Expedition Bjurälven 2016 report

Expedition Bjurälven would like to express sincere gratitude to the main sponsors in 2016, Ursuk and xDeep. Efficiency of our equipment is something we rely on. Using drysuits provided by Ursuk and sidemount harnesses provided by xDeep, we were able to reach longer into the limestone rock of the Bjurälven valley than we could ever imagine. Several other companies helped us achieve our goals safely in 2016: Oceanic Tech, Dykmagasinet in Karlstad, Klättermusen, Scubamafia and Suunto. Their products and support made the Expedition safer and helped us achieve our goals. Esri Sverige, Reel Diving, Tesla, Leica Geosystems, Suntec, Äventyrsgruvan, Divetech as well as the Swedish National Land Survey are also acknowledged for their support of the expedition. The local authorities and population were backing us up 100% as usual, making the expedition possible. We would like to thank the population of Stora Blåsjön and authorities in Jämtland County, restaurant Fjällripan, Ica Stora Blåsjön and Gäddede as well as Mikkes Skoteruthyrning.

Figure 1 Last preparations prior to a dive in the Dolinsjö cave

Compiled by Dmitri Gorski

Bo Lenander, a member of the current expedition crew, discovered the entrance to the Dolinsjö cave in 1979. The first winter expedition to Bjurälven valley was launched in 2007, following a number of unsuccessful attempts to dive in the Dolinsjö cave. Previous attempts were unsuccessful mainly due to very strong current that rips through the cave system summertime, measuring up to 20 knots. In wintertime, the water is much calmer and hardly any current can be detected. Another factor in favor of conducting the expeditions wintertime is easier logistics. All the equipment can be transported to the cave entrance using snowmobiles, minimizing the risk of damaging the fragile vegetation in the national park where the cave is located. In 2008, divers of the second Expedition Bjurälven could enter the cave and map some 50 meters of the passages beyond the entrance. Thanks to excellent cooperation with the authorities and continuing support of the local population, diving and exploration in Bjurälven continues every year. Nine years since the first expedition, the official mapped length of the cave system is 2135 meters. Dolinsjö cave is Sweden`s longest water-filled cave and among the 120 longest underwater caves in the world.

Members list 2016

Pirre Sandberg	Dmitri Gorski	Andreas Johansson	Stina Gabrielsson
Kristian Lyberg	Petter Johansson	Oscar Svensson	Janne Suhanen
Micke Tilja	Bo Lenander	Robert Staven	Antti Apunen
Mats Fröjdenlund	David Thor	Sami Paakkarinen	Leif Sigvardsson
Johan Utas	Marcin Wojturski	Øyvind Hegle	
Stefan Barth	Amanda Lindberg	Ane Mengshoel	

Figure 2 Expedition Bjurälven 2016 exploration team (Leif Sigvardsson is not in the photo)

Goals and summary

The overall goals of Expedition Bjurälven are:

1. Explore, map and document caves in the Bjurälven valley
2. Promote the caves in the area and the local community of Stora Blåsjön
3. Contribute to scientific research through cooperation with universities

The expedition was a big success also in 2016. Dreams of extending the explored and mapped part of the Dolinsjö cave to two kilometres remained just dreams for a long time. After Expedition Bjurälven 2016, the official length of the cave is 2135 meters. The cave has started to advance on the list of Sweden`s longest caves (water-filled and dry) and is currently number six. The cave system grew not only in length, but also in width and complexity. New tunnels of significant length were found as close as 50 meters from the cave entrance. Longest exploration dives to the end of the line took 6-7 hours to complete and fifth sump of the cave was discovered and explored. 21 cave researchers participated in the expedition in 2016. This includes 5 new members (1 from Sweden, 2 from Finland and 2 from Norway). For the first time, the expedition had its own medical doctor.

An extensive re-mapping of large parts of the cave was carried out in 2016. During the past nine years, a lot of inconsistent and incomplete mapping data has been accumulated by the expedition, and a clean-up was necessary in order to present an accurate map of the cave. Re-mapping was accomplished using digital compasses under water (built into Suunto diving computers) and DistoX in the dry passages. In addition, all the mapping data was corrected by using fix points in the cave located from the surface using radiolocation and advanced satellite positioning.

The weather was a concern during the 2016 Expedition. Due to various reasons, the expedition had to be carried out unusually late this year and the low amount of snow posed a problem to snowmobile transports. All the challenges were solved, but an earlier expedition will be planned for the next year in order to secure more stable snow conditions.

Substantial amount of high-quality photo and video material was collected this year. A short movie about the 2016-expedition will be produced from this material.

Exploration and mapping

A record-high number of dives (131) were performed during the expedition in 2016, see Figure 3. This can be explained both by the high number of divers exploring the cave, but also by the increased efficiency of the expedition. Total dive time increased as well, and divers spent 244 hours in the cave (including the dry sections between the sumps) during the expedition week, see Figure 4. Average dive time increased somewhat, see Figure 5.

