Expedition Bjurälven 2024

Compiled by Dmitri Gorski

Cave exploration in the Bjurälven valley in 2024 was performed according to plan and without incidents or accidents. Our focus was on two caves – Dolinsjö cave and Meander cave. It was the first time since 2019 we opened up the ice on the Dolin lake to gain access to the cave below. A lot of old line was repaired and a dive team reached the End Of Line (EOL) during a 5-hour dive. A new technique for cave documentation, photogrammetry, was applied in the exploration. In Meander cave, several dives were performed in order to attempt clearing out a tight restriction in high-flow conditions.

Bo Lenander, a member of the current expedition crew, discovered the entrance to the Dolinsjögrottan located in the Bjurälven valley in 1979. The first winter expedition to explore the caves in the area was launched in 2007, following several unsuccessful attempts to dive in the Dolinsjögrottan summertime. These attempts were unsuccessful mainly due to very strong current that rips through the cave system summertime, measuring up to 20 knots. During winter, the water is much calmer with hardly any current at all. Another factor in favor of conducting the expeditions wintertime is logistics. All the equipment can be transported to the cave using snowmobiles, minimizing the risk of damaging the fragile vegetation in the protected nature reserve.

In 2008, divers of the second Expedition Bjurälven managed to map some 50 meters of passages in the Dolinsjö cave. Thanks to excellent cooperation with the authorities and continuing support

of the local population, diving and exploration in Bjurälven continues. Fifteen years since the first expedition, the total mapped length of all caves in the area, which we someday hope to connect, is 3353 meters. Dolinsjö cave (2432 meters), is Sweden`s longest water-filled cave and among the 80 longest underwater caves in the world. Köldhålet is on the 2nd place with its 280 meters.

We would like to express our sincere gratitude to our sponsors Ursuit and xDeep for providing safe and efficient equipment that can take on most extreme conditions. We also received great support from Klättermusen, a Swedish manufacturer of outdoor clothes. Of course, our biggest thanks go to the local people and businesses (Tillväxt Frostviken, Mikkes Skoteruthyrning and Ica Blåsjöfjäll) in and around the village of Stora Blåsjön (including Blåsjöns Byamän) – who have been putting up with us for over 15 years. Authorities in Jämtland County and Voernese Sameby are acknowledged for providing their consent and approval to this project.

Figure 1 Anders Etander, Dmitri Gorski, Kristian Lyberg, Jonas Roos, Mats Fröjdenlund, Patrik Rylander, Trond Einar Solberg, Micke Tilja, Robert Staven, Per-Erik Thomasson, Ane Mengshoel, Anders Thomasson, David Thor, Linus Malmgren, Bosse Lenander, Henning Wictorin, Gunnel Fredriksson and Stefan Barth.

Documentation and media

High-quality photo material was collected this year. Micke Tilja and Robert Staven took photographs inside the cave while Anders Etander and Martin Fregelius worked on creating a photogrammetry representation of the cave.

During the expedition week a presentation was made by Mats Fröjdenlund at the local community house in Stora Blåsjön, which was filled by more than 50 people.

Figure 2 Mats Fröjdenlund making a presentation in the community house at Stora Blåsjön

Following interviews were given during the expedition:

https://sverigesradio.se/artikel/bjuralvsgrottan-ska-blir-3d-modell-dykare-tar-tiotusentals-bilder

https://sverigesradio.se/avsnitt/2352171?fbclid=iwar2wajg6k5nhzptd1wfptvzxudfjg4c0dyu5k7ph_cqfqyum8wq8ueomgp8_aem_asme0irhgqeoucwae2r87izn8kjru-nsm69ylsa300wzmip91zrlvwibk6m8m9e0-k4otm5y9lzbcqanrcpls-kw

https://www.stromsundsgratistidning.se/2024/04/23/expedition-bjuralven-2024/

https://www.svt.se/nyheter/video/1573fb8edf92da8b-folj-med-in-i-landets-langsta-undervattensgrotta-som-ligger-i-nordvastra-jamtlands-lan?spellista=WyJhc3RyaWQtdmlkZW9wbGF5bGlzdCIsIjQ2YXhwbiJd

Exploration and mapping

57 person-dives were performed during the expedition in 2024, see Figure 3. This is slightly fewer compared to the year before.

Total dive time and average dive time increased compared to previous expedition, see Figure 4 and Figure 5. This can be explained by the fact that in 2024 we reopened the Dolinsjögrottan that demanded long dives - especially to reach the EOL.

Table 1 Surveyed cave length, Bjurälven Valley

Cave name	**Mapped length [m]**
Bjurälvsgrottan	300 (unchanged in 2024)
Dolinsjögrottan	2432 (unchanged in 2024)
Köldhålet	280 (unchanged in 2024)
Spegelgrottan / Semigrottan/ D3	162 (unchanged in 2024)
Festins cave / Meander cave	179 (unchanged in 2024)

