

# THE AGE OF THE RELIC FIRN PLUG IN THE KREMENSHETSKAYA CAVE, EASTERN SIBERIA

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## Abstract

*Two main genetically different elements are present in the entrance relic firn plug of the Kremenshetskaya Cave (Eastern Siberia, Russia): the stony ice cone and layered multi-year firn accumulation. The firn accumulation was formed after 1405-1465 AD and now it is degrading. Additional collecting and dating of plant detritus from the dirt layers have to be done for a more accurate estimation of firn age and dynamic of its accumulation.*

## Возраст реликтовой фирновой пробки в Кременчетской пещере, Восточная Сибирь

*Два главных генетически различных элемента присутствуют во входном реликтовом фирновой пробке в пещере Кременчетской (Восточная Сибирь, Россия): каменный ледяной конус и слоистое многолетнее скопление фирна. Фирн был сформирован после 1405-1465 гг. и теперь он деградирует. Более точная оценка возраста фирна и динамика его накопления возможна после дополнительного сбора и датирования растительных остатков из грязевых прослоев.*

## Introduction

The Kremenshetskaya karst cave is located in the eastern foothills of the East Sayan Upland, on the top of the Kremenshet-Birusa watershed in the Irkutsk Region, Russia. The cave is a non-active relic of erosion corrosion speleosystem developed in the Riphean metasomatically altered and recrystallized limestones and carbonate-clayey aleurolites. The whole watershed is covered by dense taiga with terrestrial moss cover.

In the entrance pit there is a thick, perpetual, multi-layer firn plug (Fig. 1), beginning from the bottom of the entrance doline. The firn is at the stage of degradation. During our visit to this cave in September 1989, there was only a small window in the firn on the side of the doline, which allowed us to get into the cave. In September 1994, this small window became a large open entrance comprising a 6 m pit. The firn on the side and bottom of the doline «disappeared», being melted and covered by dirt, rock and wood fragments.

## Previous works

There is not much in the way of direct data about the age of cave icings, glaciers, multi-year snow-patches and firn accumulations in Russia. Ice cave researchers usually employ paleontological methods for age estimation (Dmitriev, 1980; Filippov, 1997; Trofimova, 1994), and in rare cases radiocarbon analyses (Filippov, 1997; Shavrina, 1999).

Dmitriev's interpretation of pollen and spores spectra from cave glacier moraines in the Kuznetsky Alatau allowed him to make conclusions that the age of the furthest moraine in the Bidzhinskaya Cave is the Late Pleistocene-Holocene, whereas the age of the flank moraine in the Krest-Syya Cave is the Late Pleistocene (Dmitriev, 1980). These conclusions are dubious because the use of the palinological method for moraines is not valid. This method should not be employed where material from different layers of ice and dirt horizons was combined and mixed due to melting and redeposition.



Fig.1. The relic firn accumulation in the Kremenshetskaya Cave

Photo by S. Lewis

In another example, the age of cave «glacier» in the Bolshaya Bajdinskaya Cave near Lake Baikal was estimated as the Late Pleistocene-Holocene using the remains of terrestrial molluscs from the dirt horizon (Trofimova, 1994). E.V. Trofimova did not publish the list of molluscs, which she found in the «glacier». My study of two dirt horizons, deposited on the floor after melting of the furthest part of the ice body in the Bolshaya Bajdinskaya Cave, gave the following results. From the lower beige layer, 56 shells of *Vallonia pulchella* (Müll.), 15 of *Pupilla*

*sterii* (Voith.) and 18 of *Vertigo alpestris* Alder were extracted. From the upper black layer of redeposited soil, 27 specimens of *Vallonia pulchella*, 14 of *Pupilla sterii* and 1 mollusc of *Vertigo alpestris* were extracted (identification by I.V. Shibanova, Institute of Earth's Crust, Russian Academy of Sciences, Irkutsk). *Vallonia pulchella* was rare species during the Pleistocene glacial epochs in Eastern Siberia (Popova, 1981: 131), and numerous species during the interglacial periods, which had relatively warm climate. The abundance of this species in sampled layers is an argument in support of the Holocene age of dirt horizons. The series of radiocarbon datings, obtained from wooden debris and mammal bone from the same ice body, shows that it was formed in the interval of  $2710 \pm 30$  –  $320 \pm 30$  years BP (Filippov, 1997).

A.G. Filippov (1997) supposed that the interior icing in the Aya Cave near Lake Baikal was formed during the boreal phase of the Holocene. This assumption is based on the interpretation of palinological spectrum from the lowest layer of ice. The icing melted completely in 1997.

In the C-26 Cave on the Belomorsko-Kulojskoe Plateau of European Russia, the highest possible age of cave ices is estimated as 200 years on basis of  $^{14}\text{C}$  dating of wood remains (Shavrina, 1999). Unfortunately, there are no actual datings, nor geological settings of samples in this publication.