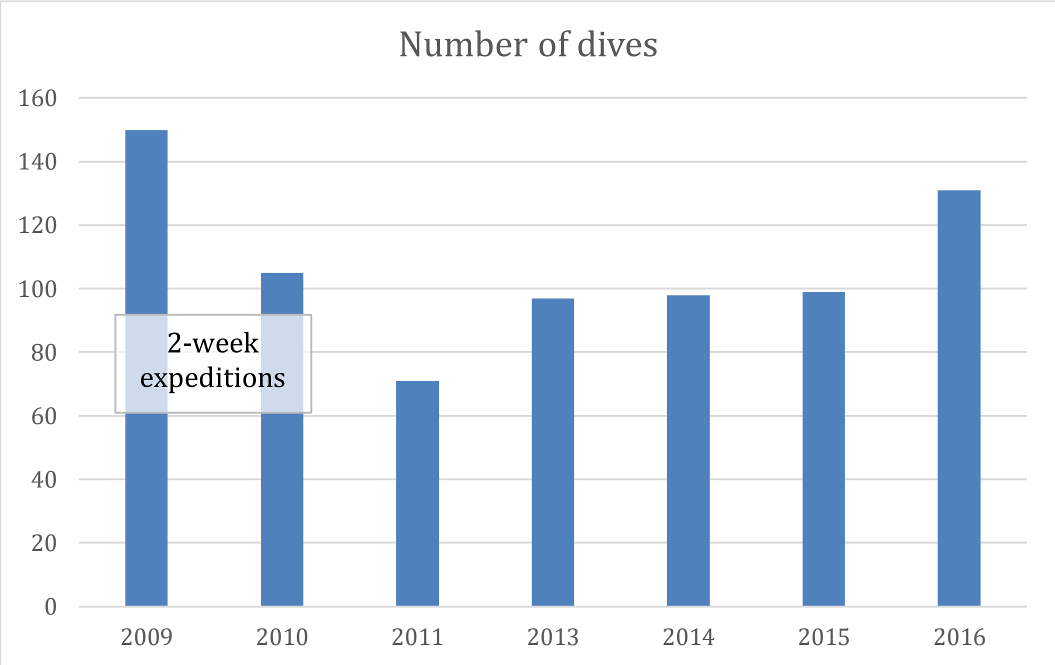

Figure 3 Dive statistics for Expedition Bjurälven

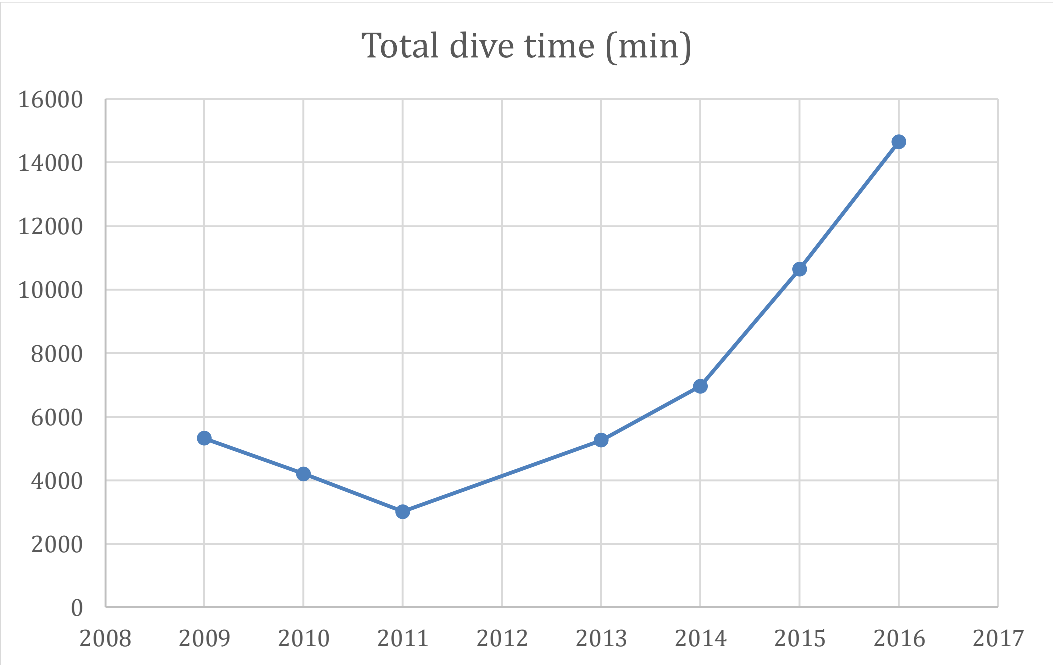

Figure 4 Total dive time during the expedition

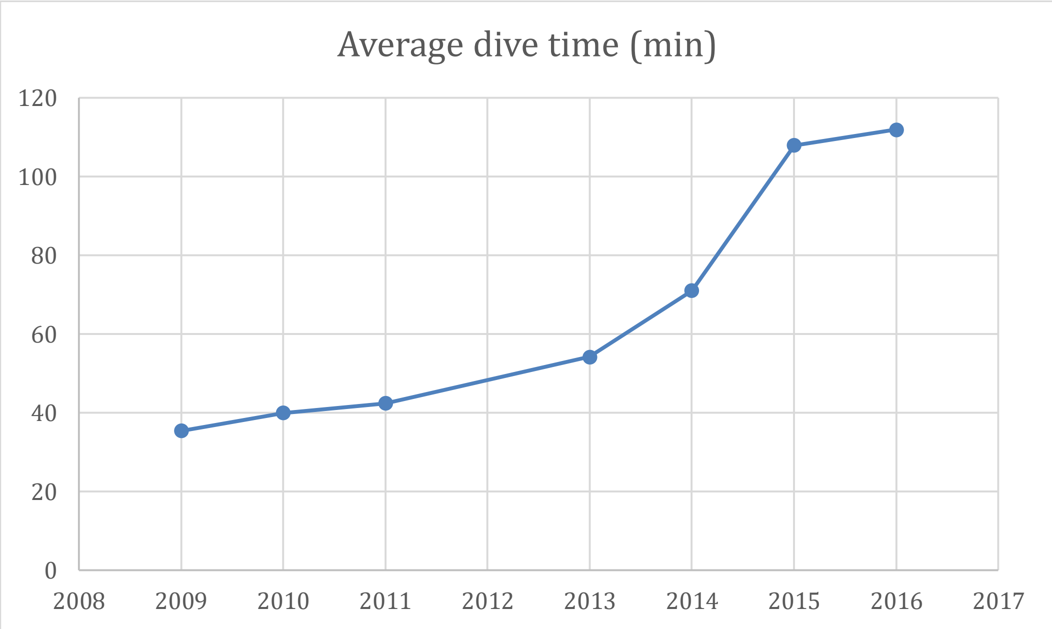

Figure 5 Average dive time per dive

The goal of introducing the five new expedition members to diving in Bjurälven was also met; all five conducted dives in the cave, some as far as to the end of the line.

When the expedition was over in 2015, a tunnel with significant flow was discovered upstream in sump 3. The tunnel was on the side of a massive rock collapse and one of the goals for 2016 was to attempt passing it. Another goal was to explore the new leads in sump 2 where a side-tunnel was found to lead to a T, see Figure 6. In general, we lacked good understanding of the flow situation in the cave since we could see downstream flow in sump 3 and upstream flow in sump 2, which did not make sense when looking at the map. A hypothesis was that there was a side tunnel of significant size where water from sump 3 was flowing towards (and past) the entrance of the cave.

The understanding of the flow situation improved significantly when a re-mapping and correction of the map was performed, see Figure 7. On the corrected map, sump 3 turned out to be connected to sump 2 through a very tight passage, almost no-mount. An attempt to negotiate it was undertaken in 2015, but had to be aborted due to the risk of collapse and increasing flow (since the passage was blocked by the diver). From the corrected map, it can be clearly seen that there is a possible connection between the sumps. On the surface, this point is located in one of the sinkholes, see Figure 8. This correlates well with the rock collapse underneath. A new attempt to negotiate the passage between sumps 2 and 3 might be undertaken in 2017 if it is deemed safe enough.