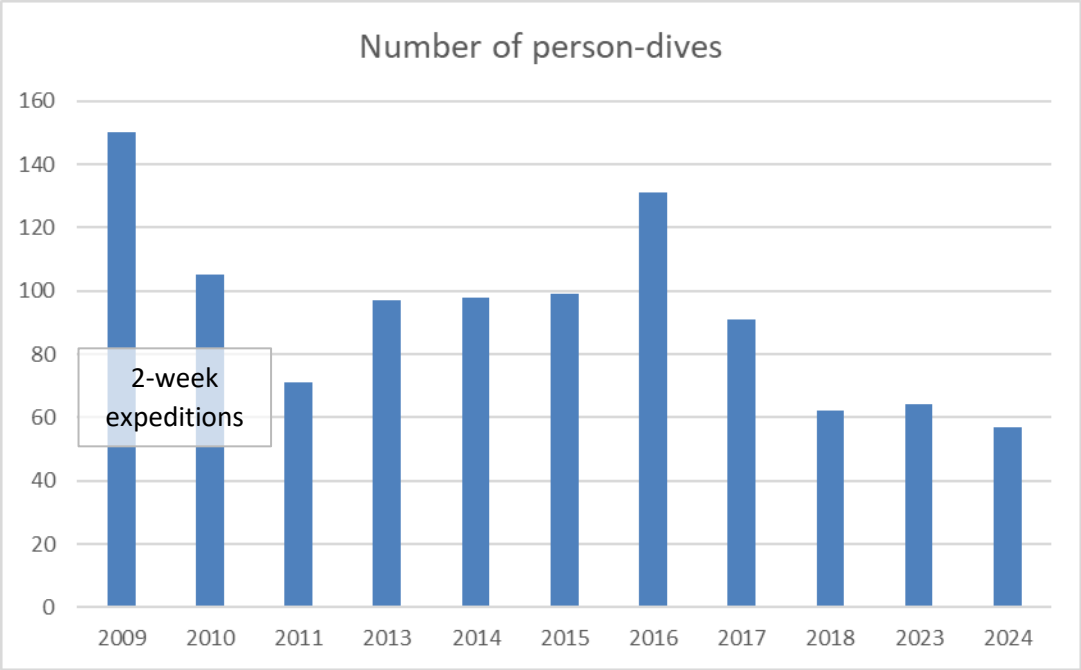

Figure 3 Number of person-dives during all the winter expeditions

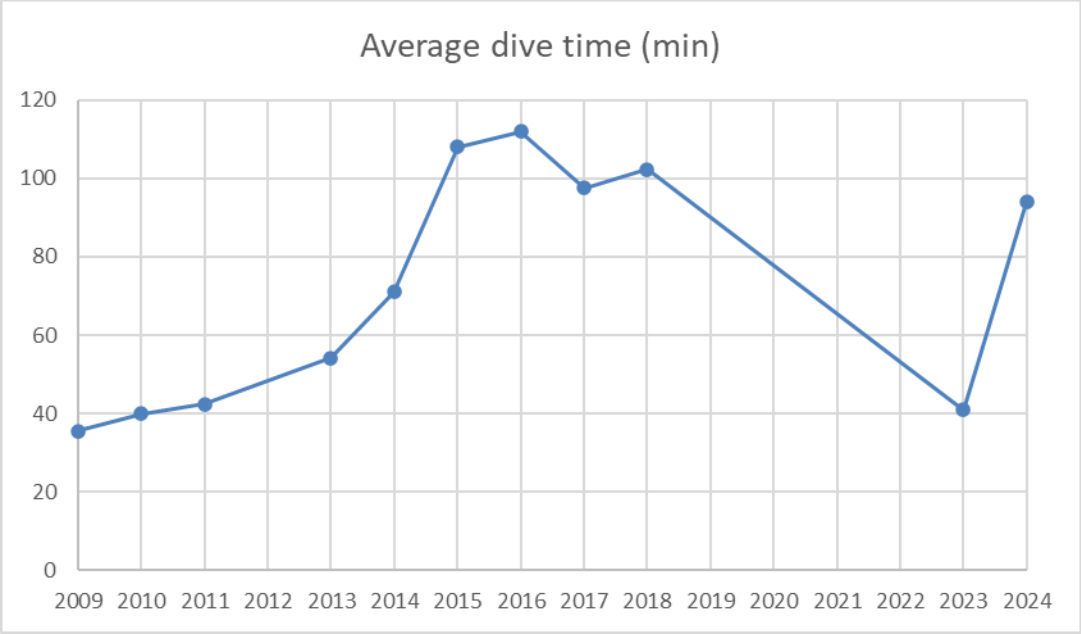

Figure 4 Average dive time during all the winter expeditions

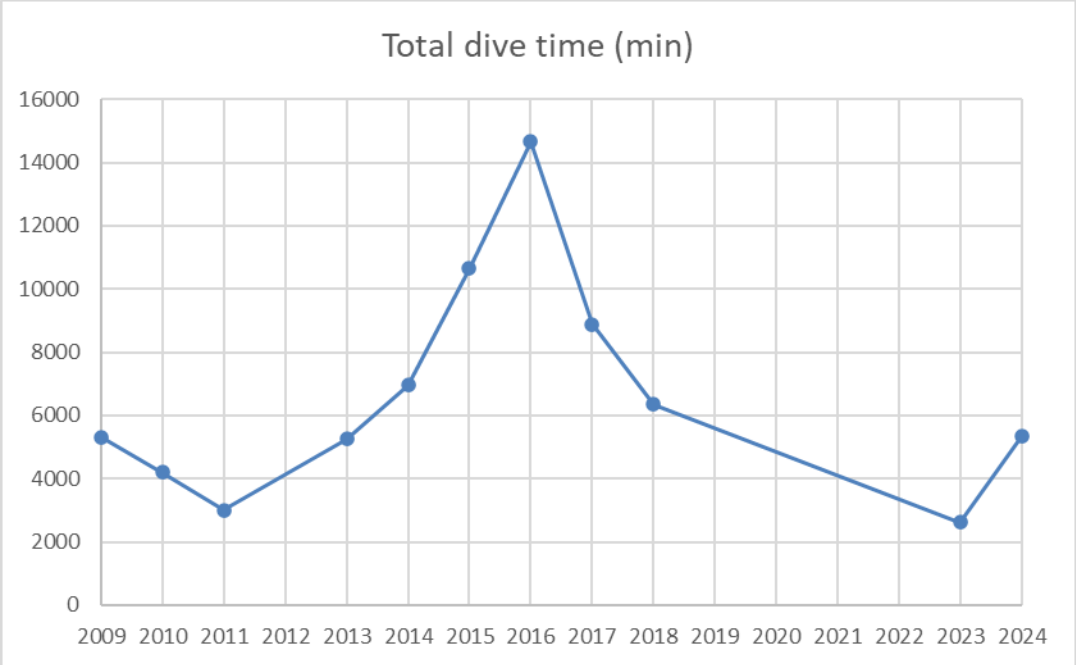

Figure 5 Total dive time during all the winter expeditions

Meander cave

By Ane Mengshoel and Robert Staven

On Monday and Tuesday during the Expedition, a dive team of four people (Robert Staven, Trond Einar Solberg, Linus Malmgren and Ane Mengshoel) visited the Meander cave.

Figure 6 Ane at the entrance of the Meander cave. Photo: Robert Staven

The goal was to see if it would be possible to negotiate “the sandstorm restriction” as we expect this cave to be connected to the Festins cave. In order to dive In the Meander cave, the water flow has to be low, otherwise it is not possible to enter the cave. The water conditions were favorable both in 2023 and 2024.

Last year, fix point 22 was installed right at the entrance of the cave, slightly above the water level. A “meander” is one of a series of regular sinuous curves in the channel of a river or other watercourse, and since this cave consists of several tight curves, it got this name (source: https://en.wikipedia.org/wiki/Meander).

