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**FEICHTNER CAVE
(KITZSTEINHORN, SALZBURG, AUSTRIA),
A DEEP CAVE SYSTEM DEVELOPING INTO CALCAREOUS
SCHISTS IN A GLACIAL ENVIRONMENT**

JAMA FEICHTNER-SCHACHTHÖHLE
(KITZSTEINHORN, SALZBURG, AUSTRIA),
GLOBOK JAMSKI SISTEM V KALCITNIH SLJUDNIH
SKRILAVCIH V LEDENIŠKEM OKOLJU

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Izvleček

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Philippe Audra: Jama Feichtner-Schachthöhle (Kitzsteinhorn, Salzburg, Austria), globok jamski sistem v kalcitnih sljudnih skrilavcih v ledeniškem okolju

Kitzsteinhorn (3208 m) v salzburških Centralnih Alpah je deloma poledenel kraški svet z dvema nedavno raziskanimi globokima jamama. Obe, "Zeferehöhle" (-560 m) in "Feichtner-Schachthöhle" (-1024 m) sta v kalcitnih sljudnih skrilavcih. Avtor v prispevku razpravlja o njenem nastanku, hidrologiji, sedimentologiji in jamski klimi.

Ključne besede: speleologija, alpska jama, opis jame, Avstrija, Centralne Alpe, Feichtner-Schachthöhle.

Abstract

UDC: 551.44(436)

Philippe Audra: Feichtner cave (Kitzsteinhorn, Salzburg, Austria), A deep cave system developing into calcareous schists in a glacial environment

The Kitzsteinhorn (3208 m) in the Central Alps of Salzburg, Austria, is a partly glaciated karst area with two deep caves recently surveyed. Both the "Zeferehöhle" (-560 m) as well as the "Feichtner-Schachthöhle" (-1024 m) are developing in micaceous calcareous schists. Observations on the genesis, hydrology, sedimentology and the cave climate are discussed.

Key words: speleology, alpine cave, cave description, Austria, Central Alps, Feichtner-Schachthöhle.

Kitzsteinhorn (3208 m) rises above Kaprun City in the Hohe Tauern massif. The Schmiedinger Kees glacial tongue covers the upper parts (Fig. 1). Karst is found in metamorphic micaceous calcareous schists (Fig. 2). Two main karst systems are known: Kitzsteinhornhöhle or Zeferehöhle (-560; Kat. Nr. 2573/2), and Feichtner-Schachthöhle (Kat. Nr. 2573/3) which has recently grown to 1024 m deep. The karst and the caves have been described elsewhere [A. A. 1999; Audra 2000a, 2000b, 2001; Ciszewski 1998; Gajewska 2000; Klappacher 1982, 1992; Klappacher & *al.* 1998; Knapczyk 1983]. Observations presented here dated from March 2000 and March 2001 during the Polish expeditions.

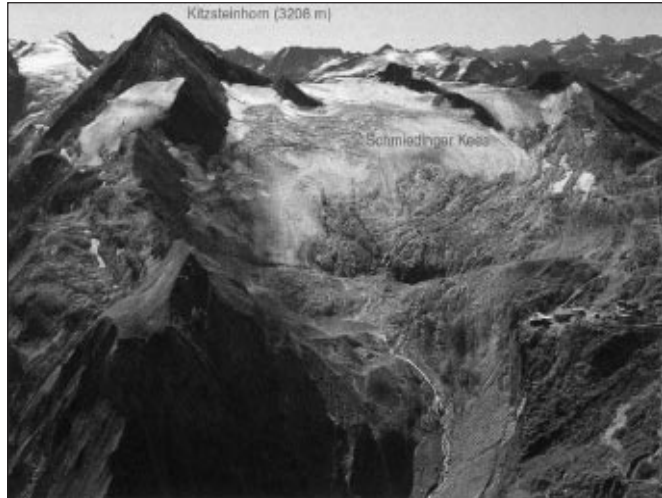


Fig. 1: Air view from Kitzsteinhorn massif, September 1991 (photography: Sliptsky, in Klappacher 1992).

