

# **KARST CAVES IN THE IRKUTSK AMPHITHEATRE, RUSSIA: ECOLOGICAL CONDITION AND PROBLEMS OF CONSERVATION**

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## **Summary**

The ecological state of the 75 best known caves in the Irkutsk amphitheatre was analysed in terms of changes to the natural state of the underground systems, anthropogenic rubbish and changes to air quality. The ecological states of all the studied caves have been altered. To assist in establishing measures for conservation of the caves, three categories were defined: strict, moderate and limited conservation.

## ***The Irkutsk amphitheatre***

Karst rocks occupy some 50 % of the Irkutsk amphitheatre, a total of more than 400,000 km<sup>2</sup>. Dissolved rocks are disposed in all stratigraphic stratum and geostructural elements of two main karst regions, the Siberian Platform and its mountain range. Karst is developed in carbonate and sulphate rocks and salts of Lower Cambrian, dolomites and limestones of Ordovician, Silurian and Devonian of Platform and Precambrian rocks of mountain regions - crystalline marbles, limestones and dolomites. Depending on geological, geomorphological and hydrogeological conditions, karst occurs on the surface of the earth or revealed at depths of more than one kilometre.

More than 200 caves have been discovered in the Irkutsk amphitheatre, the longest being the 30 km Botovskaya /1/ in the Zhigalovsky Region (Here and in the rest of the text the number /X/ corresponds to that shown on *Fig. 1*). The deepest pit is the 144m Kurtujskaya /56/ in the Cheremkhovsky Region. Urungaiskaya /67/ and Spirinskaya /69/ caves in the Nizhneidinsky Region have underground lakes, Trofimovskaya /75/ in the Nizhneidinsky Region has cascades and Argaracan /3/ in the Kachugsky Region and Mechta /9/ in the Olkhonsky Region have huge ice fields.

## **Ecological state of caves in Irkutsk amphitheatre**

It is possible to divide the processes which are changing the appearance of the caves into two groups: natural and artificial. Collapse is the main natural process in the caves of the Irkutsk Amphitheatre. Two caves, Big and Small Nizhneidinskies were formed from the one underground cavity - Nizhneidinskaya as a result of collapse of its ceilings. That is why the researches very often is writing about a single Nizhneidinskaya cave [1-3]. The same process has shortened the length of Hudugunskaya /63/ cave from 2.5 km twenty

years ago to less than 1 km. Constant collapses are observed in Mechta /9/, Zagadaj /18/ and Bolishaya Onotskaya /57/.