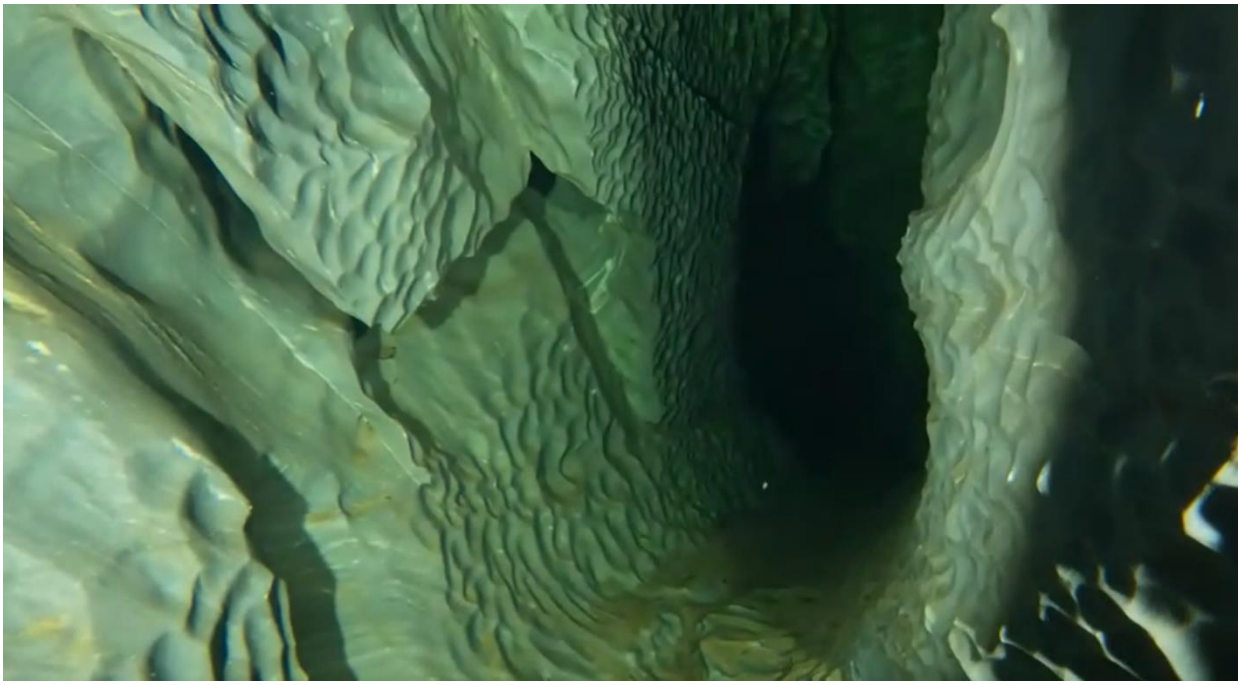

Figure 7 Still shot from GoPro: You have to dive sidewise to get through these beautiful narrow curves. Video: Ane Mengshoel

The cave starts with a beautiful horizontal marble pressure tunnel that lasts for about 12 meters and ends in a vertical shaft.

Figure 8 Still shot from GoPro: The vertical shaft about 12 meters inside the cave. Video: Ane Mengshoel

At the end of this shaft there is a sandy bottom, and you'll find yourself facing a tornado of sand. This part of the cave has been dived several times previously, but the restriction has been negotiated before. After a short video-dive, we brought in "a sand suction kit", consisting of an air

hose and a water pipe. At the outside of the cave, we had a low-pressure air compressor. This set-up helps us to remove the sand much quicker than manual digging. In the beginning the sand removal was quite efficient, but we discovered that longer water pipes will be needed in the future in order to get through.

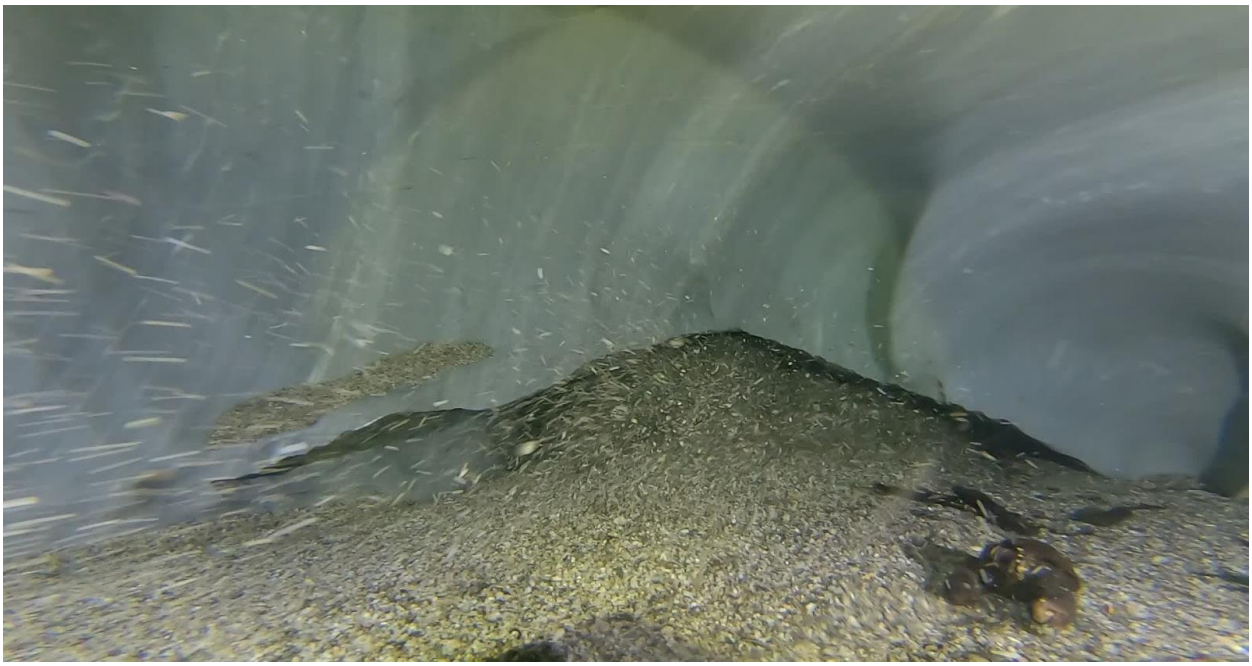

Figure 9 Still shot from GoPro, from outside of the sandstorm restriction. Video: Robert Staven

However, enough sand and gravel were removed in order to be able to get a GoPro camera on a selfie stick through the restriction. The captured video material was quite promising, as we could clearly see a larger cave passage at the other side of the sandstorm. Exploration of this cave will thus continue in the future.

