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Melting underground ice masses in Hochtor massif, Gesäuse National Park – documentation and implications for the water resources of alpine karst

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Abstract

Since 2002 hundreds of caves were surveyed in the Hochtor massif. Some cirques covered by large firn fields in 1920 are now snow-free revealing clusters of shaft caves. In some of them ice masses reached depths of hundreds of meters. During the last 15 years we observed a rapid subsurface glacier retreat in those places. This is seen as a dramatic signal of climate warming and contributes to a change of alpine landscape and biosphere. We expect adverse consequences for karst water resources in the Northern Calcareous Alps, which make a major contribution to drinking water supply in Austria.

Keywords

climate change, cave research, subsurface glacier retreat, ice caves, alpine karst, drinking water supply

Introduction

The Hochtor range in Gesäuse National Park belongs to the eastern part of the Northern Calcareous Alps. With an elevation of 2.369 m the summit of Hochtor marks the highest point, while the river Enns passes the massif in less than 600 m.a.s.l. In its upper, eastern and southern part the range is built of triassic Dachstein Limestone and Dachstein Dolomite. Despite of its rugged profile the massif is intensively karstified and penetrated by a large number of mainly vertical caves. The majority of precipitation drains the bedrock while the groundwater leaves the karst system in springs near the bottom of the surrounding valleys. Up to the 20th century the surface of glacially formed cirques was extensively covered by firn-, ice- and periglacial debris, as is documented in historic pictures and maps. Therefore the majority of shaft entrances, dolines and karrenfields in these areas had been hidden below this cover, and the massif was regarded as speleologically insignificant and poor in caves and other karst features.

2002 some members of VÖH and LVH Wien/NÖ[1] with good alpine climbing skills started investigations to document the existing karst features, especially the caves of this area, which had been nearly unexplored in respect of speleology (Fig. 1). Aside from numerous other surprising facts these explorations revealed extended subsurface ice bodies in the majority of shaft canyons in high altitude areas and cirques. Until recently those relicts of a colder climate in the past had blocked the vertical caves, but today, after the firn basins on the surface have disappeared. A rapid melting process can be observed which seems to be a further dramatic signal of climate warming.

The pristine alpine landscape of Gesäuse National Park offers the opportunity to monitor this natural process in an area nearly undisturbed by human activity. Monitoring results could be of high value for drinking water supplies in the neighbouring regions. On the other hand, the melting process of the underground ice is to some extent regarded as a consequence of man-made global warming which contributes to a change of alpine landscape, of the karst water system and the biosphere.

Methods

As far as the adverse circumstances (extremely steep terrain, weather conditions, episodic snow cover, little number of willing and fairly experienced volunteers) allow, a systematic documentation of caves and other karst features like karrenfields and dolines is driven forward. Following consistent standards all cave entrances get georeferenced and caves are mapped in scale 1:200 and 1:500 (vertical sections) respectively. Together with photo-documentations and verbal descriptions, these data are registered in the Austrian Cave Index as well as in the 'SPELIX' GIS database. The outcome as presented in this paper is one of the unexpected side-products of this systematic documentation. Becoming aware of the phenomenon, special attention has been directed to its influence on karst morphology and impact on karst water discharge.

[1] Verband Österreichischer Höhlenforscher (Austrian Speleological Association) and Landesverein für Höhlenkunde (Federal Association of Speleology)