#### Peculiarities of Radiocarbon Dating

Radiocarbon data, obtained from the Kremenshetskaya Cave, were done by Dr. L.A. Orlova in the Laboratory of Cenozoic Stratigraphy and Paleoclimatology of the Institute of Geology of the Siberian Branch of the Russian Academy of Sciences in Novosibirsk. The benzene scintillation variant of the radiocarbon method was employed for identifying the residual activity of carbon using a two-channel plant. The 5570-year period of the half-life of  $^{14}\text{C}$  was used for the age calculation. The age was calculated from 1950. The results were not calibrated using the fluctuation of radiocarbon content in the atmosphere.

#### Structure of the entrance firn plug

Relic distinct layered accumulation of firn composes the southeast wall of the entrance pit of the Kremenshetskaya Cave (Fig. 2). The layering of ice has a steep dip ( $50^\circ$ ) to the south, in the opposite direction to the existing gallery. Apparently, there is an extension of the gallery to the south – southwest direction, which is inaccessible at the present time. The layers of clear ice have a thickness of 6–40 cm. The color of the darker (dirt) layers is caused by the presence of redeposited soil, debris of host rocks and plant detritus. Lower series of layered ices, occurring in the interval of 0–1.8 m above the floor, contains essentially fewer impurities than is typical for the upper part of the firn accumulation.

Underneath the firn there is a stony ice cone consisting of rock debris cemented by hydrogenic ice. The height of the cone is 2.4 m from the level of the gallery floor; the width is 3.5 m.

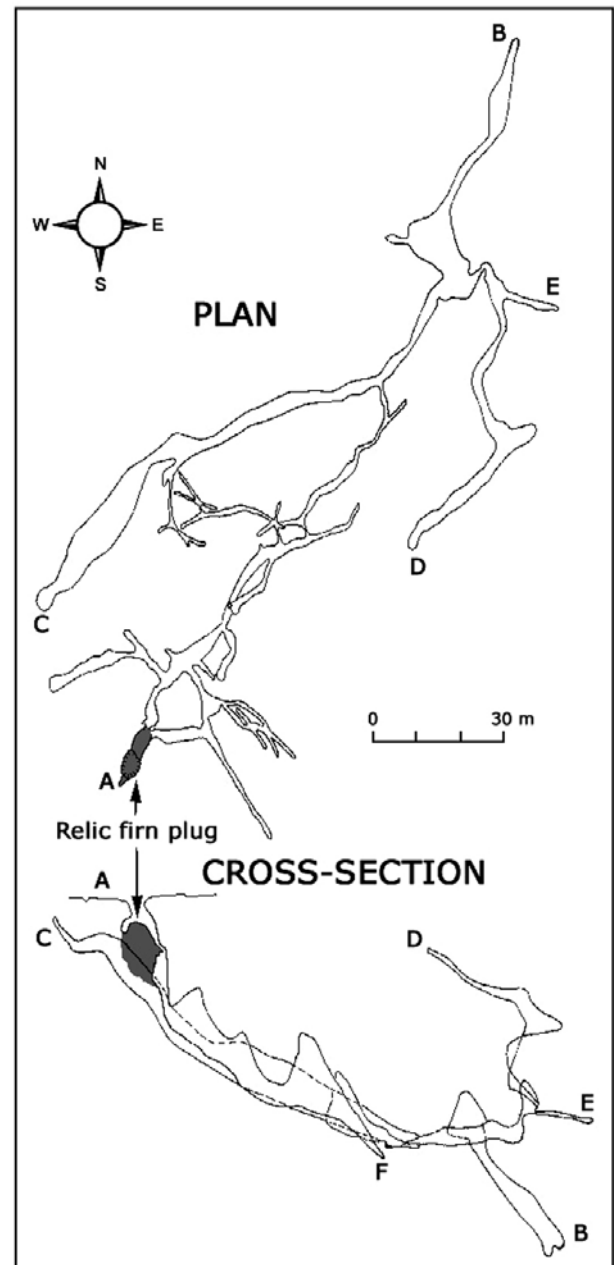


Fig. 2. Location of the firn accumulation in the Kremenshetskaya Cave

Two samples of wood were collected from the stony ice cone below the firn accumulation (Fig. 3). From the piece of charred wood, sampled at 1.8 m above the floor, the dating  $505 \pm 60$  years BP (SOAN-3409) was obtained. Another dating,  $515 \pm 30$  years BP, was made from a piece of a branch of conifer, sampled at 2.2 m above the floor. These datings show that the burial of both samples of wood debris took place practically at the same time.

#### Discussion

Obtained  $^{14}\text{C}$  data do not allow unambiguous identification of the time of the appearance of permanent ice accumulation in the cave. It is unclear whether the ice was formed at the same time with the accumulation of colluvial rock debris or if incoming water became frozen in the body of the previously existing colluvial cone.