Figure 10 Still shot from GoPro, taken with a long selfie-stick, from the inside of the sandstorm restriction. Video: Robert Staven

Figure 11 Safety diver Trond Einar and dive leader Per Erik are waiting for the divers. Photo: Ane Mengshoel

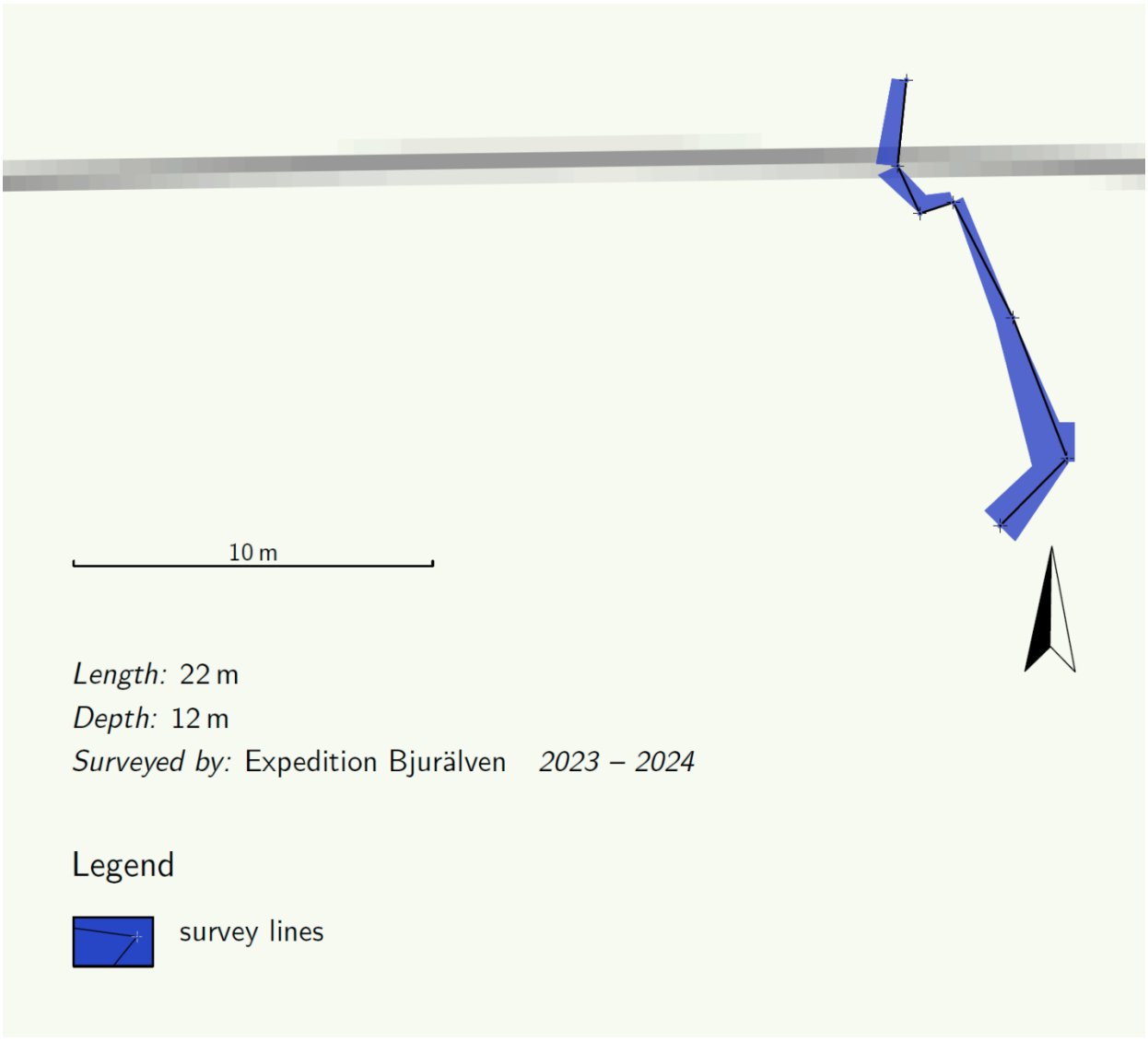

Figure 12 Survey map of the Meander cave

Dolinsjö cave

By Dmitri Gorski

One of the goals of this year`s expedition was to re-open the Dolinsjö cave. This is the longest cave in the Bjurälven area and the one where the original exploration started. The cave is strictly sidemount, since divers need to negotiate a tight restriction at the entrance and several other tight restrictions further in, some of them lasting for 5-10 meters. Some parts of the cave are relatively large, though, and several divers can swim shoulder-to-shoulder in the largest passages. Dolinsjö cave starts with a long sump (almost 500 meters) after which the first dry passage can be accessed. All in all, there are 4 dry passages and 5 sumps. There is no need for SRT climbing in the dry passages, but in some places rope has been installed to assist moving up to ledges and along slopes. Most of the dry passages are relatively stable, although the last chamber dubbed "Don`t Touch That Rock" ("which one?" – "all of them!") contains a large number of loose boulders on the floor and some parts of the ceiling have been secured in place for safety of the explorers.