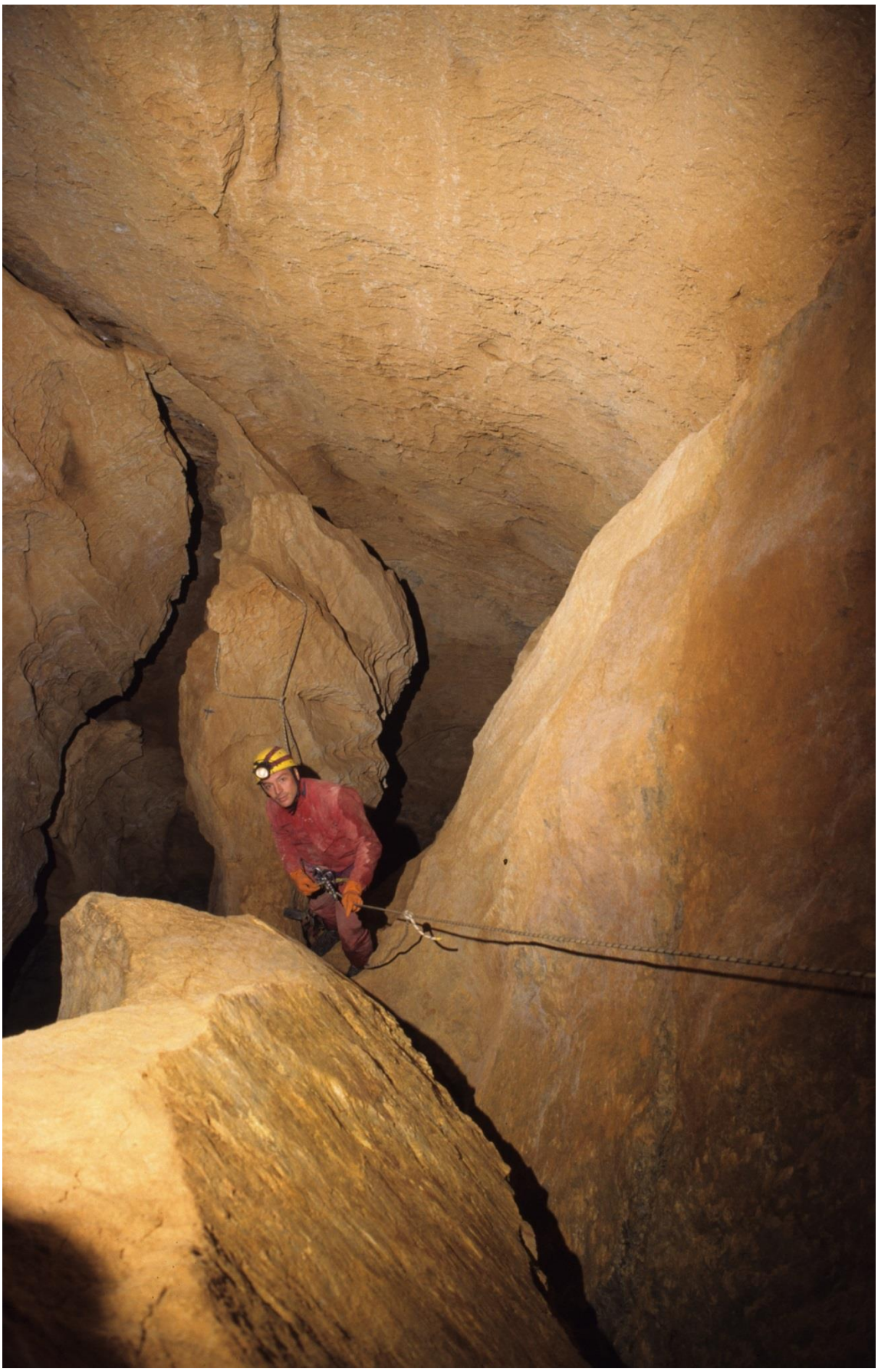

Figure 1: The cavers need good climbing skills, not only because caves and shaft canyons are often difficult to reach in the steep terrain of the Hochtor massif, but also to move up and down the shaft canyons. Photo: Eckart Herrmann.

Results

Annual field work resulted in the knowledge of more than 400 caves in the region. In the cirques of Schneekar/Schneeloch we discovered areas with more than 15 caves per hectare being accessible for man and many more dolines and blocked shafts (Fig. 2). But also in the other cirques like Roßkar, Seekar and Steinkar shaft entrances are abundant. The majority of these 'caves' is dominated by steep and winding canyon shafts, some of them leading into depths of more than 600 m, including giant single shafts of up to 170 m in depths and 30 m in diameter (Fig. 3). In contrast to other parts of the Northern Calcareous Alps, significant horizontal caves are only present at very low levels of Hochtor massif. The shaft canyons were formed in the underground by infiltrated meteoric karst waters and later became overcast by cirque glaciers and periglacial erosion in the side walls of the cirques.