The cave was also extended further upstream in sump 4. Instead of negotiating the tight passage with the flow, a way around it through the dry part of the rock collapse above was located. Fourth dry chamber and sump 5 were discovered beyond the collapse, and some 80 meters of sump 5 were explored and mapped. The collapse area itself is unstable and an attempt to negotiate the water filled passage between sumps 4 and 5 might be undertaken later. The end of sump 5 is underneath the blind valley, not far from Svenonius cave.

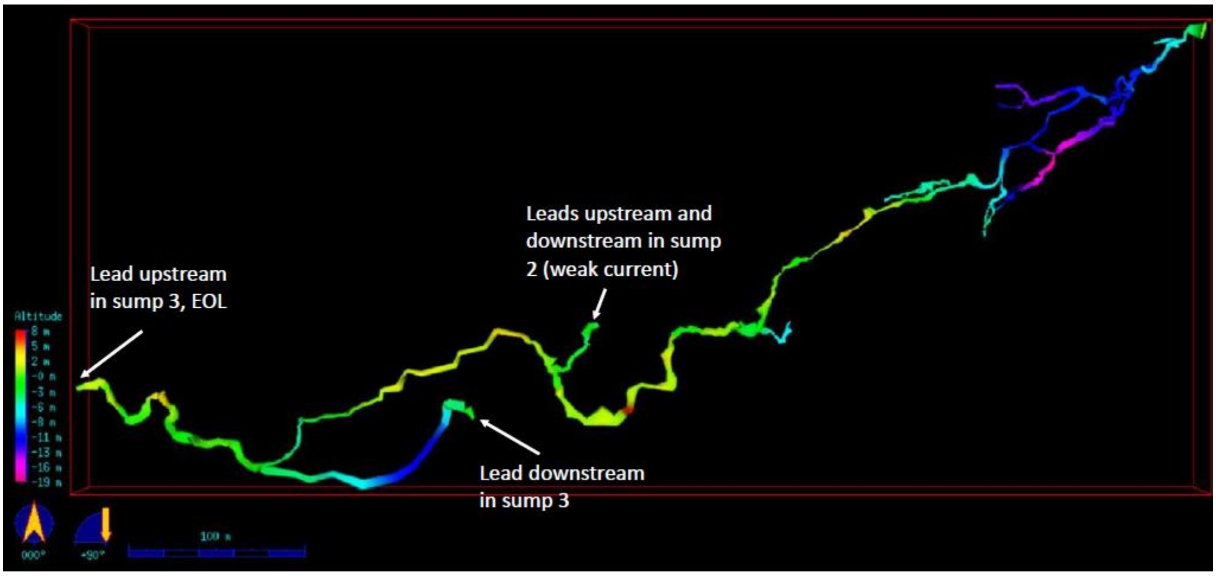

Figure 6 Map of the Dolinsjö cave by the end of the exploration in 2015 (compiled by David Thor)

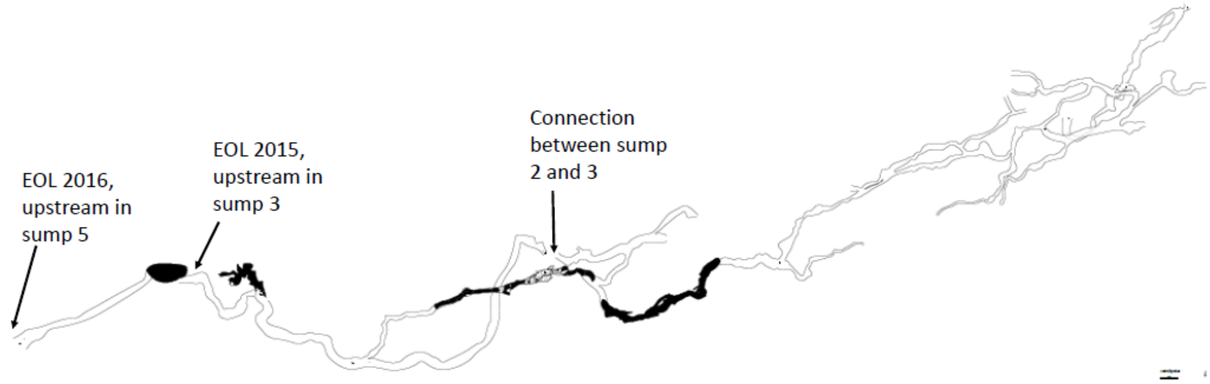

Figure 7 Map of the Dolinsjö cave by the end of the exploration in 2016 (compiled by David Thor)

Figure 8 Map of the cave and surface map of the Bjurälven valley (compiled by David Thor)

Documentation and media

A number of high-quality images were taken in the cave this year. The images will be used in our PR-work as well as by our sponsors. Considerable focus was also on recording high-quality video material, which will be used in production of a short film about the expedition. Material may be used for the longer movie, which will be produced later (year is not yet decided).

Figure 9 A diver in sump 3 of the Dolinsjö cave (photo Sami Paakkarinen)

Radiolocation

By Bo Lenander

Radiolocation and depth measurement of fix points in the cave was done on the surface with the aid of electromagnetic transmitter (M-16P and M16MK) and direction finding receiver M-16R (at 32 kHz). Divers carried transmitters to fix points in the cave, and the position of the fix points relative to the surface was determined using the receiver. Two kinds of transmitters were used. Marker M-16MK is smaller in size and more simply constructed. It transmits a signal to the surface continuously and is used to follow divers from the surface. Pinger M-16P is equipped with settings, allowing divers to choose which pre-set message/signal to transmit. Additional functionality is added through enabling simple two-way communication, where it is possible to relay a "fix point located" from the surface down to the pinger. This is achieved by turning on an array of light-emitting diodes mounted on the pinger by a signal from the surface. The M-16P Pinger is used to accurately determine position of fix points in the cave in relation to the surface (including their depth from the surface).

Speech communication between the first dry passage and the base camp was attempted using Heyphone (87 kHz). Simple Morse code messages were sent from cave to surface and vice versa using the radiolocation devices (32 kHz). List of equipment, used for communication and radio location, can be found in Table 1. M-16R, M-16P and M-16MK were developed and built by Bo Lenander (SM5CJW). Heyphone was developed by John Hey (G3TDZ) and the two Heyphones we borrowed from NGF (Norsk Grotteforbund) were built by Hans-Øivind Aarstad.