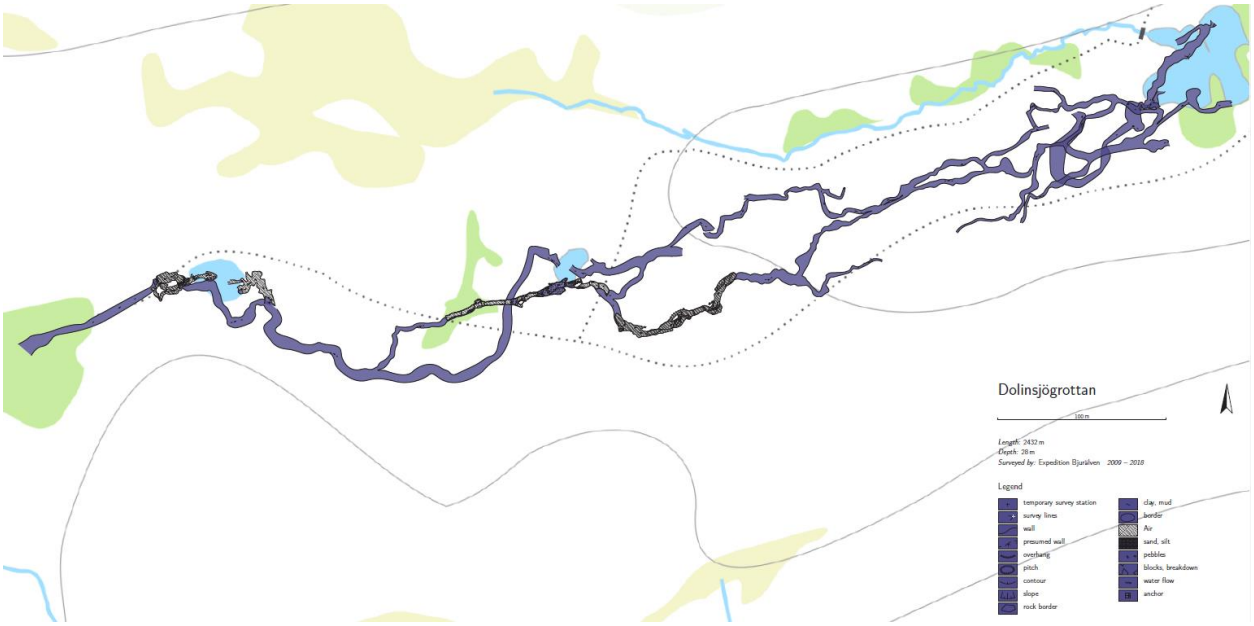

Figure 13 Map of the Dolinsjö cave

There are 2432 meters of surveyed passages in the Dolinsjö cave. The linear length of the cave is much shorter, of course, due to branching of the tunnels. The cave is fed with water from Bjurälvsgrottan – the most upstream cave in the Bjurälven valley. About half of the distance from Bjurälvsgrottan to Dolin Lake has been explored, which means that there is a potential for some 2,5 kilometers of un-surveyed cave remaining. This is, however, challenging due to the fact that the rest of the way to Bjurälvsgrottan is below a deep valley, which most probably was formed after a collapse of an ancient large cave underneath what now is the valley many millions of years ago. Our path might thus be obstructed by a lot of rubble and collapses – and some of them might be impassible. We are also reaching the limits of what can be achieved in one day, since exploration dives to the end of line now last 5-6 hours. With all of this in mind, we still choose to attempt pushing Dolinsjö cave further due to it being the most formidable lead we have for exploration.

This year our progress was somewhat stalled by the unusual amount of ice on the Dolin Lake. We are used to a meter of ice covering the cave entrance and one and a half meters was also encountered previously. This year we had to get through almost two meters of solid ice to get to free water, which took its toll on people and gear.

Figure 14 Thick ice covering the Dolin lake in 2024. Photo: Dmitri Gorski

Our specially built platform for diving in the Dolinsjö cave came to very good use, since divers could use it to stand upright in the water when kitting up.

Figure 15 The specially designed diving platform installed on the Dolin lake. Photo: Dmitri Gorski

Another point of opening up the Dolinsjö cave was the new way of documenting exploration was attempted in 2024. Anders Etander, the new member of the expedition, has brought with him extensive expertise in a technique called photogrammetry. In photogrammetry, a large number (thousands) of images are taken in all directions while swimming through a cave passage. These images are then connected together and fused into a complete 3D image of the cave. It is possible to navigate through this 3D image, which provides a feeling of swimming in the mapped cave passage.

Photogrammetry was attempted by Sami Paakkarinen once before in the Dolinsjö cave, but at that stage (some 8 years ago), the post-processing of the images was so work-intensive that we abandoned the effort. Since then, the image post-processing has had steep development due to utilization of Artificial Intelligence and is now done in a semi-automated manner. This reduces the workload considerably. Photogrammetry is described in a separate chapter further in this report.

Satellite positioning, LiDAR-data, drone mapping and Internet connection.

By Mats Fröjdenlund

GNSS

Starting in 2011 we have been performing electromagnetic direction finding of the cave divers and surveying of fixed points in the cave system. From 2014 these fixed points have been marked out in the cave using stainless steel trays (markers) labelled FP01 (Fix Point 01), FP02, and so on. Using the electromagnetic direction-finding equipment, we have been able to obtain relatively accurate points on the ground surface directly above the fixed points. Also, the depth from the surface (or the snow surface) down to the fixed point has been obtained. To make a 3D and georeferenced cave map the ground surface elevation, the depth of the cave and its X and Y coordinates are required. For this purpose, the Swedish National Land Survey/SWEPOS (https://swepos.lantmateriet.se) during the expedition in 2013, 2014 and 2015 kindly lend us both GNSS equipment (Global Navigation System Satellite = GPS, GALILEO and GLONASS) and communication equipment with connection to the SWEPOS correction services. It is possible to get a position in the reference system SWEREF 99 with uncertainty in the centimetre level. Our problem has been that the expedition site is out of reach for mobile Internet communication.

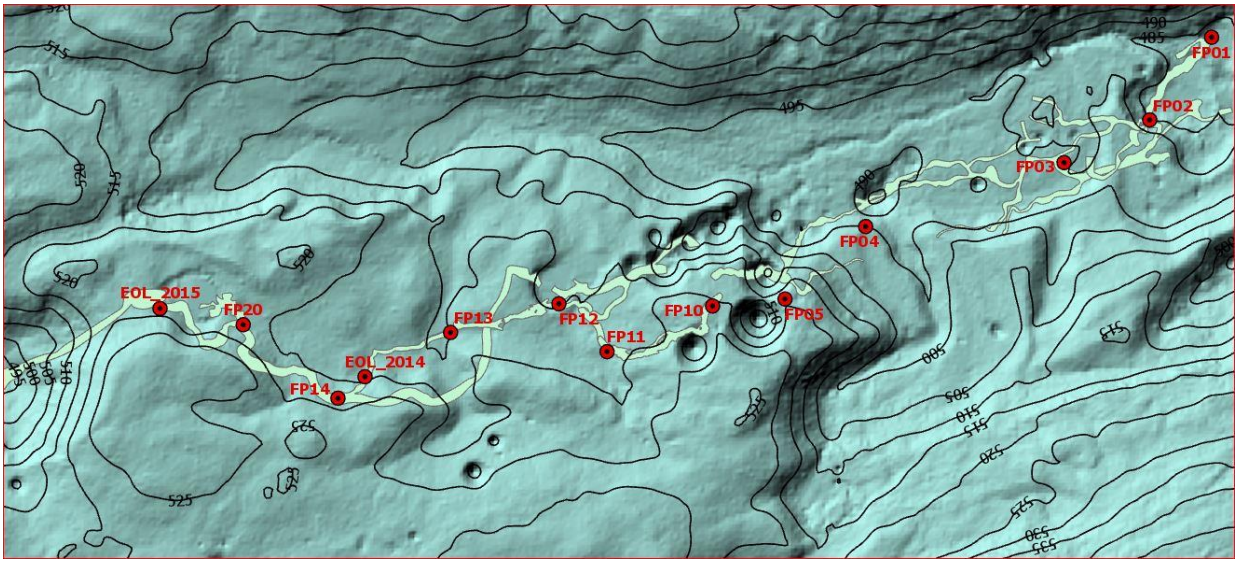

Figure 16 Map of the Dolinsjö cave and the terrain above the cave. Fix Points are marked in the cave survey.