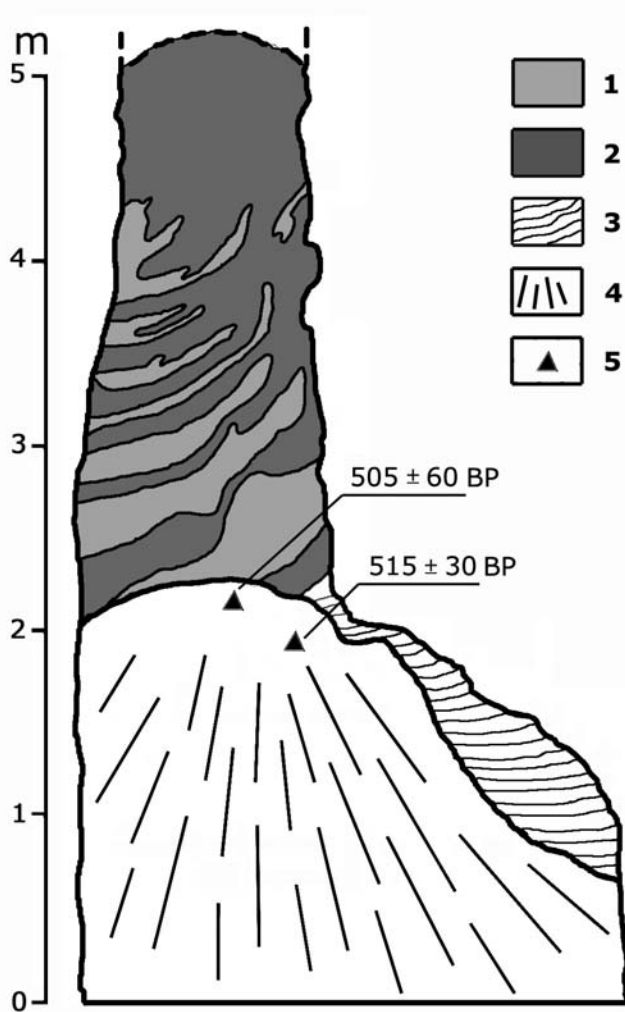


Fig. 3. Scheme of composition of the relic firn plug and the points of  $^{14}\text{C}$  sampling. 1 – white firn, 2 – dark gray firn (dirt horizons), 3 – layered ice without impurities, 4 – stony ice cone, 5 – wood debris

However, at least these samples allow the marking of the lower age limit of the perennial firn accumulation. Evidently, firn had started to form later than 1405-1465 years AD (estimation done by  $^{14}\text{C}$  dating SOAN-3408, which has a lesser error of measurement). While the time interval between the emerging of the wood debris in the colluvial cone and the beginning of firn accumulation remains unknown, it might be supposed that the firn

accumulation coincided with the beginning of the Little Ice Age (the end of XV – beginning XVI century). The collecting and dating of dispersed plant detritus from the dirt layers could clear up the actual age and dynamics of the firn accumulation.

### Conclusions

1. Two main genetically different elements are present in the entrance relic firn plug of the Kremenshetskaya Cave: the stony ice cone and layered multi-year firn accumulation.
2. The firn accumulation was formed after 1405-1465 AD and now it is degrading.
3. Additional collecting and dating of plant detritus from the dirt layers have to be done for a more accurate estimation of firn age and dynamic of its accumulation.

### Acknowledgments

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### References

- Dmitriev V.B.** (1980) Oledenenie peshcher kak chast' glaciosfery Zemli [Cave glaciation as part of Earth's glaciopause]. *Karst Dal'nego Vostoka i Sibiri* [Karst of the Far East and Siberia], Ed. E.V. Krasnov. 130-145. Vladivostok (in Russian).
- Filippov A.G.** (1997) Peshchernye l'dy Irkutskoj oblasti [Cave ices of the Irkutsk region]. *Svet* [The Light], 2(17), 13-16 (in Russian).
- Popova S.M.** (1981) Kajnozojskaya kontinental'naya malakofauna yuga Sibiri i sopredel'nykh territorij [Cenozoic continental malacofauna of the south of Siberia and neighbouring territories], 188 p. «Nauka», Moscow (in Russian).
- Shavrina E.V.** (1999) Ledyanye otlozheniya peshcher Evropejskogo severa Rossii [Ice deposits in caves of the European North of Russia]. *Peshchery* [The Caves], 25/26, Interuniversity collection of scientific transactions. 82-88. Perm (in Russian).
- Trofimova E.V.** (1994) Podzemnie l'dy peshcher Baikala [Underground ice of caves near Baikal]. *Baikal kak prirodnyaya laboratoriya dlya izucheniya global'nykh izmenenij klimata* [Baikal as a natural laboratory for the study of Global Changes of Climate]. Irkutsk (in Russian).

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