

Speleological Mapping in the Northern Part of Moravian Karst

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SUMMARY

Moravian Karst is one of the longest explored karst areas worldwide. It's situated north of Brno on a surface of 100 sq km. The longest cave system is Amaterska cave, having more than 35 km of underground corridors. The system of Amaterska Cave also contains the world famous Punkevni Caves with Macocha abyss.

The Czech Speleological Society has had a long term cooperation with the Faculty of Civil Engineering at Brno University of Technology. Several special projects have focused on karsological mapping over the past 10 years. The main aim of these projects was the precise localisation of the cave systems towards the surface and towards other caves.

A precise geodetic control point's network was established in the Northern Part of the Moravian Karst using GPS technology. This network was used for the precise localization of the cave entrances. The main sink holes on Ostrov Plateau were surveyed by GPS as well as by the Czech Speleological Society – the caving club Pusty Zleb started a new surveying of Amaterska Cave in 1993. The main polygon was surveyed using a total station with tripod set. More than a 5 km long free polygon was tied through the complicated underground terrain all the way to the end of Sloupsky Corridor. During the survey, it was proven that the old survey was invalid. The new survey was approved using the radio-beacon method.

The main target of the latest speleo-explorations in this region has been the search for a connection between Amaterska Cave and the Sloupsko-sosuvské Caves. Both caves are separated by a system of several sumps (siphons) which must be dived to get through. The radio-beacon method was also used to locate a chimney between sump No. 4 and No. 5, which is getting very close to the surface. Cavers opened an artificial shaft in this place to gain better access to this part of the chimney. A comparison of the maps of both systems led to a physical connection of both caves in November 2005.

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1. PREFACE

The Czech Speleological Society has been working together with the Institute of Geodesy of BUT (Brno University of Technology) on surveying projects in Moravian Karst for more than 30 years. Several special projects focused on karsological mapping undertaken over the past 10 years. The main aim of these projects has been the precise localisation of the cave systems towards the surface and towards other caves. During this period, a couple of diploma theses in the field of speleological mapping have been submitted by the Institute of Geodesy. Cavers cooperate with the Institute of Geodesy in the teaching of a special seminar called "Speleological mapping", which is voluntary for students of Geodesy and Cartography at BUT.

This article presents the common activities of both institutions regarding the documentation of the Northern Part of Moravian Karst and its longest cave system, namely Amaterska cave. The main aim of the surveying projects was to document the exact course of the underground corridors connected with the Sloupský potok River, with the aim of finding the connection between the system of Amaterska cave and the Sloupsko-sosuvské caves.

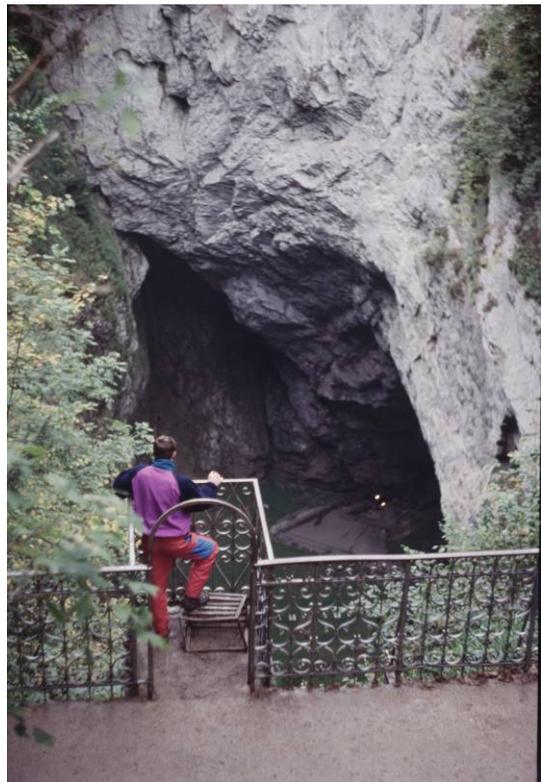
2. MORAVIAN KARST

Moravian Karst belongs to the most famous karst areas in the world. It is situated to the north of Brno on an area of almost 100 sq. km. It is the largest and most developed limestone region in the Czech Republic. A strip of Devonian limestone creating the Moravian Karst is 24 km long and 2 to 6 km wide. Underground rivers divide the region into three main hydrographic systems:

- Northern system - river Punkva and its tributary streams Sloupský Potok and Bílá Voda
- Central system - Jedovický streams and Křtinský Potok
- Southern system - Hostěnický streams Potok and Říč• ka

More than 1100 caves and abysses are registered in the entire region. Some of them are long systems formed by underground rivers. The largest system is the Amaterska Cave - more than 35 km long. There are also several caves for public visitors and the whole area is very attractive for tourists. You can also find various karst phenomena in the Moravian Karst like dead-end valleys, shake holes at outlets of karst streams, sinkholes, canyons (named "žleby") and karrens.