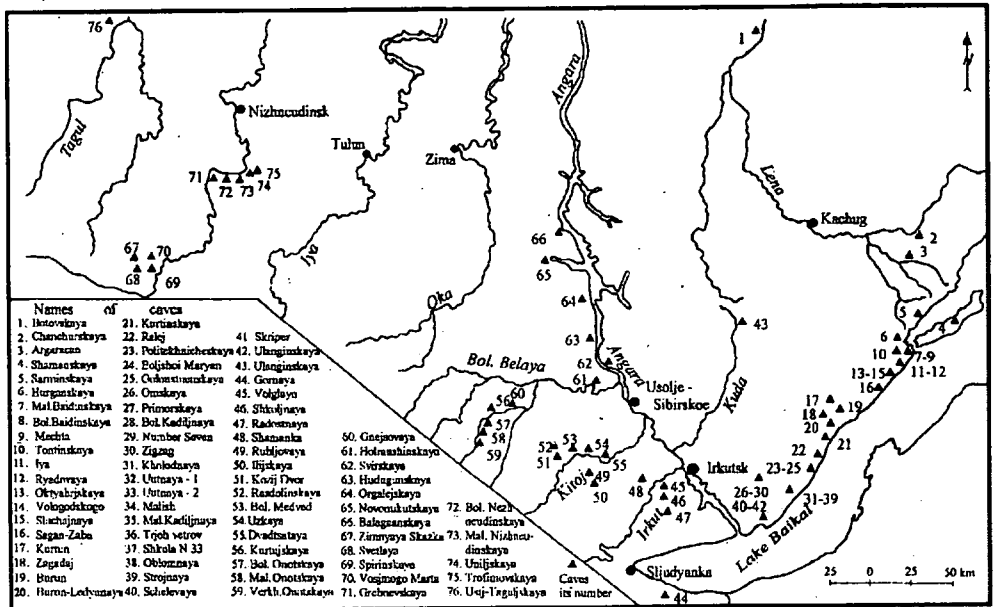


Fig. 1 Caves of the Irkutsk Region

Artificial processes are due to different kinds of human activity. As a result of the building of a hydroelectric power station on the River Angara cave Balaganskaya (Meljhetuiskaya /66/) with unique ice crystals, and wave cut caves on the west shore of Lake Baikal, were irrevocably lost. In connection with the extraction of the limestone, underground cavities with priceless archaeological materials are blocked up in Bolishaya Kadilinskaya (west Baikal). The entrance to Rasdolinskaya pit (Bezdonnaya Yama) /52/ (Angarskiy Region) has been filled by bulldozers several times. In November 1999 42 old gas ballons were thrown down in this cavity by the Angarsk Chemical Plant.

Between 1993 and 1998, with the support of the Russian Society of Nature Protection, the exploration of the ecological state of the 75 best known caves in the region (Fig. 1) was organized. According to our research, inhabitants, schoolchildren, caving and unorganized tourists are the main visitors to the caves. The single excursion (tourist) speleological route through Mechta /9/ in Malomorskaya is inoperative at the time of writing. Three groups of intensity of visits to caves were distinguished: weak, middle and high (Table 1).

The underground cavities of the Irkutsk amphitheatre are characterised by considerable violations of their ecological state by human activity. These violations included: changes to the natural state of underground systems, anthropogenic rubbish and changes to air quality.

Table 1 Visits in caves of the Irkutsk amphitheatre

Number of regions	Number of the caves in regions	Visitors in caves	Intensity of the visits	Breaching index of the ecological state of the caves		
				changing of the natural state	antropogen rubbish	changing of the air
1	2,3	inhabitants speleologists	weak	-	1	-
2	4-16	inhabitants speleologists tourists	high	3	3	1
3	17-21	inhabitants speleologists	weak	-	-	-
4	22-42	inhabitants speleologists tourists	mean	1	2	-
5	45-48	inhabitants speleologists	mean	-	-	-
6	49-55	inhabitants speleologists tourists	high	-	2	1
7	56-60	inhabitants speleologists	high	3	3	-
8	61-66	inhabitants speleologists	weak	-	2	-
9	67-70	inhabitants speleologists	weak	-	-	-
10	71-75	inhabitants speleologists tourists	mean	-	2	1

The changes of the natural state included:

- violations of underground systems: creating additional entrance(s), re-equipment of natural entrance, widening of cavity size for access.
- deformations of cave sediments: water-chemical - damage and destruction of stalactites, stalagmites, etc.; cave ice - damage and destruction of long standing ice crystals, ice stalactites, stalagmites, ice fields; water-mechanical, biogenic and antropogenic - presence of geological, palaeontological and archaeological prospect-holes. (Classification of cave sediments was carried out according to *Sokolov- Maksimovich* [4]).

Antropogenic rubbish includes:

- food wastes, food packages, used equipment.
- mould which is formed usually at low parts of underground systems after human visits.
- inscriptions by paint on cave walls and ceilings.

Changes of air included the smell of rotting organic material and of oil.

All violations of ecological state in caves were graded as: weak - 1, middle intensity - 2, considerable - 3 points (*Table 1*). According to our data, only a few caves, which are situated in the least accessible regions or which were opened not more 10 years ago, are characterised by absence of violation to ecological state. For the majority,

considerable changes to the natural state of underground systems and accumulations of anthropogenic rubbish were noted and in several caves changes to air quality were noted.

The Irkutsk amphitheatre was divided into ten ecological-speleological regions (Fig. 1, Table 1). The caves in Region 1 (north part of considered area) are in relatively good condition as they can only be entered in the winter season as the underground systems are surrounded by swamps and are on the border of a separately conserved area, the Baikalo-Lenskiy reserve. The underground systems of Region 2, the west shore of lake Baikal, in front of Olkhon Island have the most violations of ecological state as it is a popular area for summer tourism. Underground systems of Region 3 (valley of River Buguldeika) are practically without changes under anthropogenic pressure, because the majority of caves were opened not more than 10 years ago. Region 4 is one of the oldest speleological region in the Irkutsk amphitheatre, but the only access to this area is by water from 1986 tourists were limited by a conserved regime of nature. Some caves situated in the boundaries of the zone of ecological safety of Irkutsk Town form Region 5. These caves are used usually for training young cavers. Volglaya Cave /45/ is a component of the ecological path which is elaborated for the ecological museum in Bolishoi Lug Village. The underground cavities of Regions 6 (valley of River Kitoy) and 7 (valley of River Bolishaya Belaya) are visited rather intensively. Caves of Region 7 are easy accessible and convenient for visits by unprepared groups; as a result there is frequent deformations of cave sediments with flowstone often broken. In recent years, the activity of visitors in Region 8 (valley of River Angara between the Town Usolie-Sibirskoe and settlement Ust-Uda) has been lowered, chiefly in consequence of flooding by the water of Bratsk reservoir of the main site, Balaganskaya Cave /66/. Underground cavities of Region 9 are in an inaccessible area, the East Saiyan mountain (in upstream of valley of River Uda) and are therefore characterised by weak changes of ecological state. The caves of the River Uda valley near Nizhneudinsk Town were included in Region 10. This area is situated some distance from the larger towns in the Irkutsk Region but the caves are very picturesque and have a long history.