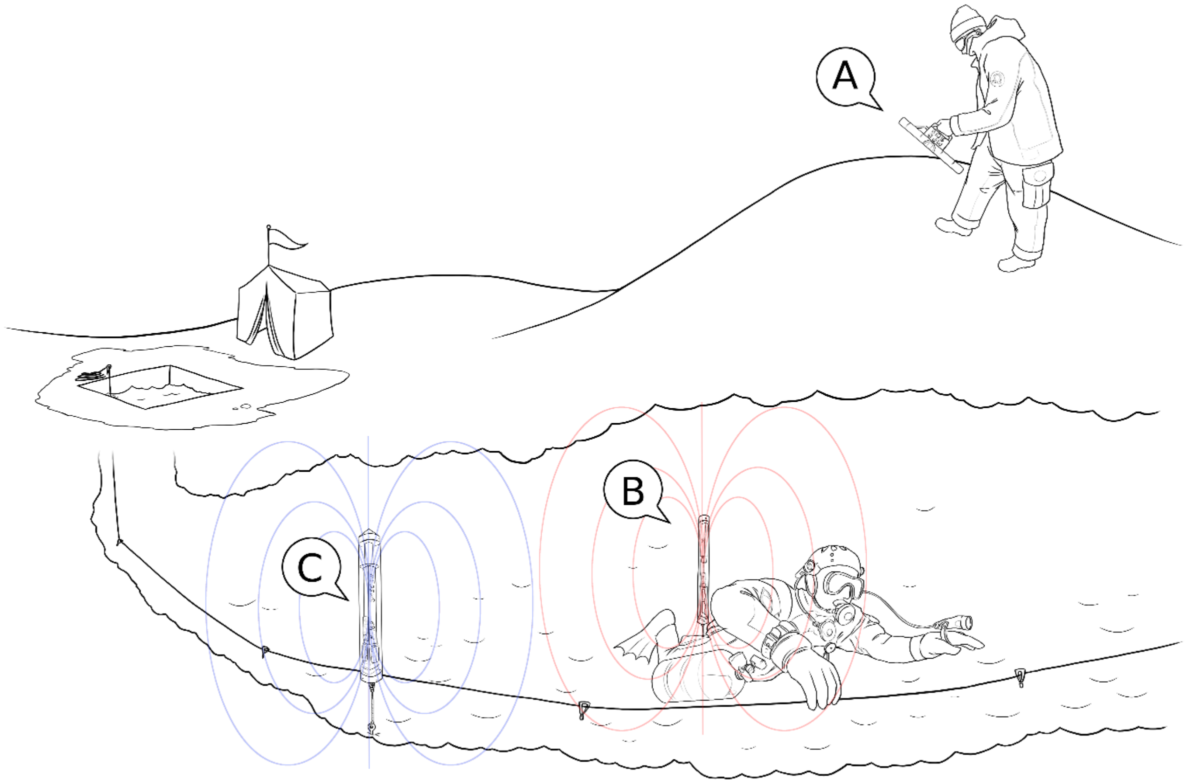

Figure 10 Direction finding receiver M-16R (A) and electromagnetic transmitters M16MK (B) and M-16P (C), illustration by Per Lenander

Figure 11 Radio location on the surface by Bo Lenander (photo Janne Suhonen)

Table 1 Equipment, used for communication and radio location

Equipment	Antenna	Size (mm)	Weight (kg)
DF receiver M-16R	Ferrit D=13 mm, L=400 mm	404x175x32	0.98
Pinger M-16P	Ferrit D=13 mm, L=400 mm	D=77, L=520	1.6
Marker M-16MK	Ferrit D=14 mm, L=256 mm	D=45, L=465	0.7
Heyphone	Earth-current 2 x 25 m max	174x85x63	0.92

More detailed technical data can be found in Table 2.

Table 2 Technical data, radio location equipment

Equipment	Frequency, Hz	Modulation	Power supply	Range (m)
DF receiver M-16R	fosc=32768	AM, CW, DSB, SSB	2 x 18650 Li-ion	55 (To pinger)
	32000	CW (Clear sign)	2 x 18650 Li-ion	55 (To pinger)
Pinger M-16P	32000	CW	8 x LR6/AA	130 (to DF)
Marker M-16MK	33844	CW	4 x LR6/AA	110 (to DF)
Heyphone	87000	SSB (USB)	8 x LR14/C	800 (to Heyphone)[1]

[1] Using big earth antenna.

The M-16R receiver was very easy to handle. The device is equipped with two spirit levels: One horizontal for locating the point directly above the transmitter (using vertical or 90deg magnetic field), and one for measurement of depth to the transmitter (using magnetic field angle 49.5deg). Depth is calculated as 2 x horizontal distance to ground zero. A narrow passband filter at 32000 Hz is used to reduce noise when searching for ground zero. When tracking a diver the filter is set to 33844 Hz and for listening to speech communication (DSB/LSB/USB), the filter is wider and is set to 32768 Hz. The sensitivity is manually adjusted. When a measurement is completed, a strong 32000 Hz signal can be sent into the cave to activate the green LEDs in the pinger clearly visible to the divers.

Six fix points were located during the 2016 expedition. Depth to the fix points was measured at those positions. We also followed divers carrying the marker devices. The cave is located at a depth of 20-45 m below the surface. The ground consists of marble at the location of the cave with a layer of gravel on top, originating from the end of the ice age.

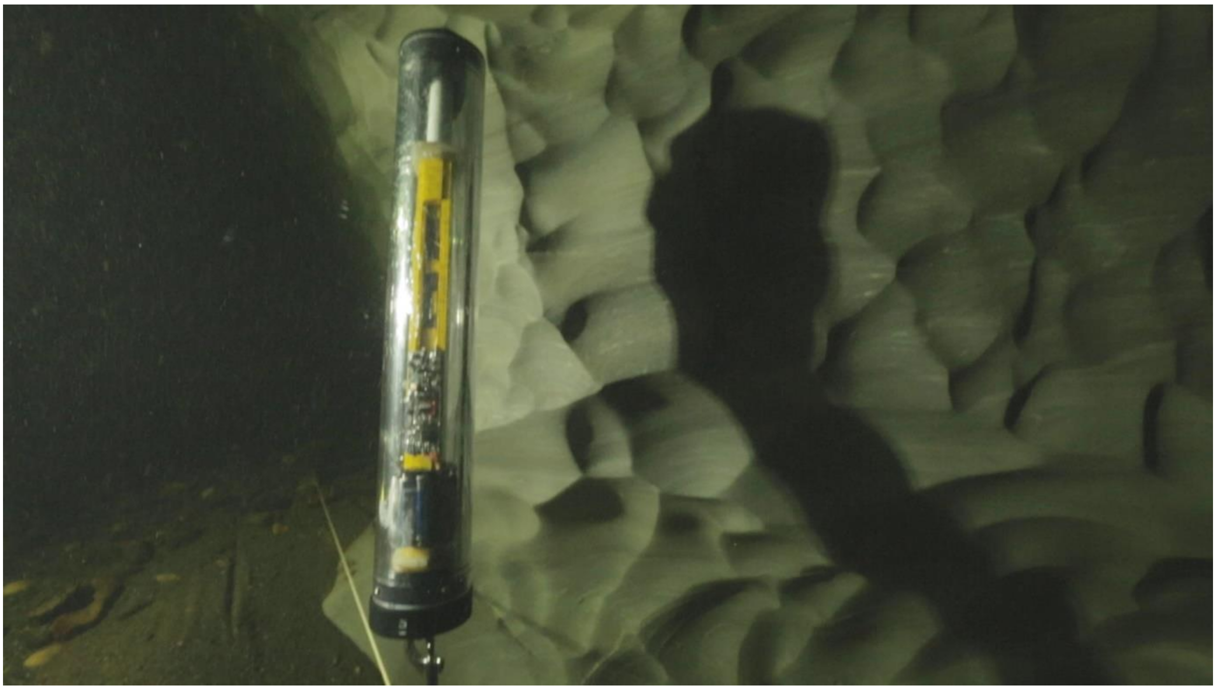
Figure 12 The M-16P pinger on a fix point in the cave (photo Janne Suhonen)