Moravian Karst was declared a national park as early as 1956 and later on there were other reserves



set up.

Moravian Karst is one of the limestone areas in Europe where the earliest serious speleological research was started by the end of 19th century. Thanks to karst researchers such as M. Kříž, J. Wankel and K. Absolon,

Moravian Karst even became well known among European speleologists. With the help of modern technology, the research was unparalleled at the time and later Moravian Karst became one of the bases for modern speleology. With regard to the discovery of new caves, extensive archeological and paleontological studies were in progress too. There was also a good international response.

3. AMATERSKA CAVE

Amaterska Cave is the longest cave system in the Czech Republic with a length of over 35 km. The cave system is bound on two main rivers: Bila voda and Sloupsky potok, creating the River Punkva inside Amaterska Cave. The whole system is created by the connection of separate caves: Nova Rasovna, Pikova Dama, Spiralka, 13C, Amaterska Cave, the Sloupsko-sosuvske Caves, the Punkevni Caves and Macocha Abbys.

3.1 History of explorations

The history of explorations of the entire system already began in the 18th century. Already in 1723 Lazarus Shopper realised the first descend into Macocha Abyss. In 1800 a first map of the Sloupske Caves was created. Systematic research began in the second half of the 19th century, when Dr. Jindrich Wankel and Martin Kriz published the first scientific studies of the Northern Part of Moravian Karst. Prof. Karel Absolons was the first to define a theoretical connection between the Sloupsko-sosuvske Caves, Nova Rasovna cave and Macocha abyss at the beginning of 20th century. He spent his whole life working on the clarification of this speleological problem. He only partly succeeded, but Amaterska cave as a main key to this problem was explored in 1969 by the Planivy Caving Club . Within a short period of time, corridors connecting caves from a water sink in Nova Rasovna up to the resurgence in Punkevni cave were explored. The last unfinished part between Amaterska cave and the Sloupsko-sosuvecke Caves remained unexplored until 2005.

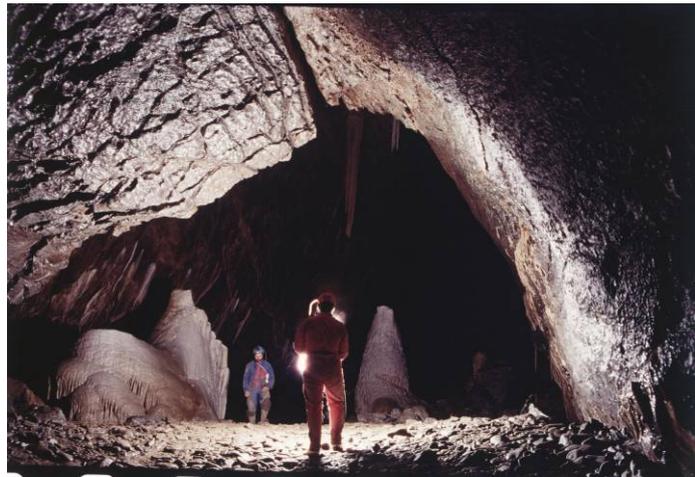
3.2 Description of the Amaterska cave

In fact, Amaterska Cave is the connection between the water sinks of Sloupsky Potok and Bila Voda and the water resurgence of the Punkva River, which is created inside Amaterska Cave by a connection of both main water streams. The cave itself is characterised by extensive tunnel passages with varying amounts of fluvial deposits and screes. The passages sometimes change into big domes. Those passages represent a higher cave level of about 20 m above the lower cave level where the rivers are still active. In some parts of the cave (Sloupsky Corridor, Labyrinth of Milan Slechta), even more such cave levels can be found. The lowest part of the system is always under water and its exploration can only be done by using cave diving techniques.