In 2024 our equipment again consists of a Leica Viva GS15 rover on a 2.0-meter-high carbon fibre pole and a Leica CS10 field computer, kindly provided by the Swedish National Land Survey (Lantmäteriet), see Figure 17. But since we didn´t find any new places to put new fix points there were no need of using the GNSS equipment this year.

Figure 17 GNSS equipment from Leica provided by Lantmäteriet

LiDAR-data and Drones.

In 2017 we managed to get the new LiDAR data from the Swedish National Land Survey (kindly sponsored by Esri Sweden). This means that we now can measure the depth of all dolines (sinkholes) using GIS and build a 3D surface model over the terrain and incorporate the 3D map over the caves in the same model. A DJI Mavic 2 Pro drone were used for the fourth time to collect orthophotos from the valley. The photos were processed in photogrammetry software ArcGIS Drone2Map® and the output was 2D Orth mosaic, elevation data such as DSM and DTM and 3D data. The result was amazing, and we will continue to collect data from drones, see Figure 18.

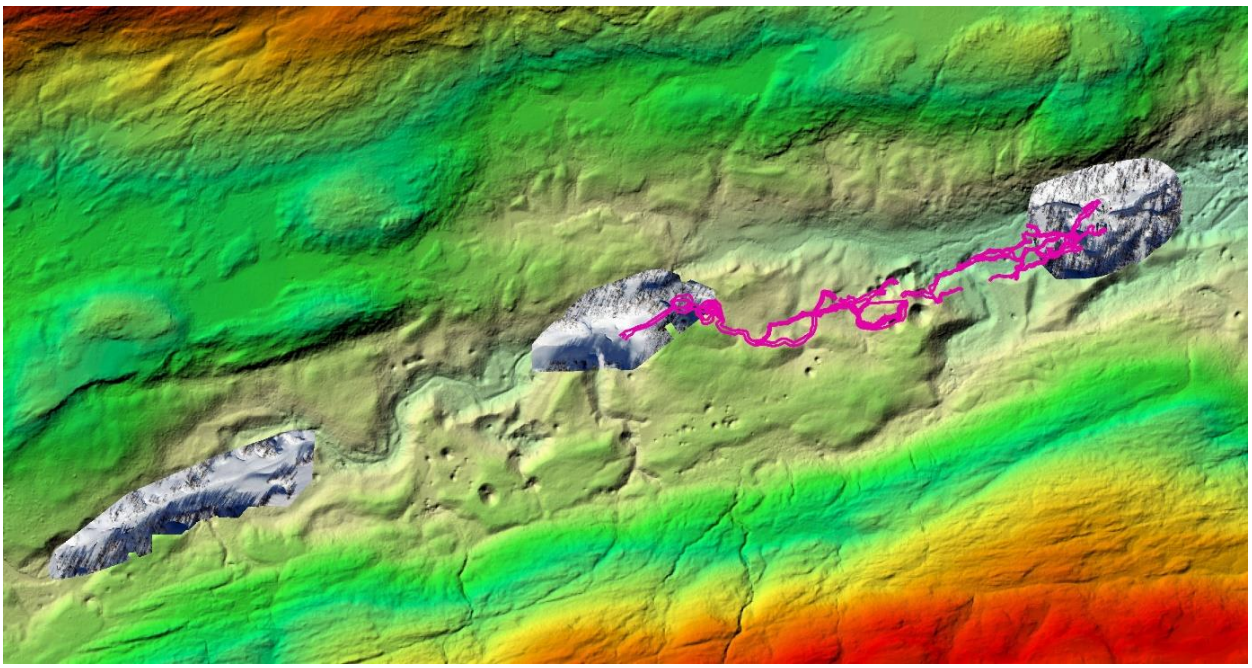

Figure 18 Combined map, showing LiDAR-data, orthophotos collected from the drones and cave survey.

Handheld LiDAR.
This year we didn´t user any LiDAR for collection 3D collections.

Radio communication and Internet connection
The overall communication in the Expedition is made by VHF-radio on 150 MHz. We also have two base antennas for secure the communication in the area from Leipikvattnet to Bjurälvsgrottan. The terrain, valley with high mountains around, makes it impossible to get in contact with the Internet through 3G or 4G even with directional antenna. In case of emergency, we must send one person to Leipikvattnet with VHF-radio as relay station. It´s also possible to use satellite phones e.g., inReach to the Iridium network or StarLink.

Electromagnetic direction finding

By Bo Lenander

On demand from surveying cave divers, electromagnetic direction finding, or radiolocation, has been used to find the point on surface that is located directly above the electromagnetic transmitter in the cave. The transmitter gives a vertical pulsating magnetic field that can be detected on the surface above the cave. The pulsating magnetic field is vertical in a position directly above the transmitter (ground zero) and also in the very weak return field, far away from ground zero. Figure below shows vertical position of the electromagnetic field. Note the high concentration (strength) in the field directly above the transmitter in comparison with that in the far field. In the return far field the vertical field direction is found everywhere in the same height level as the transmitter – but very weak!

