Name of research institute or organization:

Swiss Society of Speleology, sections Bern and Interlaken

Title of project:

Exploration of the Jochloch Cave

Part of this programme:

SGH Bern, SGH Interlaken

Project leader and team:

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Project description:

In 1983, the construction of the new restaurant building at Jungfraujoch required galleries to be built above the railway station in order to place and secure the rooftop anchors. During these construction works, the high-alpine *Jochloch* cave (Fig. 1) was discovered: a small cavern of about 100 m length in a thin layer of limestone (Fig. 2) between two layers of granite [Keusen 1987]. The southern part of the cave and its side-branch were accessible at the time of discovery, but were later partially filled with concrete for the construction works [Häuselmann 2004]. The northern part was originally blocked with ice, but because of the increase in temperature in the rocks - as a consequence of climate change and the new restaurant building operations - the northern part of the cave became accessible for an extent of about 100 m by 2002 [Häuselmann 2004]. A pollen analysis was made of samples from various layers in the sediments that were taken just before the construction works, suggesting that the cave was formed during the upper Pliocene or lower Pleistocene. However, there were strong limitations for determining the age of the cave using the pollen method (*palynostratigraphy)* [Groner 2004].

In August 2002, the cave was mapped in detail for the first time by a team of the Swiss Society of Speleology sections Bern and Interlaken [Häuselmann 2004]. Another visit took place in June 2004 and again five years later in April 2009 [Häuselmann 2009]. The main goal of the latter visit was to follow up on the evolution of the ice deposits in the cave after the rock had been warming, and to verify whether further exploration would be possible as a consequence. The team concluded that the ice indeed had shifted towards the north by about 10 meter but also that after this location, a lot more hoarfrost was present: they actively had to dig their way through the ice in order to reach the end point of the cave of 2004 [Häuselmann 2009]. It was recommended to revisit the cave in the future for further monitoring. The expeditions were done in collaboration with Geotest Ltd. and with permission from the Jungfraubahnen. Finally, in 2012, the Jungfraubahnen opened the new tourist attraction *Alpine sensation* that guides the tourists through the large entrance hall of the cave on a footbridge (Fig. 3) towards the *Eispalast*.

This year (2017), three expeditions to the high alpine karst cave *Jochloch* at Jungfraujoch took place in April, June and July. The main goals of the expeditions were - like in 2009 - to monitor the changes in the ice coverage in the cave due to the increasing temperatures, to examine possibilities for further exploration (incl. mapping) beyond the *Endmäander*, to document the cave via photography and videography, and to a minor extent also professional caving photography.

To our unpleasant surprise, during the first expedition in April 2017, rubbish was found in the first few halls and cleaning took place during the first and the third expedition. The rubbish was (locally), spread out and shattered into smaller pieces possibly indicating the presence of some animals, like foxes or martens, that may have entered via the Jungfraujoch tunnel system, as was suggested by [Häuselmann 2004] through findings of excreta.

A strong cold air flow in the direction of the entrance hall was felt in April in the first flattener between the large entrance hall and the first hall, but it was less noticeable in June and in July. This air flow is likely due to the temperature gradient in the cave [Häuselmann 2004]. The temperature in the entrance hall was roughly +5°C with a relative humidity of 60%, while in the *Endmäander*, the temperature was about -2°C with a relative humidity of 100%. [Häuselmann 2004] has reported a range of about +2°C to an estimated -3°C. This change may be attributed to the warming of the rocks and/or the new tourist activities in the tunnels (e.g. installation of lamps in the cave entrance hall, see Fig. 3), and is to be verified.

Although [Groner 2004] suggested that ice in the cave possibly has entered from outside, today we know that much of the ice is hoarcrystal ice deposited on the walls of the cave. Apart from one patch of water ice on the cave floor at the entrance of the *Kristallkammer* (also seen in 2009 but then still thicker), there was no indication of running or meltwater in the cave. In 2009, very small ice stalactites were seen in one location [SGHIweb 2009]. The southwestern parts of the cave have plenty of loose rocks on the cave floor due to freeze-thaw cycles, and scallops are visible on the walls in some of the sections (Fig. 4) giving clues about how the cave was formed [Häuselmann 2004].