The M-16P pinger (Figure 12) is designed to float vertically, self-aligning the magnetic field. It is equipped with a selector, enabling the divers to choose one of four pre-programmed messages:

- **OK** (used when moving/swimming)
- **FIX** (used when the pinger is at a fixpoint)
- **DLY** (to signal delayed return to the surface without any need for help)
- **SOS** (to signal a problem where divers need help)

A receiver in the pinger is listening between the transmitted signals. When a strong signal at 32000 Hz is received by the pinger, the green LEDs illuminate the white top of the device. This is a signal from the surface indicating that the fix point is located and the divers can move the pinger to the next objective.

Figure 13 A diver equipped with a M-16MK marker (here attached to the rear d-ring) can be followed and identified from the surface (photo Janne Suhanen)

The M-16MK markers are of simpler design without any pre-programmed messages. The markers are equipped with individual signals and tilt sensors to tell if the marker is floating (when in water) or hanging (when in a dry passage). Four markers sending morse codes E/A, I/U, S/V and H/4 (floating/hanging) were used by the expedition. It is rather easy to follow a single diver equipped with a marker. However, if two divers with markers are close to each other, their transmissions mix up and the direction finding is more difficult.

Another issue is that the magnetic field is very strong near the ends of the ferrit rod antenna inside the markers. We noted influence on both a digital (Suunto) compass and an Ipad. It was necessary to reset the devices after they were placed close to the marker (on the same d-ring in case with the diving computer). Neither of the devices was damaged permanently. One way to avoid this is to use a loop antenna as it does not concentrate the field in the same way a ferrit rod does for the same operating range.

Plan for the future is to measure the magnetic flux density (B) in an EMC-lab. The reason is to see if the antenna system can be modified to achieve a lower flux density close to the antenna. Measurements will be performed for M-16R (transmitter), M-16P and M-16MK.

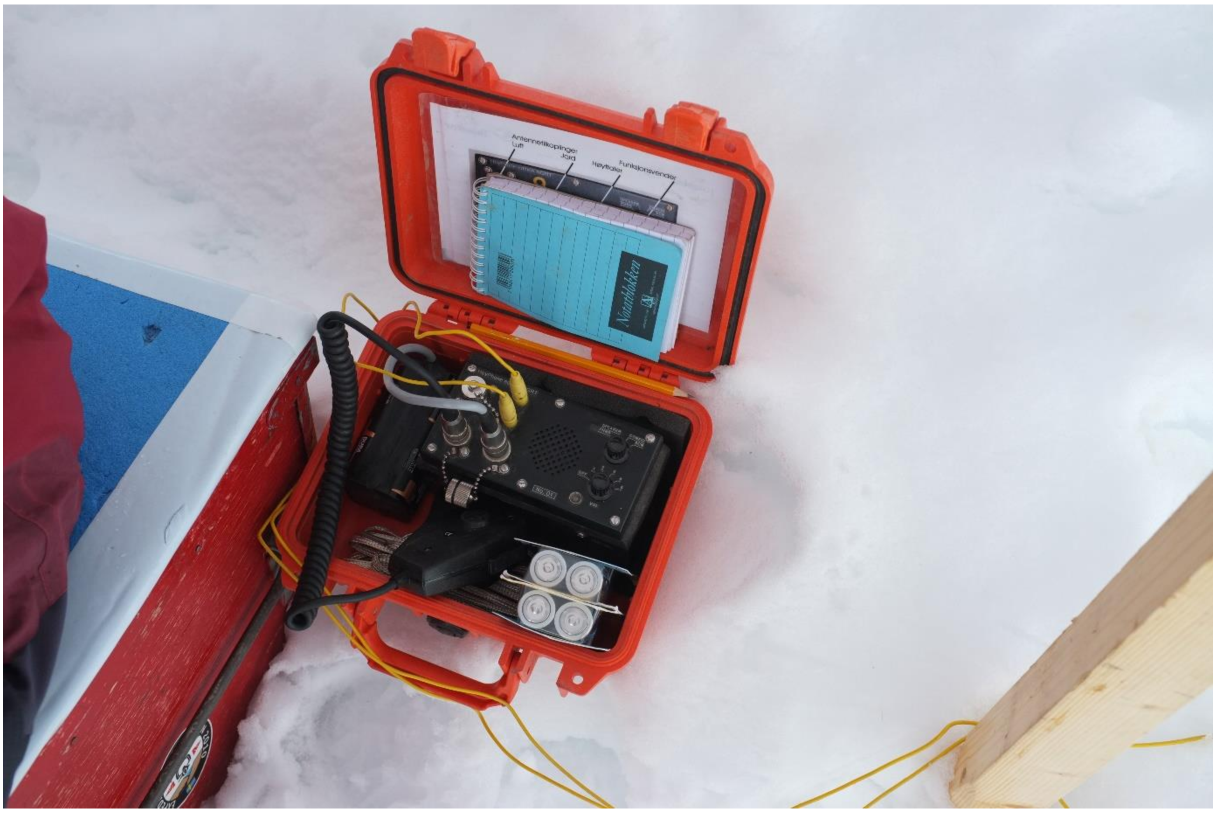

Figure 14 Heyphone in its transport case, yellow wires (max 2x25m) go to both earth antenna connectors (photo Bo Lenander)

Heyphone communication with sporadic good connection was achieved over 330 m horizontal distance with earth antennas in the same east-west direction and 20 – 30 m between earth connections. Severe problems were experienced with battery connections in the battery holder/box.