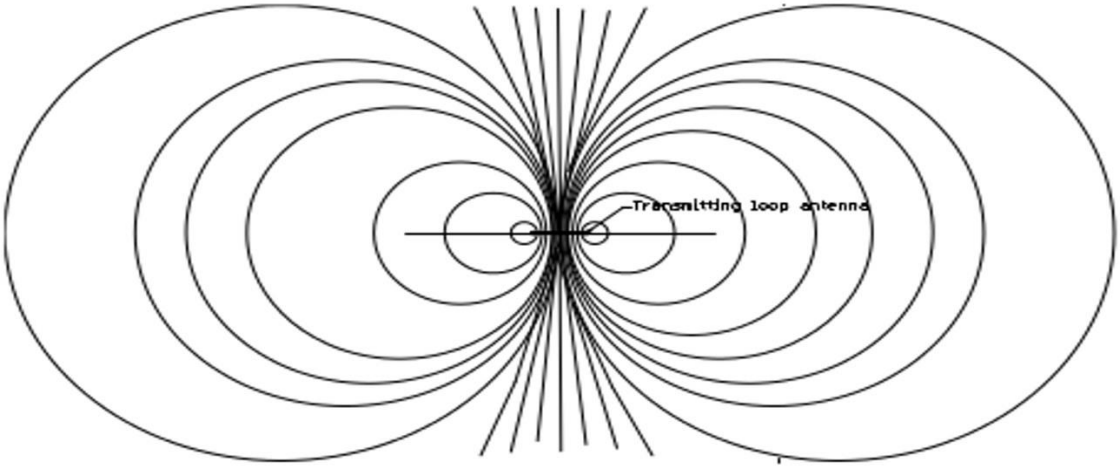

Figure 22 Vertical projection of the electromagnetic field.

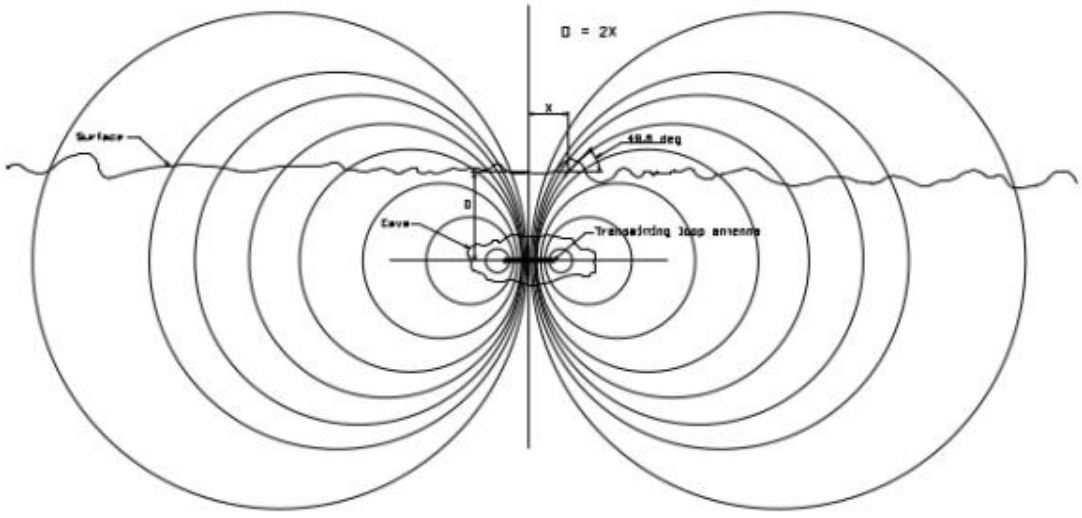

Figure 23 The electromagnetic transmitter is located in a cave and the distribution/angle of the magnetic field on the surface can be measured with a direction-finding receiver.

If the terrain above the cave has deep valleys there is a high risk of finding the vertical far field in the height level of the transmitter! This year, 2024, the work was concentrated to the waterfilled passages of Dolinsjögrottan. Two several hours long dives of a team of three divers have been followed. The actual positions were reported to the divemaster at the cave entrance using radio. No fix points were measured this year.

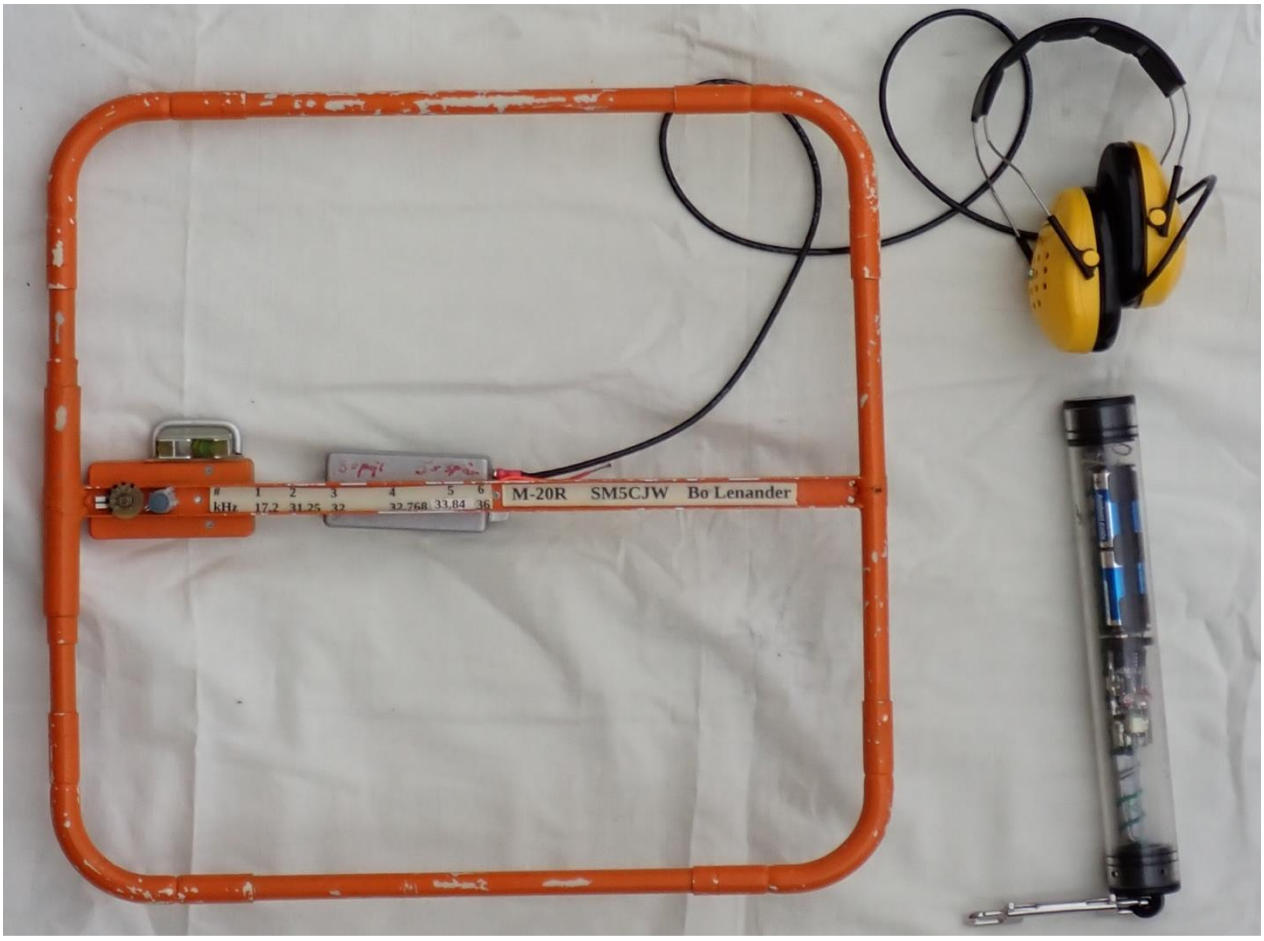

Figure 24 Direction-finding equipment: receiver M-20R and transmitter M-16MK.

