Speleogenesis of the Anhydrite Caves „Schlotten“ in the Harz Region, Central Germany – State of Research and Open Questions

M. Kupetz[1], F. Knolle[2]

[1] Verband der deutschen Höhlen- und Karstforscher e.V. (VdHK), Dr. Manfred Kupetz, Schulweg 1a, D-03055 Cottbus, manfred.kupetz@t-online.de
[2] Verband der deutschen Höhlen- und Karstforscher e.V. (VdHK), Dr. Friedhart Knolle, Grummetwiese 16, D-38640 Goslar, Germany, fknolle@t-online.de

Since the 17th century, the copper shale miners have known large phreatic anhydrite caves in deep setting without natural entrances and named them „Mansfeldische Kalkschlotten“. They are situated in the Mansfeld Trough (Landkreis Mansfeld-Südharz, Saxony-Anhalt, Germany) within anhydrite rock from the Zechstein (Upper Permian, Fig. 1). The largest of these Schlotten caves are the Wimmelburger Schlotten. The VdHK is preparing a monograph on these caves.

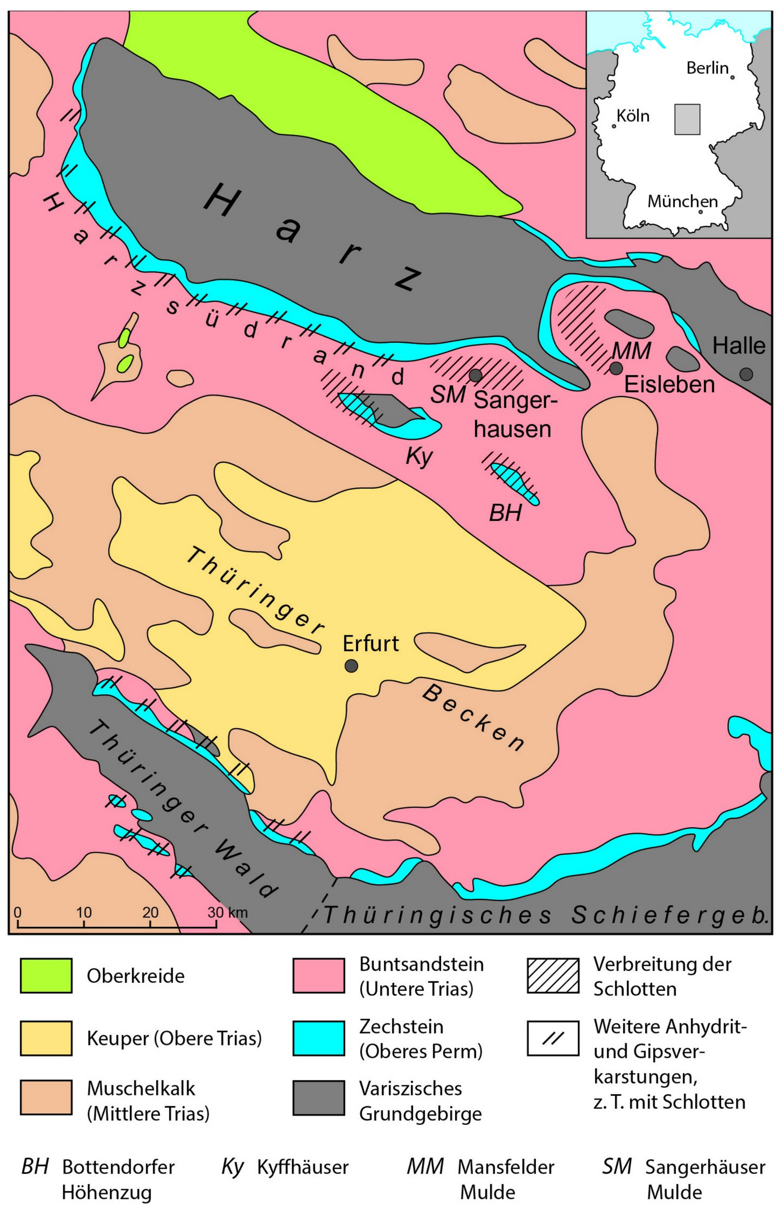

Fig. 1. Simplified geological map showing Zechstein (Upper Permian) karst outcrops with known and presumed Schlotten cave occurences in Middle Germany, data from BGR (1981) and Franke (2015).

The formation of these largest Central-European anhydrite caves was possible, as three geological circumstances came together (Fig. 2):

(1) Feeding inflow of carbonate-rich groundwater through a limestone karst aquifer,
(2) impermeable rock (anhydrite) as hanging wall, and
(3) linear water outflow through a fault zone in the anhydrite.