From visual inspection, the *Kristallkammer* (Fig. 5) had less ice than reported in 2004 [Häuselmann 2004], and there were no big ice crystals. Contrarily, the squeeze after the *Kristallkammer* was fully covered in ice, initially leading to some confusion about our position in the cave because we used the map of 2002. Since our colleagues have had to dig through the ice in order to reach the *Endmäander* in 2009 [Häuselmann 2009], it seems that the ice has migrated mainly between 2004 and 2009 although also afterwards a decline in ice coverage in the *Kristallkammer* is noticed (2017) accompanied by a different ice morphology due to sublimation or melting. We were spared the effort of digging because another caving team had visited the cave in November 2015: they had to dig their way through the hoarcrystal ice before us [Lütscher 2017]. We found their temperature logger in the *Endmäander* during our expedition in April, got in touch, and replaced it for them with a new one during the expedition in June (Fig. 6).

The possibility of continuation beyond the *Endmäander* was examined and seems indeed feasible, provided that the relatively loose mix of ice and sediments on the cave bottom be displaced to make more space to pass, and provided that the distance to do so is not too far. An attempt was made to estimate the distance between the *Endmäander* and the *Kaverne 2* using an Avalanche transceiver but no accurate result was obtained because of the transceiver model and inhomogeneities in the rock. Such methods had proven useful in caving for short distances (approx. 5-10 m) in order to locate the exit of a cave on the surface with respect to the end point below the surface, but seem to be less useful for longer distances. In order to estimate precisely the distance from the *Endmäander* to the ice surface, a visit was made to the premises of Geotest Ltd. in November 2017 to discuss the position of the cave within the rocks. From the 3D-model of Jungfraujoch, the distance from the *Endmäander* to the ice surface is probably roughly about 20-30 meter. If it exists, the cave exit is probably located below the ice, above the Bergschrund on the north face of the Jungfraujoch rocks (in Berner Oberland) west of the Sphinx.

During all three expeditions, caving pictures and video footage were taken as well as specific pictures of the ice crystals (Fig. 7, 8) for use in a textbook on arctic science by Dr. Carol Norberg. The biggest crystals were hexagonal and measured up to about 12 cm in diameter (Fig. 8). There was no visible change in crystal size between the expeditions of April and June.

We owe many thanks to the Jungfraubahnen and to the Jungfraujoch station personnel for the permission to enter the cave and for the great practical support. We also thank the local staff of the Jungfraujoch research station as well as the HFSJG staff at the University of Bern for their great support and enthusiasm. Finally, we are also grateful to all our collaborators for the very useful information and feedback.

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[Lütscher 2017] Pers. comm. Dr. Marc Lütscher. 19 April 2017.