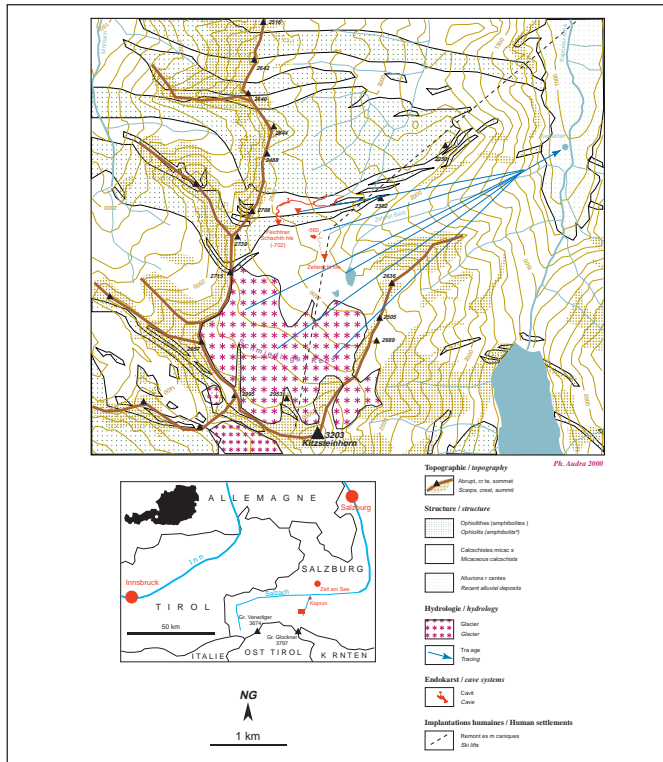


Fig. 2: Map from Kitzsteinhorn massif (topographic and structural setting after Höck & Pestal 1994).

MORPHOLOGICAL SETTING

The cave opens at the top of a small glacial rock bar, not far away from the present glacial front. It is obvious that this cave system was recently covered by the glacier and sometimes acted as a sub-glacial sinkhole (Fig. 3).

GEOLOGICAL STRUCTURE

A great part of the massif is composed of micaceous calcareous schist belonging to the Fusch facies, one of the Pennic "Upper slate mantle" (*Oberen Schieferhülle*), in which are included some ophiolitic slices (amphibolites). These rocks were put in place during the alpine range collapse causing metamorphism [Höck & Pestal 1994].

Calcareous schist presents a greyish mass of calcite crystals into which are inserted small white mica crystals (muscovite, Fig. 4). Aligned parallel to the foliation, their abundance changes according to the different beds, which can be centimetres to decimetres thick. With abundant mica growth, beds become grey-brown. In cross-section it resembles a zebra skin. Beds where mica is abundant weather quickly and mica evolves as clay, giving the rock its dark-brown colour. Overlying rock strata collapse following these micaceous bed foliations.

In the cave, strata dip is regular, 65° to the North (Fig. 5). In places, there are flexures and tightly spaced folds (above the bivouac, in the be-



Fig. 3: Feichtner cave entrance in summer (photography: B. Köppen).

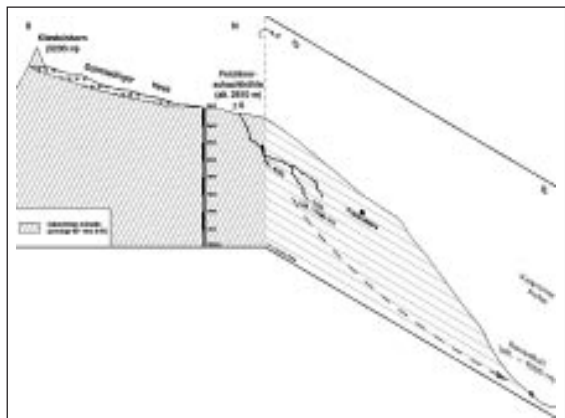


Fig. 5: Geological cross-section near Feichtner cave area.