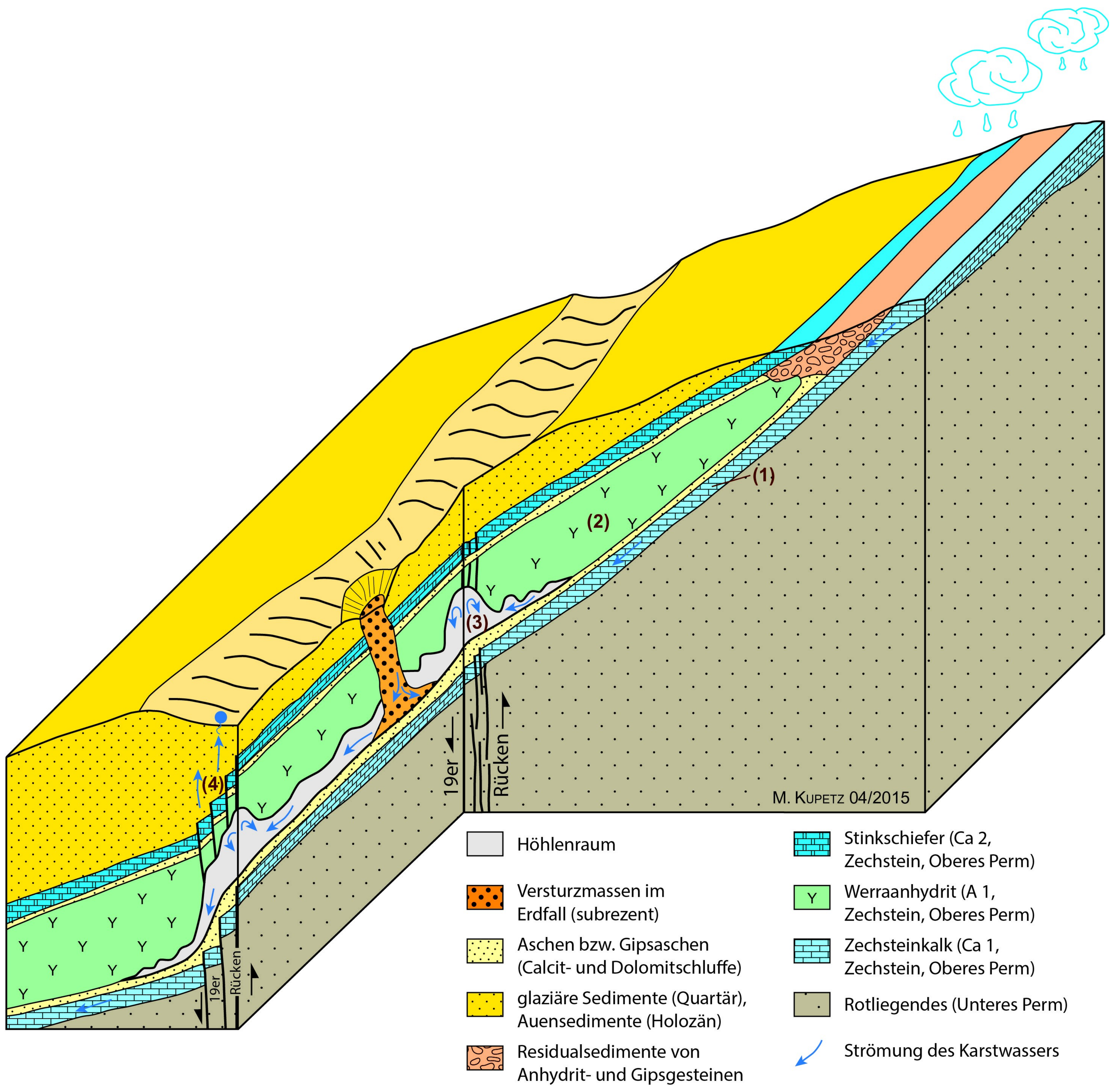

Fig. 2. Semidiagrammic drawing showing speleogenetic processes concerning the Wimmelburger Schlotten caves, explanations see text.

The water feed is effected by meteoric waters sinking into a limestone aquifer underlying the anhydrite rock. The easy-soluble, but impermeable anhydrite is the hanging wall of the caves and induces the formation of a pressurised water aquifer between limestone and anhydrite. The impermeability is caused by the quick closing of joints and faults due to gypsification of the anhydrite accompanied by volume increase before open karst fissures and galleries can develop. So the Mansfelder Schlotten can be classified as strata-boundary caves between limestone and anhydrite rock. The cave rooms start to develop along outstanding faults. The attribute of these faults is to be horizontal shear zones with sigmoidal joints. That means that the opening distance of these faults calculated perpendicular to failure extension must be bigger than the ability of gypsification to close it.