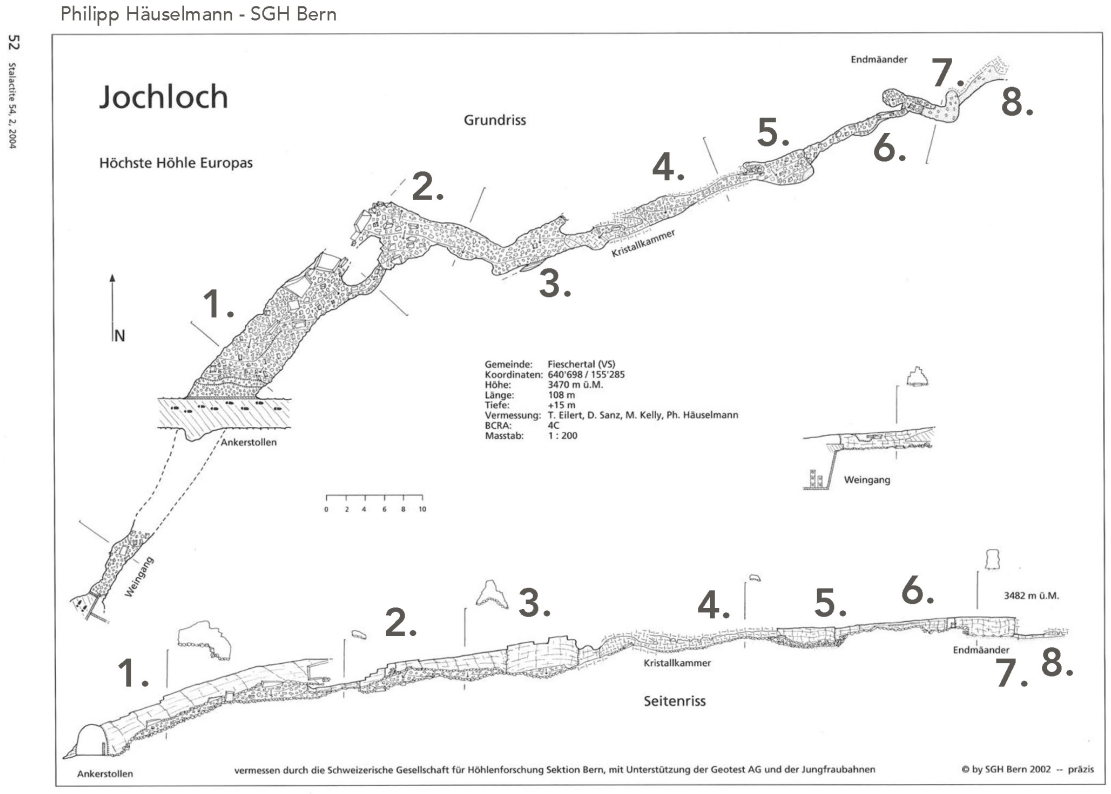

Figure 1. Map of the Jochloch cave (Dr. Ph. Häuselmann – SGH Bern, 2002).

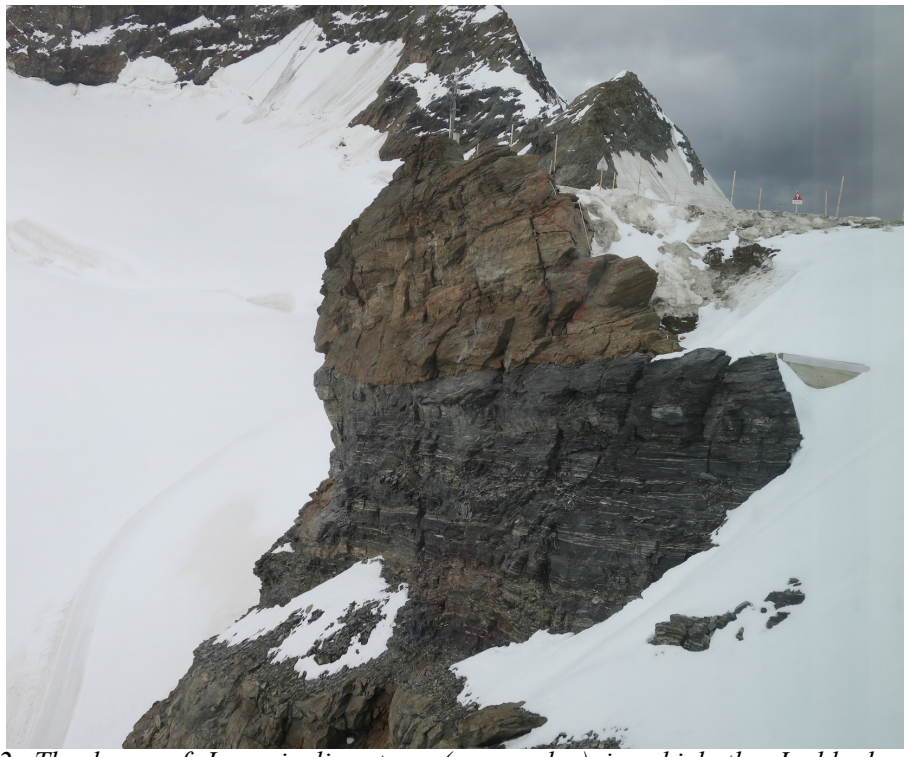

Figure 2. The layer of Jurassic limestone (gray color) in which the Jochloch cave was formed, between the layers of Jungfrau "granite" (top, brown color, mainly mica-rich gneiss and schist [Groner 2004]) and Gastern granite (bottom) [Groner 2004]. Picture by Veerle Sterken, July 2017.

Figure 3. The large (tourist) hall of the Jochloch cave. Picture by Christian Lüthi, July 2017.

Figure 4. Cross-section of the Jochloch cave between the first hall and the Kristallkammer. Visible in the foreground are some scallops hinting at a phreatic origin of this part of the cave, while on the floor are many tiles from freeze-thaw cycles as mentioned by [Groner 2004]. Picture by Christian Lüthi.

Figure 5. Martin Gasser in the Kristallkammer (left, April 2017) and Christian Lüthi in the Endmäander (right, July 2017). Pictures by Veerle Sterken.

Figure 6. Christoph Seiler and the temperature logger in the Endmäander (June 2017). Picture by Veerle Sterken.