Satellite positioning

By Mats Fröjdenlund

Radiolocation of cave divers and surveying of fix points in the cave has been performed during every expedition since 2011. Starting in 2014, the fix points have also been marked out in the cave using bolts and stainless steel trays labelled FP01, FP02, and so on. Using the radiolocation equipment, a relatively accurate point on the ground surface directly above a fixed point can be obtained. Also, the depth from the surface (or the snow surface) down to the fixed point can be obtained. In order to make a 3D and georeferenced cave map both the ground surface elevation, the depth of the cave and its X and Y coordinates are required for the point on the surface. For this purpose, the National Land Survey/SWEPOS (https://swepos.lantmateriet.se) kindly lent us both GNSS equipment (**G**lobal **N**avigation **S**ystem **S**atellite = GPS and GLONASS) and communication equipment with connection to the SWEPOS correction services during the expeditions in 2013, 2014 and 2015. Network RTK (**R**eal **T**ime **K**inematic) is a technology for accurate GNSS positioning in real time. The technique is based on the support system of fixed reference stations, such as SWEPOS. The so-called correction data is calculated at the SWEPOS command centre and sent to the user's GNSS equipment. The user can then get a position in the reference system SWEREF 99 with uncertainty in the centimetre level.

The equipment used during the expeditions consisted of a Leica Viva GS15 rover with built-in 3G modem on a 2.5-meter-high carbon fibre rod and a Leica CS10 field computer, see Figure 15. Long-term measurements (at least 15 minutes at each site) utilizing the RINEX method (**R**eceiver **In**dependent **Ex**change Format) were performed during the 2016 expedition. This technique is very useful in areas with poor mobile coverage. The GNSS equipment borrowed directly from Leica Geosystems Sweden was then used to obtain data for the fix points on the surface obtained by radiolocation. The measurement information from the field computer was transferred nightly to an Excel file with X, Y and Z values in SWERREF 99 TM format. Depth value and time for the measurement were also included. GIS software ArcGIS® from Esri was used to visualize the points on an aerial photo of the area.

Figure 15 Leica Viva GNSS equipment.

Data for six new fix points was obtained with the GNSS during the 2016 Expedition, and there are now 21 different GNSS measured values along the Dolinsjö cave. The equipment was returned after the expedition and we hope to borrow an equivalent system for the Bjurälven Expedition 2017.

Five weeks after the expedition we received the post-processed GNSS data from the National Land Survey. Our assessment is that the XYZ values of the points are measured/calculated with an accuracy of +/- 50 centimetres thanks to the correction of the data.

The Swedish National Land Survey through Metria AB is planning to perform laser scanning (LiDAR) of the area in 2016. When the scanning is performed it will be possible to measure the depth of all dolines (sinkholes) using GIS and build a 3D surface model of the terrain above the cave.

Loan of advanced equipment from Leica Geosystems Sweden and post processing of data from the National Land Survey enabled us to achieve desired accuracy in determining the position of the cave in relation to the ground surface. Best measurements of the data so far could be achieved in 2016. Half of the measurements are better than 1 centimetre in XY-plane and better than 10 centimetres in Z-direction (depth). Geo-referencing in three dimensions was possible to perform.

Certain terrain features (deep valleys) made the data analysis complicated. It has been difficult to get so called Fix solutions. Fix solutions can provide us good measures down to cm-level. Code solution provides less good values (dm-level up to the meter-level).

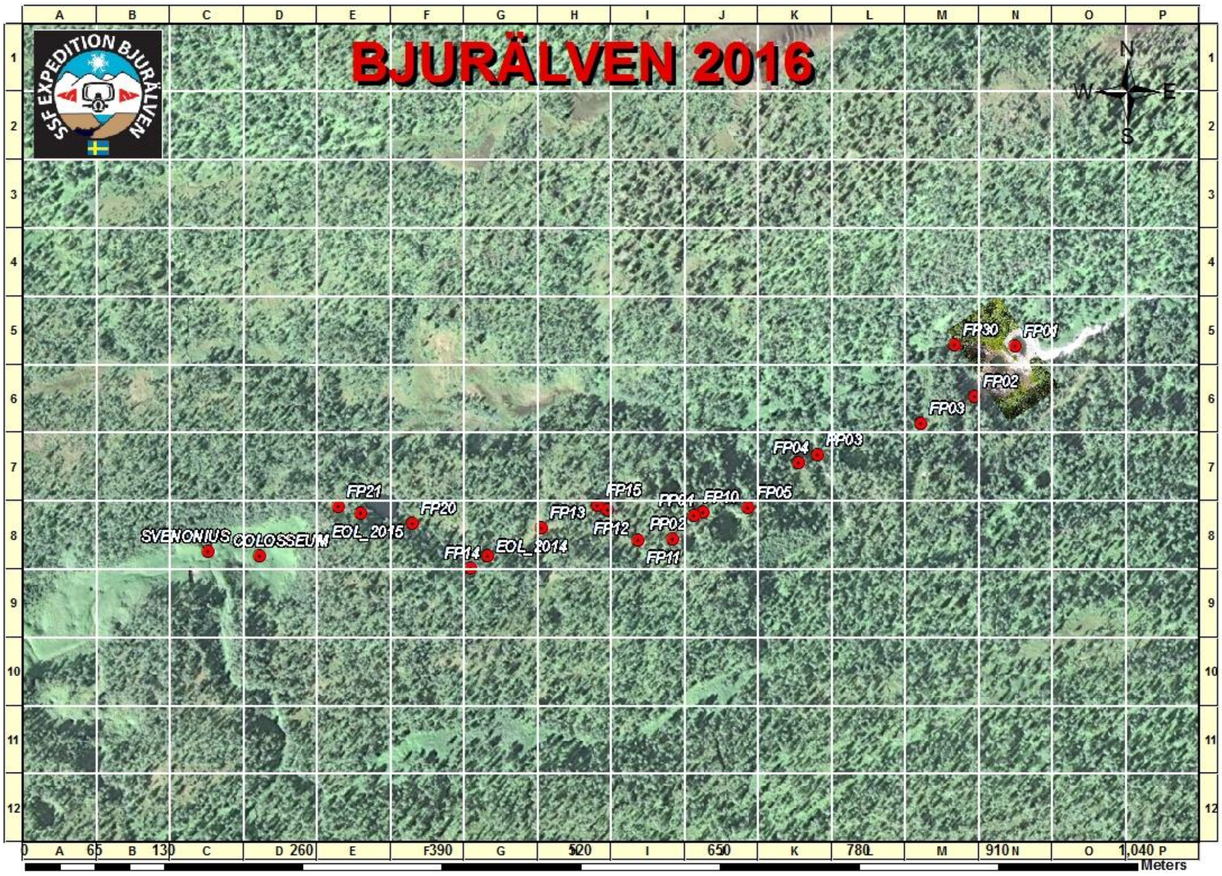

Figure 16 Direction finding points 2016 mapped on an aerial photo (with permission from Lantmäteriet) in ArcMap®.