## 2. Conserved caves of the Irkutsk amphitheatre

Designation of caves as State Nature Monuments is a widespread method of cave conservation. The majority of caves have scientific, aesthetic, instructive and sport importance. There are 34 conserved caves in the Irkutsk amphitheatre. With the aim of devising measures for conservation of their natural state, three categories have been identified. The first category comprises caves with strict conservation, where only specialists should be allowed to work on the permission of Russian Society of Nature Protection. These should include underground systems with items of collection value, that is, palaeontological remains, archaeological cultural stratum (in the case of the latter, these caves should have the double status of geological and archaeological monuments) and fauna. It should not be permitted to publish the geographical position of these caves for reasons of conservation. The second category, with moderate conservation, should include underground cavities of great scientific importance and should only be accessible for scientific excursions and research. In these caves, scientific experiments have been undertaken and unique ice or dripstone formations adorn the walls, ceilings and floor. The

third category, with limited conservation, should include caves with recreational and sport value and for these purpose they can be visited.

### **2.1 Caves with strict conservation**

In the Irkutsk amphitheatre eleven caves in limestones, marbles and dolomites of the Archean, Proterozoic and Lower Cambrian have been included in this category (see *Table 2*). The Boljshaya and Malaya Nizhneudinskaya caves are situated at 250 metres above water edge of the River Uda, at the level of its 14th terrace that has been dated back to the Pliocene [5]. These underground cavities were first described in 1875 by the Polish geologist *I.D. Chersky* [1-2]. He found the remains of fossilised Quaternary fauna in the sediments of Malaya Nizhneudinskaya including *Rhinoceros antiquitatis tichorhinus*, *Antilope borealismihii*, *Myides brantii* and *Egnus hemionus*. An expedition of the Palaeontological Institute of Academy of Sciences of the USSR worked in the caves in the 1930's. In the course of the work, new bone material was found, confirming and adding to Chersky's conclusions [3]. A number of things indicate that the Boljshaya and Malaya Nizhneudinskaya caves could have served as a refuge for stone age people. In the deposits of Malaya one, the wooden end of a harpoon, covered by a thick crust of limestone, was found and some of the fossil animal remains showed signs of damage caused by human [6]. Apart from the scientific value, the cave's aesthetic significance should not be overlooked. This is particularly true for Malaya cave. A number of transparent ice stalagmites, 0.5 metre high, are situated near its entrance, and its walls are covered by micro waterfalls. A small ice crust is noted in the Boljshaya cave.

Palaeontological material, witnessing to the fact that the area to the west of Baikal was inhabited by an animal of the wide open steppe, *Egnus hemionus* Pall, was revealed in Malaya Kadiljnaya cave/35/ [7]. Archaeologists have found the remains of New Stone and Iron Age cultures in sediments of a number of underground cavities in Baikal area including stone and bone instruments, household tools and fragments of clay pottery with a variety of ornaments in the Hurganskaya /6/, Boljshaya Kadiljnaya /28/, Tontinskaya /10/, Boljshaya and Malaya Baidinskaya caves /7-8/ [7-8].

Boljshaya and Malaya Baidinskaya caves are characterised by their underground ice fields. Starting from 1995 the melting of this ice has been observing, in average an intensity is reaching of 10 cm per year in Boljshaya Baidinskaya and 1 cm in Malaya. The remains of malacofauna, revealed in the lower part of underground ice field in Boljshaya Baidinskaya cave, witness to the ice's formation in the Pleistocene-Holocene [9]. Insects of Class Entognapha were found in Primorskaya /27/, Trjoh vetrov /36/ and Oblomnaya /38/ caves.