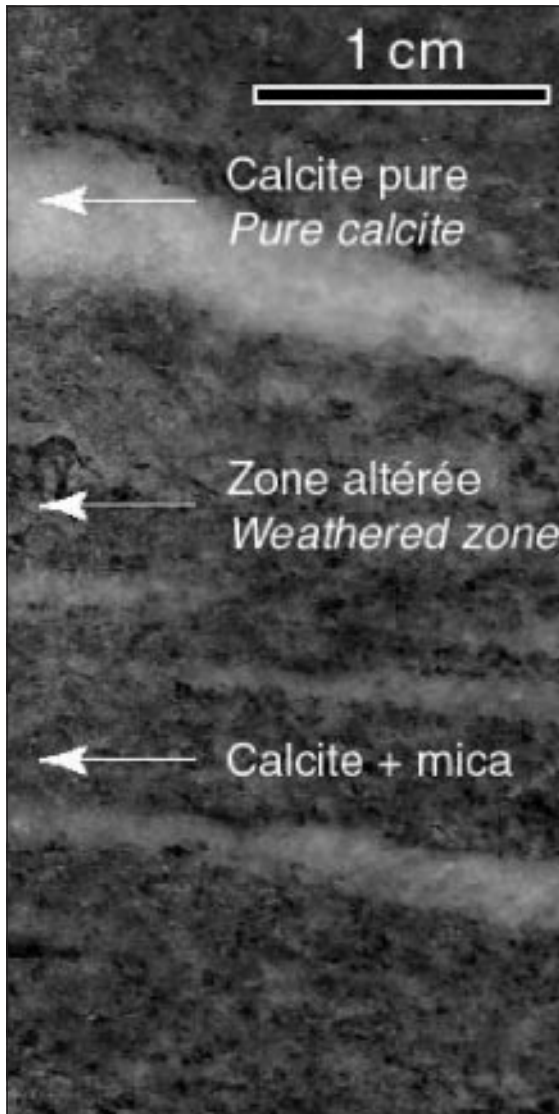


Fig. 4: Polished cross-section of a micaceous calcschist slice (image: Ph. Audra).

During the melt season, a large amount of water invaded the system that could not be evacuated, the spring being plugged by ice and till. The cave system then flooded. The water level rose to a maximum to the level of the meander located in the middle of Zyklopengang (-380) corresponding to at least 600 m of pressure head, based on the present knowledge of the cave. Clay deposits confirm this phenomenon.

ginning of the Crystal's gallery).

Jointing is weak: there are only some dispersed joints and a very low micro jointing. Therefore, except for collapses linked to foliation, the host rock is very compact, making mooring installation easy.

PRESENT AND PAST HYDROLOGY

During winter water flow is nearly stopped. Only some restricted dripping occur in the main gallery at -450 m and in the downstream series below -600 m.

During summer melting, water flow is moderate, but even to high to explore. Consequently, some low points can be flooded locally during high water, such as "Schlüssel zur Unterwelt" (-350) and the squeeze at -450 m, that fills each year with sand and gravel because of a streamlet coming from the gallery.

Dye tracings were made by the power company looking for subglacial water losses [Klappacher 1992]. They have shown that most of the Kitzsteinhorn underground flows feed the Kesselfall spring, located in the gorge around 1050 m asl., just next to the cable-way departure. Transfer velocities show very rapid flows.

The entrance is at present not directly connected with glacial outflows, but it was during glacial events.