Figure 2: In an area of the cirque called Schneeloch that was covered by a firn field up to the 20th century, there appears a high density of scree-covered shafts with melting ice bodies inside. Photo: Reinhard Fischer.

When field work began in 2002 we supposed numerous shaft dolines with only a few meters in depths being completely clogged by blocks. Scree slopes seemed to spread over bedrock in thick formations. But then we observed currently sinking depressions, and some years after the vanishing of firn fields we noticed that periglacial debris had built just a thin layer between the karstified bedrock and the firn cover. Subsequently we could find our way into deep shaft systems where we found remains of an expanded former ice filling, but only sparse remnants of debris. We detected stratified ice bodies (and fresh snow) down to 250m below the surface. (Besides, we discovered a block glacier in a cirque east of Hochtor peak, called 'Tellersack'). In places where debris still covers the rock surface the opening of new shafts or genesis of new dolines within a year could be observed accidently in some cases (Fig. 4).

Figure 3: The basis of a 170-m-step in the shaft canyon Schneekareishöhle, 250m below surface shows breakdown structures caused by former ice filling and freeze/thaw cycles. Photo: Michael Kopitsch.

Figure 4: In 2016 a currently formed doline in Schneeloch scree slope was found accidently. Photo: Josef Hasitschka.

Discussion

According to extreme densities of shaft canyons, a reasonable underground ice volume is supposed to be there, which still rests unrecognized in the karst underground but will probably disappear within the next years or decades. In contrast to glacier monitoring on the surface (and for some horizontal ice caves) no comparable long term observation on these shaft fillings is known.

In high alpine karst with bare bedrock the water storage capacity of epikarst is low. Therefore the inner mountain ice formation could play an important role to balance the discharge of karst springs, and a loss of cave ice could contribute to shortages in water supply during dry weather periods in summer. Without respect to the specific cave formation in the Hochtor range huge, but melting ice bodies in alpine shafts seem to be a widespread phenomenon (WEIßMAIR 1995, SPÖTL & PAVUZA 2016), also in karst massifs with important water supplies for parts of the Austrian population including major cities like Wien, Graz and Salzburg.

In many cases existing ice bodies contain datable organic substances like wood and bones. Respective radiocarbon datings from other parts of the Northern Calcareous Alps delivered ages reaching back to the holocene climate optimum (ACHLEITNER 1995, HERRMANN et al. 2010). It can be assumed, that during the quaternary climate fluctuations shafts opened due to melting ice plugs. The open shafts were covered by scree periodically, but they did not get filled up with debris.

Recommendations and future perspectives

Cave documentation is almost entirely done by volunteers. Scientific benefit should be taken as long as some people are willing to address themselves to this time-consuming, demanding and dangerous work. To get a better understanding of formation and origin of underground ice bodies observable stratifications should be recorded and radiocarbon datings should be done whenever possible.

Apart from the fieldwork it would be of great interest to compare dated historic pictures of the national park‘s stock of images and other accessible sources with the present surface status, to gain a more detailed picture of firn retreat and subsequent (re-)uncovering of karst phenomena. This was a detail task in the project ‘Landschaft im Wandel’ (Changing Landscape) which aims to describe the changes of the landscape in the Gesäuse National Park and its surrounding areas from the beginning of field mapping to the time of the founding of the National Park (HASITSCHKA et al. 2014). Finally, it should be mentioned, that up to now no continuous surveys of karst spring discharges were implemented at the springs in this massif; a cooperation with recognized institutions like

Joanneum research is recommended. For scientific speleology a provisional estimate of the ancient and present underground ice mass in Hochtor range remains as open question.
Caves are natural archives of the past, and in this special case the retreat of snow and ice makes more and more alpine shaft caves accessible for human entry. Therefore surprising explorations can be forecasted – not only in terms of untouched ground but also in new scientific problems.

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