### **2.2 Caves with moderate conservation**

Eleven caves have been allocated to the category of moderate conservation. These were formed in limestones, dolomites and marbles of the Archean, Proterozoic and Lower Cambrian (see *Table 3*). Argaracan Cave, discovered by the geologist G.P. Vologodsky and A.P. Vagina in 1968, is one of the largest caves in the Region. Its underground cavern is of the complicated multi-level cavity kind. The first level is characterised by the presence of an ice field with area 35 m<sup>2</sup> and thickness 2 m. The ice is of congelation genesis. At present, observations are being conducted for the dynamic of underground icing, according to bench marks. Towards the end of winter crystals of sublimation ice up to 8-10 cm in

cross section are formed near the entrance. On the second level of the underground cavern, stalactites, stalagmites and draperies of pink, white, red and brown colours are wide spread. There are also small lakes with calcite formations. The walls and floor of the third level are covered by liquid clay of a red-brown colour, and in some places rock slide deposits occur.

Hudugunskaya cave /63/ is an example of an underground cavity aligned along systems of tectonic fissures. The majority of passages lie in two main directions, 40-50 degrees and 300-320 degrees. Because of collapses, the length of this underground cavity has decreased from 2.5 to 1 kilometre during the last twenty years.

Mechta Cave /9/, formed in crystalline limestones and marbles along tectonic and lithogenetic crevasses, was discovered in the 1960s. It is characterised by its 200 m<sup>2</sup> underground ice field. Exotic ice formations occur here. They have the names "Ded Moroz" (Father Frost), "Snegurochka" (Snow Maiden) and "Raketa" (Rocket). Red-brown and, in places, snow-white corallites are widespread on the walls and ceilings. All galleries of the inner cave are littered with rock slide deposits with some blocks as large as 4 x 2 x 1.5 m.

Unique needle crystals of pseudomorphs of quartz on aragonite have been revealed in the Boljshaya, Malaya and Verkhnyaya Onotskaya caves /57-59/. Cave "Jewels" in the forms of oolites, from a few millimetres to 5 cm in size, have been found on the bottom of a lake with a depth of 20 cm, in Rasdolinskaya pit /52/. In the opinion of S.A. Kokorina [10], these "jewels", which have a specific weight of 2.856, are formed of manganese calcite [CaMn(CO<sub>3</sub>)<sub>2</sub>].

Classic "sugary" ice stalagmites up to 1.5 m tall occur near the entrance of Zagadaj cave /18/. A geological prospecting hole in clay which was dug in one of the cave's halls is more than 8 m deep. The lakes of the Zimnyaya Skazka /67/ and Spirinskaya /69/ caves represent a single hydrodynamic system. Bench marks are situated here. Deposits of the lower level of Politekhnikeskaya cave /23/ are full of mammalian bones. Further palaeontological exploration is required to determine the category of conservation for this underground cavity.

### **2.3 Caves of limited conservation**

The largest horizontal cave in the Region - cave Botovskaya, and the deepest pit, Kurtujskaya, were included in this group (Table 4). Botovskaya cave is a cavity of the carcass kind with alternation of narrow passages and small grottoes. Aragonite crusts were found in this cave. A feature of the Kurtujskaya pit is a sheer 50 m shaft, the deepest in the study area. Five caves on the west shore of lake Baikal have become widely known: Iya, Ryadovaya, Oktyabrskaya and Vologodskogo /11-14/ which are on a karst plateau at 250 m above lake level and Sluchajnyaya /15/, 4 km from the plateau. All these cavities are used as tourist caves. Iay cave had an ice field, whose size in November 1977 was 226 sq.m, in July 1997 complete thaw of it was registered. Other caves of limited conservation are Vosjмого Marta /70/ and Svetlaya /68/ where thread like crystals of ice are observed in winter.

### **Conclusions**

The ecological state of underground systems in the Irkutsk Region has been derogated by anthropogenic pressure. Hence, it is necessary to accelerate the process of

awarding to caves the status of State Nature Monument and of determining a conservation category for every cave. These processes have been delayed by a lack of local knowledge and of specialists. For this reason, it would be desirable to conduct scientific expeditions, possibly international, in order to appreciate the scientific value of the caves and to suggest recommendations for the conservation of their natural state. This is urgently required, as the caves of Baikal west shore are the most frequently visited. Moreover, from the 5<sup>th</sup> of December 1996 Lake Baikal was inscribed in the World Heritage list.

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