In the Crystal's gallery, water flowed eastward, as suggested by several morphologic marks: scallops above Bear chamber (Sala z Miskiemi), asymmetric erosion of old flowstones located over the natural bridge above Umarlych Naciekow pitch. It means that water rose and flooded Crystal's gallery (Kryształowa Galeria). After, it poured as a torrent over Bear chamber threshold until the whole gallery flooded.

FLOWPATH INITIATION AND EVOLUTION

Flowpaths initiate at the intersection of a vertical joint and steeply sloping foliation layers. They act as sloped tubes in a flooded regime, at least during the flow season. Then they evolve as vadose canyons and pits, by enlargement and linear entrenchment. Corrosion and mechanical erosion from waterfalls and rock debris brought by torrents occur, promoting mechanical breakdown in schist (Fig. 6).

Crystal's gallery is laid out following strike direction (Fig. 7). It used to evolve mainly in phreatic conditions. After the ceasing of water flow in the conduit, flags collapse along beds limits. These flags are only several centimetres to several decimetres thick, up to several square metres in area. Walls located on the upward side of dip were smoothed by corrosion those on the downward side are unstable and fall as flag breakdowns (Fig. 7).

Corrosion puts into evidence



Fig. 6: Entrance shaft series. Note calcareous schist strata strong dip (photography: B. Köppen).

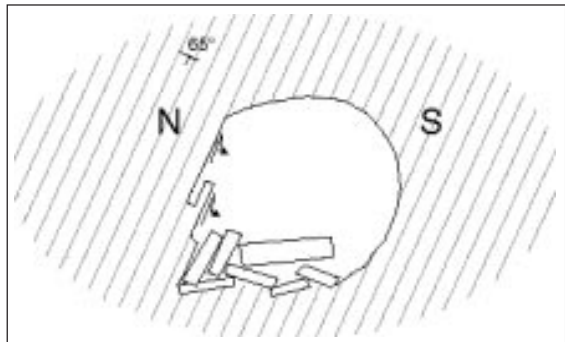


Fig. 7: Schematic cross-section of the Crystal's gallery (- 450).



Fig. 8: Calcareous schist karren (photography: Ph. Audra).

lithological contrasts. Less micaceous more soluble beds are hollowed, while more micaceous ones jut out for several centimetres. With air and moisture contact, they weather and become brown before disintegrating. On surface karren, on the contrary, where frost is active, the hollowed parts are the more micaceous beds (Fig. 8).

Zyklopengang large voids are linked to the presence of thick (1-3 m) micaceous-rich beds that are more weathered. The initial flowpath initiated in the more soluble calcite-rich beds, following strong dip. After being enlarged, overlying weathered micaceous flags felt, giving large breakdowns and evolving as large sloped chambers.

MINERALS AND FLOWSTONES

A copper deposit (malachite?) from a quartz dike was found in the scree at the bottom of Umarlych Naciekow shaft. Presence of this mineral can be explained by local metamorphism characteristics (high pressure and temperature), as also shown by local metallic ores (gold, copper...).

Calcite flowstones are abundant from Crystal's gallery (-450), this being very unusual for high alpine cave systems located just below a glacial front.

These flowstones show a pure white colour most of the time with sometimes some greyish rings (30 cm thick flowstone floor after Umarlych Naciekow shaft - KH 4 sample).

Moreover, large eccentrics with triangular cross-sections occur in Crystal's gallery (KH 5 sample).

Calcite deposition in such an unusual environment can be explained by a combination of characteristics specific to the area.

- Discontinuous alpine meadows over the cave system give percolation enough aggressivity.

- Very slow percolation across weak jointed rocks allows water supersaturation. At the end of summer, frost arrives and stops snow and ice melting; however; joints that have a low hydraulic conductivity do not stop dripping throughout winter so calcite deposition continues.
- At the end of winter dripping stops nearly completely. Flowstones begin to dry up slowly and evaporation causes the formation of eccentrics.
- Common-ion effect favours calcite deposition as the least soluble of the Ca-bearing dissolved minerals [Atkinson 1983]. This last factor appears to be efficient, knowing that water contains some sulphates (Table 1).
- Finally, other metallic elements, such as copper, included in the host rock could change the chemical equilibrium and favour calcite deposition. This could also explain some bluish flowstones seen in Zeferehöhle (Ciszewski, pers. comm.).