Science and research

No science and research activities were carried out in 2016. The goal of the expedition is to give research a higher priority in 2017.

Expedition Bjurälven from a medical perspective

By Stina Gabrielsson

Is it dangerous to dive in a cave? Is dry caving dangerous? I asked these two questions at the presentation I gave on Expedition Bjurälven at the annual meeting of the Swedish

Speleological Society. Several different answers were given by the audience and many considered cave diving considerably more dangerous compared to dry caving (the audience consisted mostly of dry cavers). During a project with the size and complexity of Expedition Bjurälven there are always many risks to consider. It is important to carefully analyse all steps in the expedition from the safety point of view, from the car trip up to Stora Blåsjön to hygiene during breakfast. There is a group within the expedition working with safety matters. The main focus is on preventing accidents and injuries, but also on preparing plans in case an accident does happen.

Following text describes a risk analysis. There are four main activities in the expedition, where the risk of injury or accident is highest: diving, transports by car, transports by snow mobile and dry caving. Some consider the hot sauna followed by swimming in zero-degree water the fifth risk. We all have good understanding of what can happen during dry caving and car transports. When it comes to snowmobile transport, the risks are similar to transport by car (there are some differences, of course – the activity is performed in a place with no roads but a lot of trees, which of course has an influence on rescue options). Long exposure to extremely cold water during diving, alternated with dry caving, are the special features of the Expedition Bjurälven. The fact that a rescue mission has to be mounted in multiple dry and wet passages makes it a tough challenge.

Some risks during diving are caused by technical problems such as failure of a breathing regulator due to freezing. Freezing of a diving regulator most often leads to a freeflow which can quickly deplete the supply of gas. There are also numerous cases in Bjurälven where freezing of a diving regulator led to the opposite, a complete stop of the gas flow. This phenomenon was established to originate from the moisture in the breathing gas, which at very low temperature can form ice plugs in the breathing hoses. This problem was solved through extra filtration and drying of air filled into the diving tanks. Another risk, related to technical issues with diving equipment, is puncturing a hole in a glove or a drysuit. Rapid loss of body temperature poses a considerable threat in the conditions the expedition operates in. Accidents, where a diver falls in one of the dry passages or is caught in a collapse in a water-filled passage, would result in a person with disabled mobility and rapid cooling. More diving-specific risks include problems with equalizing during the many ascents and descents in a multi-sump dive, preventing the person from exiting the cave. Decompression sickness, the risk most often associated with diving, is not a big safety problem in Bjurälven due to the relatively shallow passages and little amount of nitrogen, absorbed by the body during a dive.

One of the most important ways of preventing accidents and injuries in Bjurälven is making sure that everyone involved in the expedition has a sufficient level of training and knowledge for the kind of diving they do (sub-arctic cave diving). It is also of utter importance that all the equipment is tuned in for this kind of diving. This could mean, for example, tuning the breathing resistance in the regulators so that the risk of freezing is minimized. In the case of freezing it is important to have a sufficient supply of gas to be able to solve any upcoming issues and exit the cave safely. With that in mind, part of the gas supply is always reserved for emergencies. Safety tanks placed in the cave also decrease the risk of running out of breathing gas. All dives start from a hole in the ice we prepare for every expedition. In order to make the start and end of each dive as comfortable and safe as possible, a special platform was built and installed in the ice hole to simplify kitting up and down. Divers can stand in waist-high water on the platform and adjust their equipment instead of floating on the surface.

An expedition of this size also requires a considerable surface organization. There is always a dive manager who keeps track of the dive plans and divers in the cave. Safety divers have their equipment ready in case someone in the cave requires assistance. A new option this year was the possibility to have communication between the first dry chamber and the base camp using Heyphone (borrowed from Norwegian Caving Federation). As the explored length of the cave grows (and so do the exposure times for each exploration dive), the opportunity for two-way communication from inside the cave is becoming more and more important. It takes approximately 25-30 minutes to negotiate the last water-filled passage on the way out.

In case of an accident it is important to be prepared and have access to correct equipment to deal with any injury. There is a warm tent and hot beverage in the base camp, allowing to quickly warm up a person with low body temperature. There are also a number of first-aid kits in the base camp with equipment, allowing to deal with more complicated injuries (cervical collar, fracture stabilizer and a stretcher that can be used in dry cave, water-filled cave and in transportation by snowmobile and helicopter). A water-tight emergency canister was placed in the first dry passage this year in order to further improve the safety. The canister contained dry undergarments, spare dry gloves, wool underwear, sleeping pad, food, chemical heating packs, duct tape and pain killers. Using this, an injured diver might be able to improve his chances of safely getting to the surface without outside assistance.

During the previous years most of the problems were related to freezing of the breathing regulators, a problem now more or less eliminated. During this years expedition only one incident was recorded: A diver ripping a dry glove inside the first dry passage. This incident led to rapid cooling of the diver, who was able to exit the cave on his own. On the surface, he was taken care of and could change to dry warm clothes and ingest hot food. Preparations for the next expedition in 2017 have already started and the goal is to further increase the safety. Focus will be on emergency drills: transporting injured diver inside dry and water-filled cave passages and rescue from the ice hole.

Expedition Bjurälven through the eyes of a new member

By Stina Gabrielsson

I feel butterflies in my stomach the whole week before the expedition starts. Preparations have been going on since the autumn and everything culminates this week. I attended a course in side-mount diving (side-mount means having the tanks on the side instead of on the back), and a course in how to dive side-mount in caves. An electrically heated undergarment was acquired, I did plenty of test dives with the new drysuit from our sponsor Ursuk and the rest of my diving equipment have been trimmed to suit the needs of Expedition Bjurälven. I am more prepared than I have ever been for any other diving trip in my life, but I still feel nervous. The extreme environment on land and the fact that I am going to have the medical responsibility during the expedition do not let me relax. But the adventure beacons, my worries go away and finally the D-day comes - the journey North is about to begin!

In the car on our way up, Amanda (Lindberg) and me talk about all possible things. Mostly about the coming week, everything from the breakfast routines to the evening meeting. Andreas (Johansson) and Oscar (Svensson) are in the other car. All three of my fellow travellers have been telling me a lot about how fantastic this week is going to be, and they shared a lot of experiences with me. For them, this is the best week of the year. It almost feels like I have already been to the Dolin lake and the cave underneath. I get more and more excited about the experience to come.