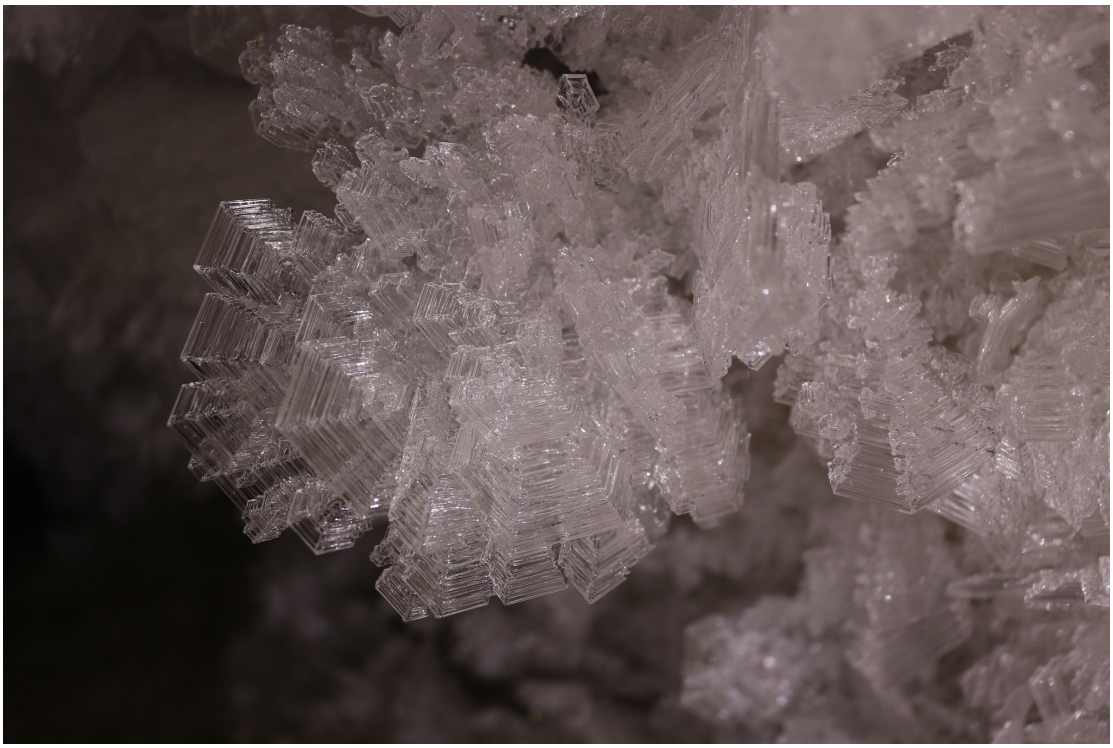

Figure 7. Large ice crystals near the Endmäander (June 2017). Picture by Veerle Sterken.

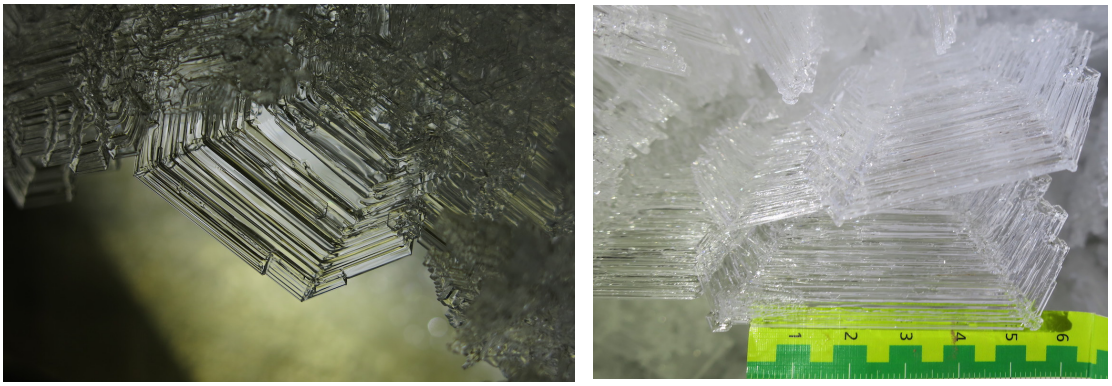

Figure 8. Ice crystals in the Jochloch cave. Pictures by Christian Lüthi (left) and Veerle Sterken (right), July 2017.

Key words:

Cave exploration, hoar ice crystals, caving photography

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