of Ca, Mg, K, P, Si and Sr (Strontium accumulation is less pronounced than in the opened karst landscapes). Thanks to biogenic homogenization of the nutrients distribution in litters within the ecosystem, plants, that settle in the small areals of sulforendzinas and whose root systems predominantly assimilate organic soil horizons, concentrate mineral elements on nearly the same levels with the same species on loamy soils, adjacent to soils on gypsum in the soil cover.

The presence of additional sources of biophilic elements calcium and sulfur in covered karst landscapes leads to improved forest stand quality class, growth in number of species in the soil cover and presence of Ca-phylous plant species, atypical for the moraine landscape (juniper, rose, monkshood).

Mineralization and ionic composition of cave streams waters in covered karst landscapes and cave waters in opened karst landscapes are close due to homogeneous composition of karstifying stratum of sulfate rocks.

In landscapes of mantled karst, as in conditions of opened karst, in lakes with sulphate mineralization the accumulation of lime sediments as a result of sulfate reduction is taking place from the early Holocene (according to radiocarbon dating). Due to the formation of lime deposits (with thickness up to 35 cm) and retreat of the lake borders, a specific soil catenas with peaty-dark humus residually carbonate soils (Histic Calcaric Regosols) on slopes and peaty residually carbonate soils (Hyper calcaric Histic Regosols) on swampy lake terraces formed within a radius of several tens of meters from the coastline.

High forest stand quality class and abundance of grass are typical on peaty-dark humus residually carbonate soils (Histic Calcaric Regosols). On peaty residually carbonate soils (Hyper calcaric Histic Regosols) on swampy lake terraces, where the thickness of lime sediments is maximal, there are atypical for northern part of forest belt carex-grass-spirea communities with oppressed spruce trees in the stand.

Lime sediments consist mainly of $CaCO_3$, the total content of oxides-admixtures amounts to 13-17%. Low level of MgO together with high concentrations of SO_3 (4,08-5,29%) and especially Sr (up to 1233 mg/kg) indicate a genetic relationship between the lacustrine lime sediments and gypsum.

Due to the presence of calcium carbonate layer in the profile of soils formed on lime sediments the pH-reaction in all mineral soil horizons is within an alkaline part of scale.

The soils of mantled karst landscapes formed on lime sediments, as soils of gypsum karst landscapes of other types, creating more favorable conditions for humus formation, than in soils of typical moraine landscape: the humus content reaches 9.14%.

One more common difference is the high ash content of organic horizons, due to a large extent the increased accumulation of calcium. As peatlands of opened karst landscapes, lacustrine peat bogs on lime sediments characterized by increased accumulation of Ca, S, Sr, Br and Cu, which complemented by accumulation of elements that are not characteristic for peatlands on opened karst - P, Mn, Zn and Ni (for the last 3 elements and copper, apparently, carbonate barrier of deposition is acting, the high accumulation of Br and P caused phytogenic, and Ca, S, Sr - lithogenic factor).

An increasing of ash content in plant organs, typical for karst landscapes of different types, in ecosystems on lacustrine lime sediments usually occurs due to accumulation of elements-indicators of karst gypsum - calcium and strontium, and also zinc, and bromine. Simultaneously, the role of calcium carbonate substrate in at least half of the cases seen in deconcentration of Cl, Mn, Fe, Rb and, in some cases, Ni and Cu.

Conclusions

1. Gypsum karst landscapes essentially differ by geochemistry of soils, waters and vegetation from moraine landscapes, which predominate in the zone of boreal forests.

2. Geochemistry of gypsum karst landscapes of different types (opened, covered and mantled) is significantly differs.

3. Gypsum karst landscapes of different types belong to different classes of geochemical landscapes according to classification of geochemical landscapes by A.I. Perelman. Sharp geochemical specifics of opened karst landscapes demands an inclusion to Perelman's classification an additional Gypsum (acidly-calcium sulfate) class of geochemical landscapes in boreal zone.

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DOES ECOTOURISM EXIST?

E.S. Fedeneva
“Stalagmit – Tour” Company, Kungur

HYDROGEOLOGY OF KULOGORSKIY SPELEOMASSIV (ARKHANGELSK REGION, RUSSIA)

N.A. Franz, I.E. Vyahhi
Speleoclub “Labirint”, Arkhangelsk
Institute of geoecology, St.Petersburg

Main role in water income of Kulogorskaya cave system play floodwaters of the Pinega river. Pinego-Kuloy canal built in 1928, serves as an important element that ensures the delivery of aggressive spring water directly to the absorbing ponors laid down in the bottom of Kulogorski ledge. During the spring flood water fills the vast maze of karst in the depth of the karst plateau, and its discharge is carried out by slow horizontal filtering through the floodplain alluvium in the riverbed of Pinega river and Pinego-Kuloy channel.

GENESIS AND AGE OF UNDERGROUND ICES OF BOLSHAYA BAIDINSKAYA CAVE AT BAIKAL

Filippov A.G.*, Shevelev A.S.**
*Boreal Oil Sands Services Inc., Calgary, Canada
**OOO «Petrographica», Irkutsk

The Bolshaya Baidinskaya Cave preserves the most interesting cave ice body in the Pribaikal region, Eastern Siberia. Contrary to the Dr. E. Trofimova’s publications declaring snow-firn genesis of the cave ice body and its Upper Pleistocene-Holocene age, the authors expose data of field observations showing that the ice body consists of two genetic types of ice: lacustrine and ice build-up. Non-calibrated radiocarbon age of the lower dirt horizon from the bottom of the ice build-up is 2710±30 B.P. (COAN-3047). Thus, the ice body appeared around three thousand years ago.

INTERACTION OF DYNAMIC COMPONENTS IN GROUNDWATER AND SURFACE KARST AT SOUTHEASTERN PART OF BELOMORSK-KULOISK PLATEAU.

E.V. Shavrina
State reserve “Pinezhsky”

The studies of the dynamic processes in karst thePinega state reserve are conducted more than 25 years. The period of the directed observations to activities exogenic prosses territory reserve have complied with its)significant growing. This has brought about essential changes to look underground and surrface карстового of the relief. The observations to activities of their development allow valuing climatic trend modern period, bringing about breach of the balance surface and underground karst.

THE EXPERIENCE OF INTERVAL PHOTOGRAPHY USEAGE FOR KULOGIR CAVES MONITORING

I.Vyahhi, S.Sorokin, N.Frants
Institute of geoecology RAS
Tver State University
Arkhangelsk speleoclub “Labirint”

Digital interval photography can provide unique data for cave research. Short-time recordings can be done with available digital cameras. For medium time range external power is required. For long duration we recommend to use Canon cameras with CHDK software and external microcontroller-based timer. Main problem for image quality is condensate on outside surfaces of camera box.

SNOW AND ICE FORMATIONS IN ALTAI CAVES

V.K. Wistinghausen
Russian geographical society, Altai Republic