After arriving to Stora Blåsjön we sleep for a few hours and on the day after it is time to prepare the tracks for the snowmobiles. It feels good to be outdoors after having spent 14 hours in the car! The others tell me that there is not so much snow this year, but all I can do is admire the landscape around me, covered in meter-deep snow; the scene is magnificent! Time flies fast and soon we have to return back to Stora Blåsjön and meet the other expedition members. We eat dinner together at Fjällripan (Sweden's best Italian restaurant as far as I am concerned). Cars with other members of the expedition arrive all the time, and there are many familiar faces also for me. The meeting in Tuna-Hästberg a couple of months earlier worked as it was supposed to, and we are not strangers any more. We are all going to be an even stronger team when this week is over.

A special rhythm is established already from day one. We have a meeting after the dinner at Fjällripan where we go through everything that has happened during the day and plan for the next day. After that there is time for sauna. Everyone is tired and goes to sleep fairly early. The old school in Stora Blåsjön has all the facilities we need. The expedition leader wakes everyone up and the first thing we hear is the weather report. Then there is breakfast and we all get in the cars to go to Leipikvattnet where the road ends. We pack the snowmobiles and drive the last couple of kilometres to the basecamp. There is a lot of snow shovelling during the first days of the expedition. We build the basecamp, cut a hole in the thick ice and prepare everything for diving. We dig out the cave entrance and place out the safety tanks.

I got to do my first dive in the Dolinsjö cave on the second day of the expedition. My goals were set low: I was going down into the water and then maybe past the entrance of the cave if everything would feel ok. Marcin (Wojturski) and Amanda (Lindberg) were my diving buddies. We helped each other out with the dry suits and other equipment before going down to the hole in the ice, where we could put our tanks on. We dived with three tanks each, all of them with separate regulators. The butterflies in my stomach were back just before the dive: was I really going to dive in this tight cave with its zero-degree water? I checked all the equipment one last time and, after exchanging "ok" signs with Amanda and Marcin, let the air out of my dry suit. I submerged slowly towards the platform that was installed in the ice hole. I stopped for a moment, listening to my own breathing, switched on my torch and swam out into the water below the ice. It was really cold, but felt ok nonetheless. For a couple of minutes, I just swam around the pool that was Dolin lake during winter. After exchanging another "ok" sign with my team it was time to find the entrance to the cave. The entrance is tight and after a moment of hesitation I moved my third tank into a slightly different position and pushed my way into the cave. Finally I was inside Bjurälven! This feeling is hard to describe. We took a short tour of the cave and I surfaced in Dolin lake after the dive with a huge smile on my face (probably similar to the cat in "Alice in Wonderland"). I did my second dive the day after, doubling the dive time and enjoying every minute of it. I went deeper and deeper into the cave during the rest of the week, finally reaching the first dry chamber. I never got tired of admiring the beautifully carved walls of the cave. All my previous hesitation disappeared quickly, and I soon realised that I definitely wanted to go back!

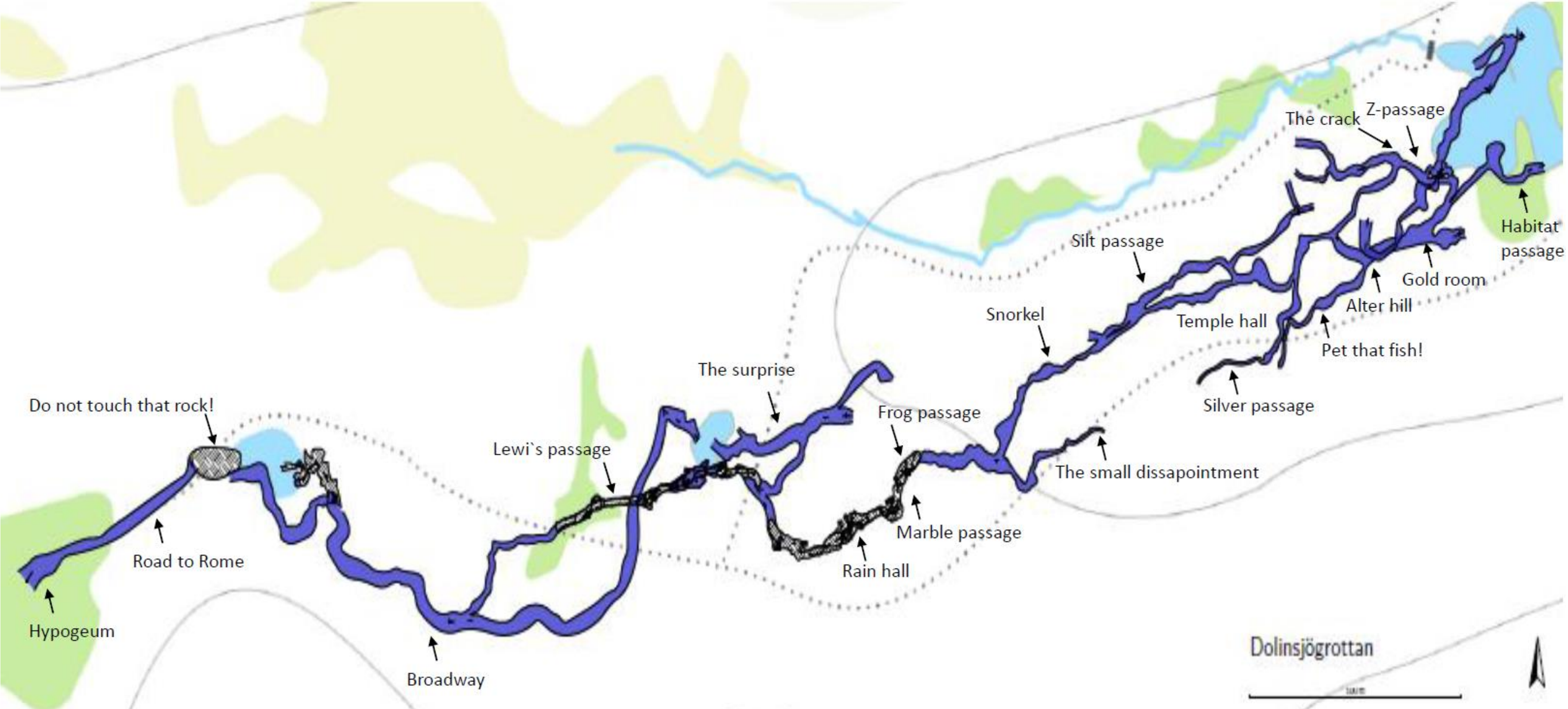

Figure 17 Map of the Dolinsjö cave with names of the various passages