Table 1: Chemistry of karst water sampled during winter low water, March 1998 (after Pavuza, in Klappacher & al. 1998).

Sample location	Ca (mg / l)	Mg (mg / l)	HCO ₃ (mg / l)	SO ₄ (mg / l)
Feichtner (-530 m)	28	< 1	85	< 5
Kesselfall spring	38	< 1	99	13

Old massive flowstones appear from Zyklopengang second part but they occur mainly in the final part of Crystal's gallery and in the downstream series. They were corroded during past floodings and shaped with an asymmetric profile. An attempt of U / Th dating did not give any results, the isotopic ratio showing the opening of the crystalline system (Quinif, Cerak; KH 3 sample). Such massive flowstones are known in other caves located close to the surface and presently corroded by active dripping.

Gypsum crust presence over schistose walls dried up by draught (near first squeeze in Zyklopengang) is also linked to evaporation and sulphate occurrence in the host rock.

FINE CLASTIC SEDIMENTS

The insoluble calcareous schist remnant (muscovite, clay issued from mica weathering) seems to be easily transported as suspended load by water. It therefore does not hinder flowpath evolution by filling in. These clays were deposited by decantation during past floodings. Clay deposits do not exceed 1 cm thick; this shows that high water had a relatively low suspended load. On the top of the deposit, the flat-laying muscovite crystals give a copper-coloured aspect to these clays.

In Crystal's gallery cross-sections are wide; flow current was weak and fine sediment deposition occurred. In the low points, thicker clay deposits occurred, compounded of fine laminated greyish sediments with muscovite crystals, each lamina corresponding to a high-water event (KH 6 sample). Upon drying, mud-cracks occurred; during flooding, these expand and push out a clay rim along polygon limits.

In the squeezes giving access to Crystal's gallery, where current is notable during present summer flowing, sand followed by clay lens deposit by decantation when water level decreases.

UNDERGROUND MICROCLIMATE

In winter the cave entrance inhales; this suggests an upper entrance exists. The negative temperature freezes down to the 78-m shaft (-230 m). As it warms gradually, relative dampness decreases and walls dry up. Thanks to this dry air, the weak temperature of the cave (2.5° C at -500 m) is quite easy to endure.

At the bivouac, draught rises from the bottom. It seems that the convergence point the with entrance draught is in Zyklopengang and that it then rises following huge chimneys.

In the squeezes leading to Crystal's gallery, draught direction changes daily, following outer thermal cycles. Part of the draught follows the dry gallery and disappears into chimneys. A connection with Zeferehöhle located at only 500 m distance is not excluded. A minor part of the draught can be followed in the downstream series until -930 m.

CONCLUSION

This high-alpine cave system shows several original features: thick flowstones located just below glacial front and within a calcareous-schist host rock, it is probably the deepest non-limestone karst cave in the world.

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V LEDENIŠKEM OKOLJU**

Povzetek

Kitzsteinhorn (3208 m) v salzburških Centralnih Alpah je deloma poledenel kraški svet z dvema nedavno raziskanima globokima jamama. Obe, "Zeferehöhle" (-560 m) in "Feichtner-Schachthöhle" (-1024 m) sta v kalcitnih sljudnih skrilavcih. Avtor v prispevku razpravlja o njenem nastanku, hidrologiji, sedimentologiji in jamski klimi. Ta visokogorski alpski jamski splet kaže več izvirnih značilnosti: debele plasti sige prav pod ledeniškim čelom in to v kalcitnem sljudnem skrilavcu. Glede na kamnino je to najbrž najgloblja jama na svetu, ki ni v apnencu.