Amaterska Cave can be divided into 3 main parts: Sloupsky Corridor, Bila voda branch together with Old Amaterska cave and Macosky Corridor. Amaterska Cave can be entered by one natural entrance in Cikansky Sink Hole or through an artificial one under Konsky Spad in Pusty Zleb canyon.

3.3 Sloupsky corridor

One of the last unsolved problems of Moravian Karst was the connection between Amaterska Cave and the Sloupsko-sosuvecké Caves. In 1989 a sump at the end of Sloupsky corridor was dived through and around 1500 m of new corridors were able to be explored. The way to the Sloupsko-sosuvské Caves was blocked again by the sump. The Pustý Zleb Caving Club concentrated its activities on solving this problem in 1987 when digging works in Sloupské Vintoky cave started. A massive research of an underground passage of the Sloupský Potok River started in 1992. In the same year, a new survey of Amaterska Cave was also begun.



U Dvou Velkých dome – Amaterska cave

4. SURVEYING WORKS

A precise map of a cave is always the most important tool of a cave explorer. The mapping of the caves and karst has a long tradition in the Moravian Karst. The very first serious maps were created as early as the 18th century. In light of the fact that most of the main cave passages have already been explored, current explorations require more precise maps. Therefore, the classical methods of speleological mapping are not sufficient and the use of methods of mine surveying becomes necessary.

4.1 Methods of speleological mapping

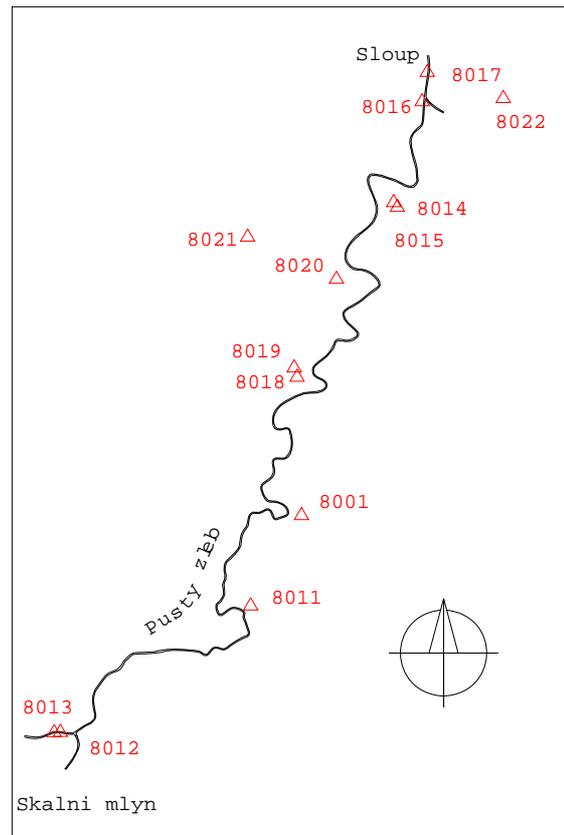
It is necessary to point out the methods of mapping being used in Moravian Karst to understand the problematics. Basically we can split them into 3 basic groups:

1. Precise mapping – Methods of classical and mine surveying are being used. Angles are measured using theodolites (perhaps compass theodolites) or total stations. Lengths are measured by using electronic distance meters (EDM) or steel tapes.
2. Classical speleological mapping – Usually magnetic survey when hanging or a geological compass is used for azimuth measurement. Lengths are measured by tapes and inclination by clinometers.
3. Orientation mapping – Mostly expedition mapping or mapping in hardly accessible passages like underwater sumps, abyss etc. Simple instruments are used for surveying. Marked guide lines and depth gauges are used to measure the underwater passages.

4.2 Surface activities

4.2.1 Basic network

To be able to localise separate caves and their relations in between in the region, it is necessary to have a good network of surface points. A network of such points was created using GPS static methods. The stations of a basic network DOPNUL were used to determine the transformation parameters from global coordinate system ETRF-89 (WGS-84) into the national coordinate system S-JTSK. A surveying network created by a couple of polygons measured by total stations was inserted in between “GPS” points. As the heights are usually even more important for speleological hydrological studies, a precise levelling method was used for the calculation of point elevations in the Bpv height system (Datum). All the points were stabilised by fixed nails or plastic marks. These points are later used to survey the cave entrances and underground polygons. Each point has its topography to allow its localisation later on. RMS in plane coordinates of these points was in all the cases better than 30 mm.