The direction-finding equipment, designed and built by Bo Lenander SM5CJW, was a transmitter M-16MK and a receiver M-20R working at 32 kHz. The maximum range for this setup is about 150 m vertical distance. The transmitter M-16MK has a position sensor (transmitter hanging or manually pointed upwards) so three different codes can be transmitted:

1. Transmitter hanging: Short pulses (morse code **E**) = All OK – swimming to next fix point.
2. Transmitter upside down: Short + long pulse (morse code **A)** = FIX-point to be located.
3. 1. and 2. shifted (short + short + long + short +……) = SOS

The size of the M-16MK transmitter: D=45 mm L=320 mm
The direction-finding receiver, M-20R, has a 500 x 500 mm frame antenna. This receiver is a superheterodyne with 9 MHz IF and 400 Hz IF band width. This receiver has also been used on several occasions listening to the world heritage electromechanical transmitter SAQ at 17200 Hz!

Expedition through eyes of a new member

By Anders Etander

I dive a lot, and I mean a lot. Over the past 11 years, I've averaged about 200 dives a year. I love diving in mines and caves and have been an overhead diving instructor for many years. Being part of the Bjurälven project has been a goal of mine for the past 10 years, but I haven't had the opportunity to participate until now, in 2024.

Even though I knew half of this year's expedition members beforehand, it's a bit unique joining an expedition that's been ongoing for so many years. Everyone knows, more or less, what needs to be done and in what order it's best to do things. I'm kind of at a loss, trying to help as much as I can. It can also be challenging to find the balance between following routines and taking your own initiatives; sometimes a “why don't we do it this way instead?” might have an explanation—it's been tried and rejected.

This year's expedition began, like in previous years, with a planning meeting at the Tuna Hästberg mine. It was fun meeting everyone, and as the diving manager at Tuna Hästberg, I was able to offer a couple of extra open days for fun diving and practice for those who traveled the longest to attend the meeting. We couldn't plan everything at this meeting, so a couple of follow-up online meetings were needed to finalize all the details—what to bring, who would do what, etc. As a newcomer, it all felt a bit structured yet chaotic, which might be because everyone else has done this several times before. From an efficiency perspective, even the planning might need planning.

Eventually, this year's expedition began. We arrived as the first car at the school in Stora Blåsjön late on Thursday evening, setting up the venue for everyone else who would arrive later. It was interesting to see the unofficially assigned sleeping spots and how the "old-timers" settled into their familiar places. I suppose I'll do the same next year.

Friday and Saturday were dedicated to setting up camp. Friday was spent finishing the snowmobile track that had been prepared but needed some last fixing in curves and slopes. Saturday, the actual camp was set up with its two tents, toilet pit, filling station, and most importantly, the hole in the ice and diving platform. The structured chaos re-emerged, but with everyone's positive attitude, the tents were soon up. The most time-consuming task was the hole in the ice and the diving platform. The ice turned out to be 1.7 meters thick, while our ice drill was only 1.5 meters. It took a day and a half of drilling and sawing to gradually break through and lower the constructed diving platform into the water. It was hard work that used muscles I don't typically engage in my daily desk job. But it was satisfying, that's for sure.

Finally, the preparations were complete, and diving could begin. What an experience to dive in these wonderfully beautiful caves with their characteristic bowl-shaped ceilings and floors. There was barely any current, and the water temperature was warmer than I expected—about two or three degrees Celsius. After a couple of dives to get familiar with the cave, I started my project to create a 3D map of the cave. This is work that Martin Fregelius and I have been doing for several years. We've worked on 3D imaging of underwater mine sites, but we've never tackled a cave before. Unfortunately, Martin had to cancel his participation, but he supported and worked with my collected material remotely.

To build a 3D image, we take many photos while slowly moving forward. There must be at least a 60% overlap between images, so it's a slow process for a cave as large as Dolinsjö cave. In total, I took 18,800 photos during six dives. These images are then processed in a special software that starts by identifying unique pixel formations in each photo. It then compares the

information in one photo with the others to identify matches and thereby a 3D structure can be built. The final step involves overlaying the actual photographic surface to create a 3D image of the object.

Collecting material in the Dolinsjö Cave posed unique challenges. The cave is quite narrow in some places, meaning the camera is very close to the surface, so you can only move a few centimeters to get enough overlap between images. Another challenge is the structure of a cave with cavities and offshoots in all directions. It's hard to know where you've been and what still needs documenting. My optimism during the first few days turned to a bit of frustration as it became clear that merging material from different days was difficult. In my eagerness to maximize expedition time, I abandoned some of the structured approaches to photographing. More images and more material are not always better. The result is that the 18,800 photos cover about 140 meters of the cave, but the outcome is 3–4 separate models that don't seem to merge. The work isn't done yet, but it seems likely that we need to return and "try again, do it right." I learned a lot about how we should structure the data collection for the 2025 expedition, and preparations have already started.

We had six diving days, and by Saturday, the whole camp was dismantled. Everything was packed in its designated place and box; inventories of materials, shortages, and purchase needs were documented to facilitate next year's expedition.

Now, with a bit of distance, looking back on the Bjurälven 2024 expedition, it's with pure joy. What an experience to be part of exploring Sweden's longest cave system, at least as far as it's been discovered. The experience is undoubtedly due to the cave, the diving, and the mountain environment. But none of this would have been possible without all the people involved in the expedition. All the participants, of course, but perhaps especially the locals who helped with food, snowmobiles, carrying, and lifting. All with joy and lots of laughter. I'm already looking forward to next year's expedition. Of course, I'll dive back into the 3D project and move it forward, but mostly, I'm eager to see all the wonderful people again and be part of the community during the expedition.

One last internal note. Linus, next year, you might want to hide Gunnel`s pastries better than just putting them in your backpack!