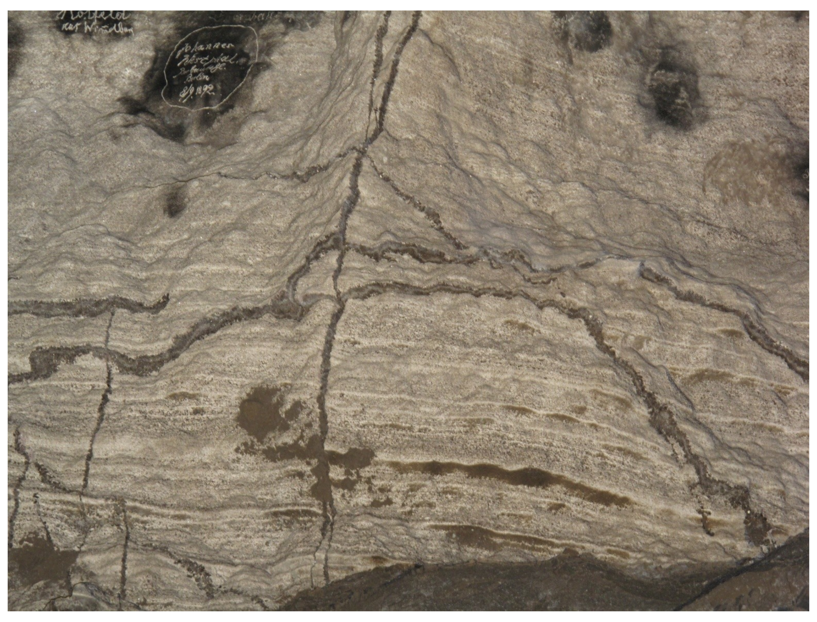

Fig. 3. Normal fissures and joints in the anhydrite rock close quickly due to gypsification.

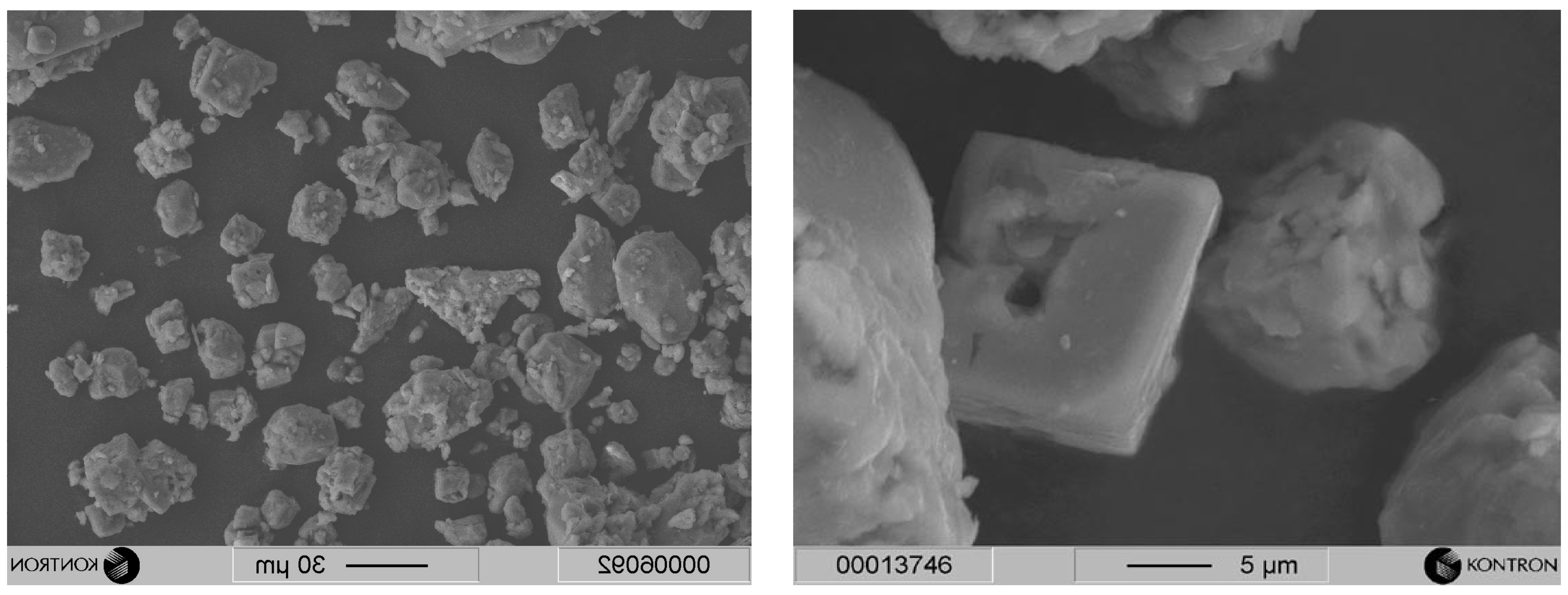

Fig. 4. (a) “Ash sediment” consisting of residual sediments and newly grown calcite, dolomite, and gypsum, (b) newly grown dolomite rhombohedron.

When the carbonate-rich water meets the anhydrite rock, a further condition has to be fulfilled:

(4) the solubility equilibrium changes, and fine-grained calcites and dolomites precipitate (proved by REM, EDXS and X-Ray tests).

So the water gains a secondary calcium-sulphate solubility and large hypogene cave rooms develop by density-driven convection and stillwater leaching. The karst water regime is a siphon-drainage system. The precipitated calcites and dolomites are the main resp. genetically most important components of the dolomite silts and fine sands typical for the Schlotten caves and were traditionally named „ashes“ or „dolomite ashes“. Up to now, they were classified generally as carbonatic residuals from the anhydrite leaching which could be falsified by this study. In fact the “ashes” are a mix of residues, precipitated (secondary composed) calcite and dolomite as well as allochthonous components.