4.2.2 Mapping of the cave entrances and surface karst phenomena

Each cave entrance in Moravian Karst is marked with a metal plate with a registration number. These plates are also used as basic points for an underground survey of the cave. The most important caves in Pustý Zleb canyon were connected “into coordinates” by attaching their basic points into the surveying network.

During the GPS measurements on Ostrovska Plateau, carried out within the framework of the diploma theses, the borders of the most important sink holes were also surveyed using GPS Stop & Go method. The exact localisation of the sink holes on the plateau helps not only the karst scientists, but also enables the protection of these phenomena. Sink holes are later taken out of the agricultural cultivated fund and no fertilising is permitted on the surface at the top of the cave systems.

4.3 Mapping of Amaterska cave

Several surveying campaigns have been running since Amaterska cave was explored in 1969. Pribyl and Rejman (1980) published a map of the system at a scale of 1:2000. Cavers from the Czech Speleological Society have ascertained that this map is not precise enough in some parts. Therefore, a decision for a completely new survey was taken. The Holstejn Caving Club started with a resurvey of the old part of the system in 1988. Compass theodolite was used to survey the main polygon. Resurveying of Nova Amaterska Cave started in 1992.

4.3.1 Main polygon

The main polygon was surveyed using a total station with tripod set. A more than 5-km long free polygon was tied through the complicated underground terrain up to the end of Sloupsky Corridor. Horizontal angles were measured in two sets. As many of the points as possible from the Pribyl and Rejman (1980) measurements were used. To approve the correctness of the survey, a radio-beacon method has been used. Coordinates of 187 new underground points were determined in the underground network adjustment. Aprior RMS of all the measurements were approved by using the radio-beacon method and the accuracy of the end point of Sloupsky Corridor in front of the first sump comes to 2.5 m. During the survey, it was proven that some parts of the old survey were invalid.

4.3.2 Other parts of the cave

Precise surveying techniques were used only to survey the main corridors. Other parts were mapped using geological compass, tape and clinometer. These surveys were adjusted to the main polygon points. During many surveying trips other separate parts of the system were mapped. The surveying of underwater passages was started at the same time.

Detailed sketches were made during those surveys to enable the creation of maps describing the cave morphology after data processing. Many surveys were very difficult on account of the cold water and lots of mud filling up most of the cave corridors in Moravian Karst.

4.3.3 The Radio-beacon method

Radio A radio-beacon was first used to determine the position of an underground cavern against the surface already in 1972. Two members of the Pusty Zleb Caving Club constructed a new version of this device for the purpose of looking for the connection between Amaterska Cave and the Sloupsko-sosuvske Caves. It was also used to verify the Amaterska Cave survey and later to determine the place where the new entrance shaft into the system was to be dug out. This shaft helped the cavers to access the passages behind complicated underwater sumps.

The radio-beacon is created in two parts: a transmitter placed underground and a receiver on the surface. Both of these create a set of two inductors with inductive binding with a very low factor of binding. A transmitter antenna is placed horizontally in the underground passage and an attendant on the surface then looks for a place with strongest signal using a receiver antenna in horizontal position.

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Shaping the Change

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Survey in hard accessible muddy passages in Sloupsky corridor of



Radio-beacon receiver

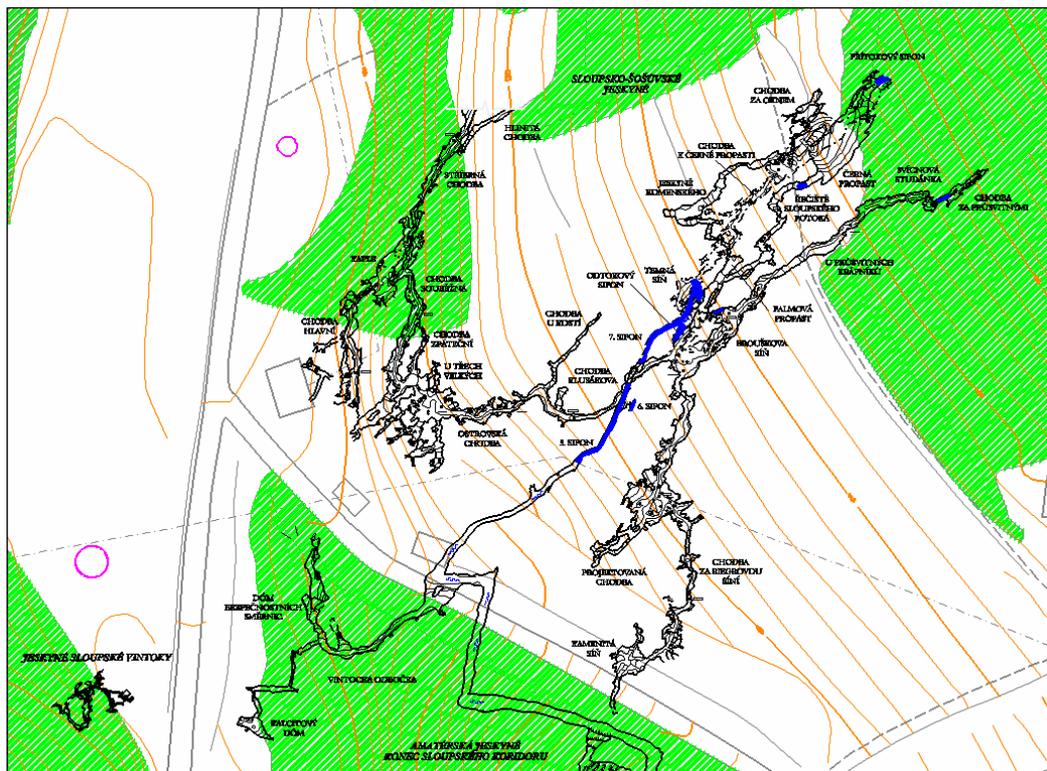
This position is later made more precise with the antenna in vertical position, searching for the minimum of the signal.

5. MAP PROCESSING

All the surveying data were processed digitally. GPS data were processed using LEICA Ski Pro software. For network adjustment a G-NET software was used. Data from speleological mapping were calculated in specialised software On-Station. Maps based on the surveying sketches were manually drawn into printed polygons. These maps were scanned and digitised in Microstation software where final digital maps were created.

6. CONCLUSION

A basic surface surveying network was created through a mutual cooperation of the Czech Speleological Society and the Institute of Geodesy BUT. This network can be used for all the future mapping activities in Northern Part of Moravian Karst. A resurvey of Amaterska Cave was started and it is expected to be completed in upcoming years. The new entrance to Amaterska Cave in the south of Sloup village was opened from the surface thanks to new precise maps. Finally the connection between Amaterska Cave and the Sloupsko-sosuvské Caves was found in November 2005 during diving explorations in the Seventh Sump. The survey of this part of Amaterska cave between the 1st and 7th sump is currently ongoing. The maps created are used not only by cavers but also by various scientists like geologists, hydrologists and also for purposes of nature protection.



The authors would like to thank to all the amateur cavers who participated in the above- mentioned activities and helped to create the maps of caves. Without their hard work in their free time it would not be possible to explore a single meter of the new cave in Moravia Karst.

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BIOGRAPHICAL NOTES

Jan Sirotek graduated from Brno University of Technology in 2000 as a surveying engineer. Since 1990 he has actively been participating in cave research in Moravian Karst, mainly in its Northern part. He has been a member of the Czech Speleological Society since 1991. He has been the president of the Pustý Žleb Caving club since 2000 and the Head of the Cave Diving Commission of the Czech Speleological Society since 2002. He leads the mapping team which is working on the survey of Amaterska Cave and is the author of many maps of dry and underwater caves in Moravian Karst. He has also participated in many expeditions to Slovakia, Austria, Hungary, Romania, Albania, Monte Negro, France and Mexico during which a documentation of various cave systems was done. Most important are the mapping activities of Dalovica cave which belongs to the longest cave systems in the Balkans. He has also carried out the documentation of large underwater cave systems in Yucatan in Mexico. Jan Sirotek is currently working as a Sales Manager in GEODIS BRNO Ltd, which is the leading Central European Company in the field of surveying, photogrammetry and geodata processing.

Josef Weigel was graduated in 1975; 1981 first scientific degree (Ph.D.); 1987 Associate professor Brno University of Technology (BUT), since 1979 member and since 1992 National delegate for Commission 2 of FIG, since 1994 chairman of the Czech National Committe for FIG. Since 2004 he has been the Head of the Institute of Geodesy BUT. His activities focus on geodetic networks, theoretic geodesy, the theory of errors and adjustment, GPS measurements and also cave measuring and speleology.

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