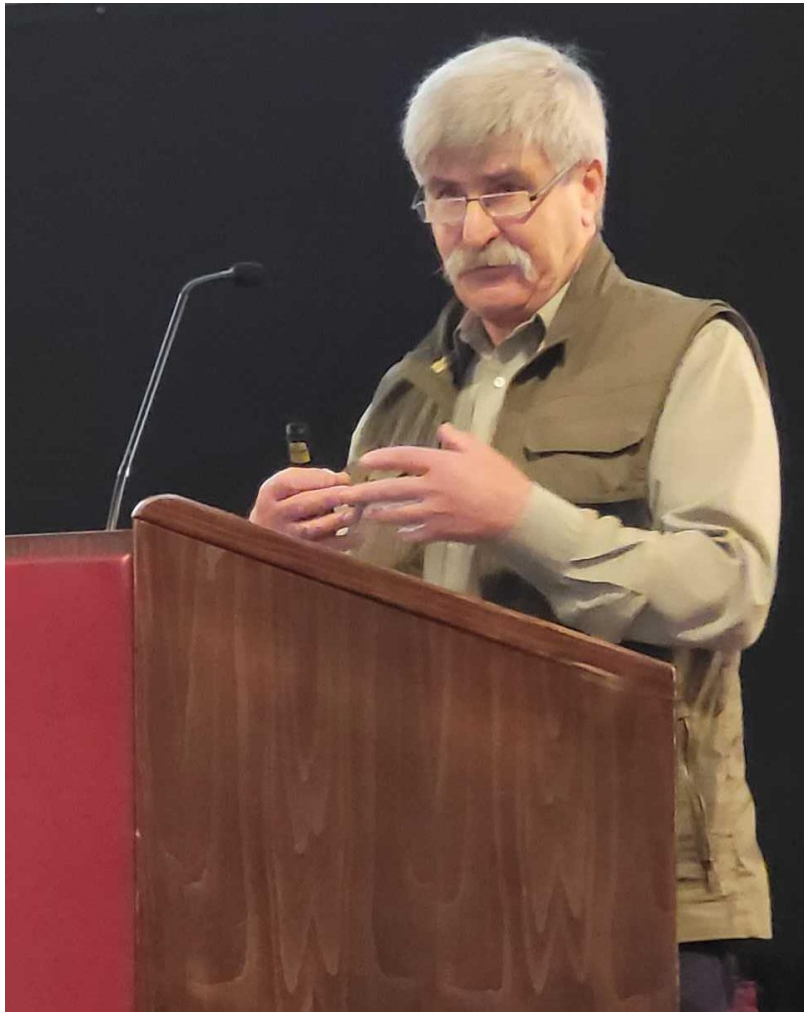
In memoriam Alexander Klimchouk



Klimchouk‘s definition of hypogenic cave genesis:

“**The cave-forming agent rises from below**.”

At Austrian Academy, Vienna, Nov. 2022
Photo: S. Kempe

Karst in Gypsum and Anhydrite of Germany

Stephan Kempe, Sven Bauer, Friedhart Knolle, Firouz Vladi

Verband der deutschen Höhlen- und Karstforscher e.V.

Arbeitsgemeinschaft für Karstkunde Harz e.V.
Im Verband der deutschen Höhlen- und Karstforscher e.V., München

Gypsum bearing strata are:

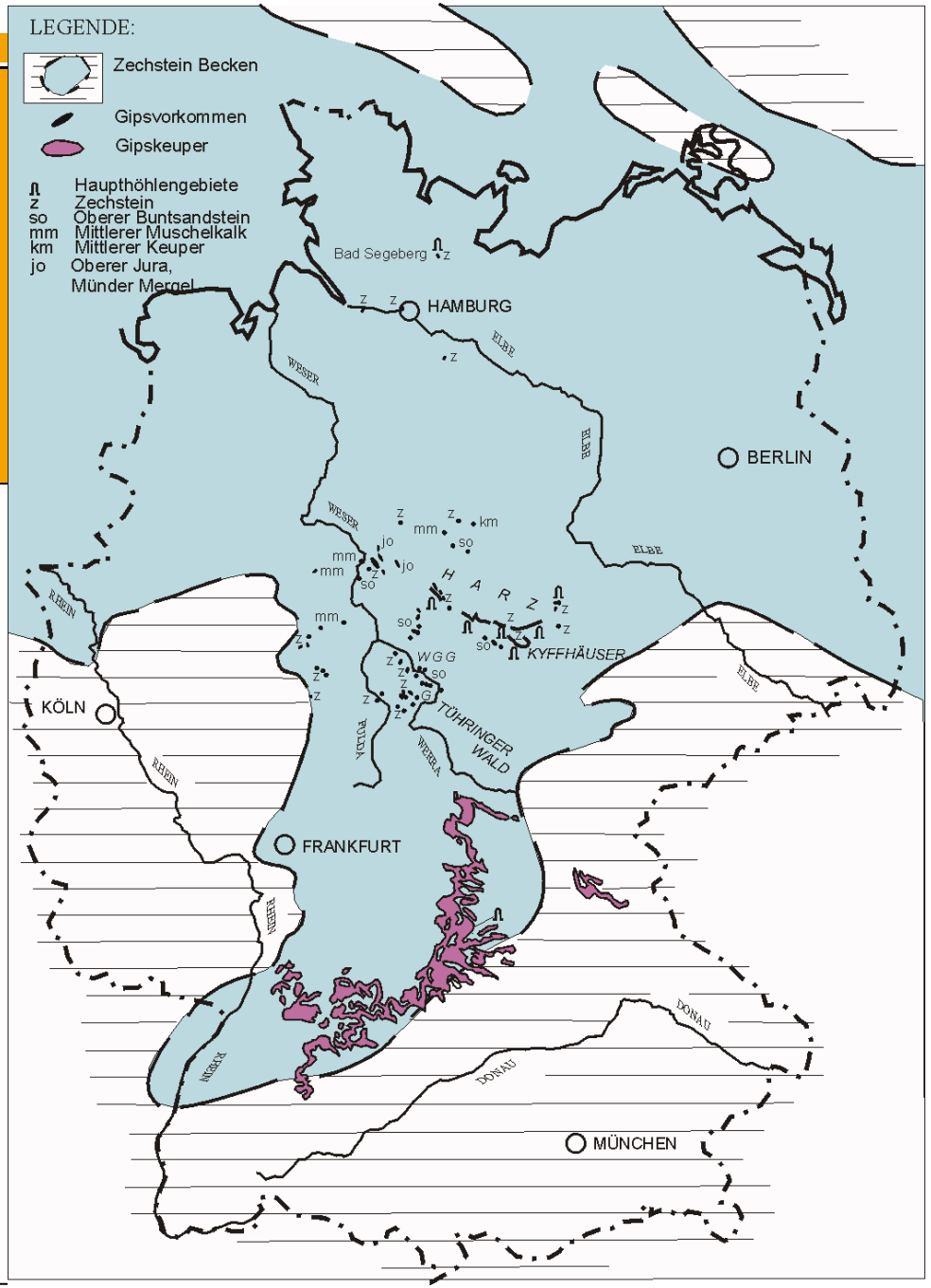
1) Upper Permian (Zechstein) (blue)

2) Upper Buntsandstein (Röt)

3) Middle Muschelkalk

4) Middle Keuper (purple)

5) Upper Jurassic (Münder Marl)



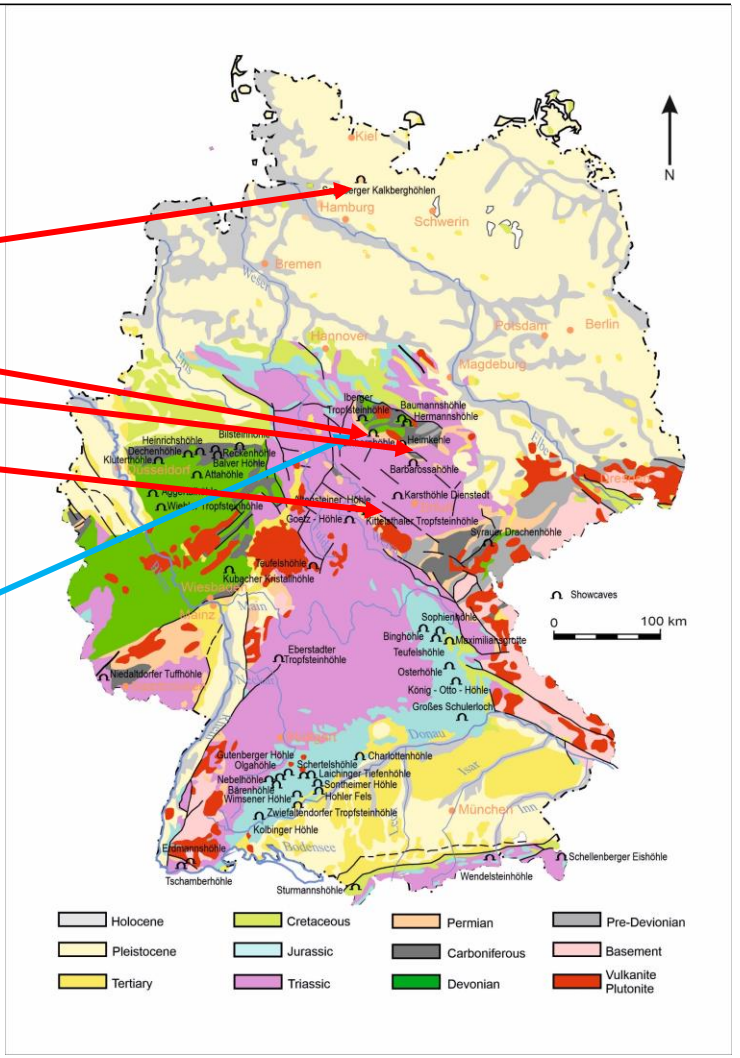
Outcrops, however, are very small and hardly visible on the geological map of Germany

There are three showcaves in gypsum/anhydrite:

1) the Segeberger Kalkberghöhle
2) the Heimkehle/South-Harz
3) the Barbarossahöhle/Kyffhäuser

and one gypsum mine, the Marienglas Cave

With 250 km^2 area is the South-Harz the largest gypsum karst in Germany, followed by Mansfeld area and the Kyffhäuser. By number, the South-Harz has most of the caves.

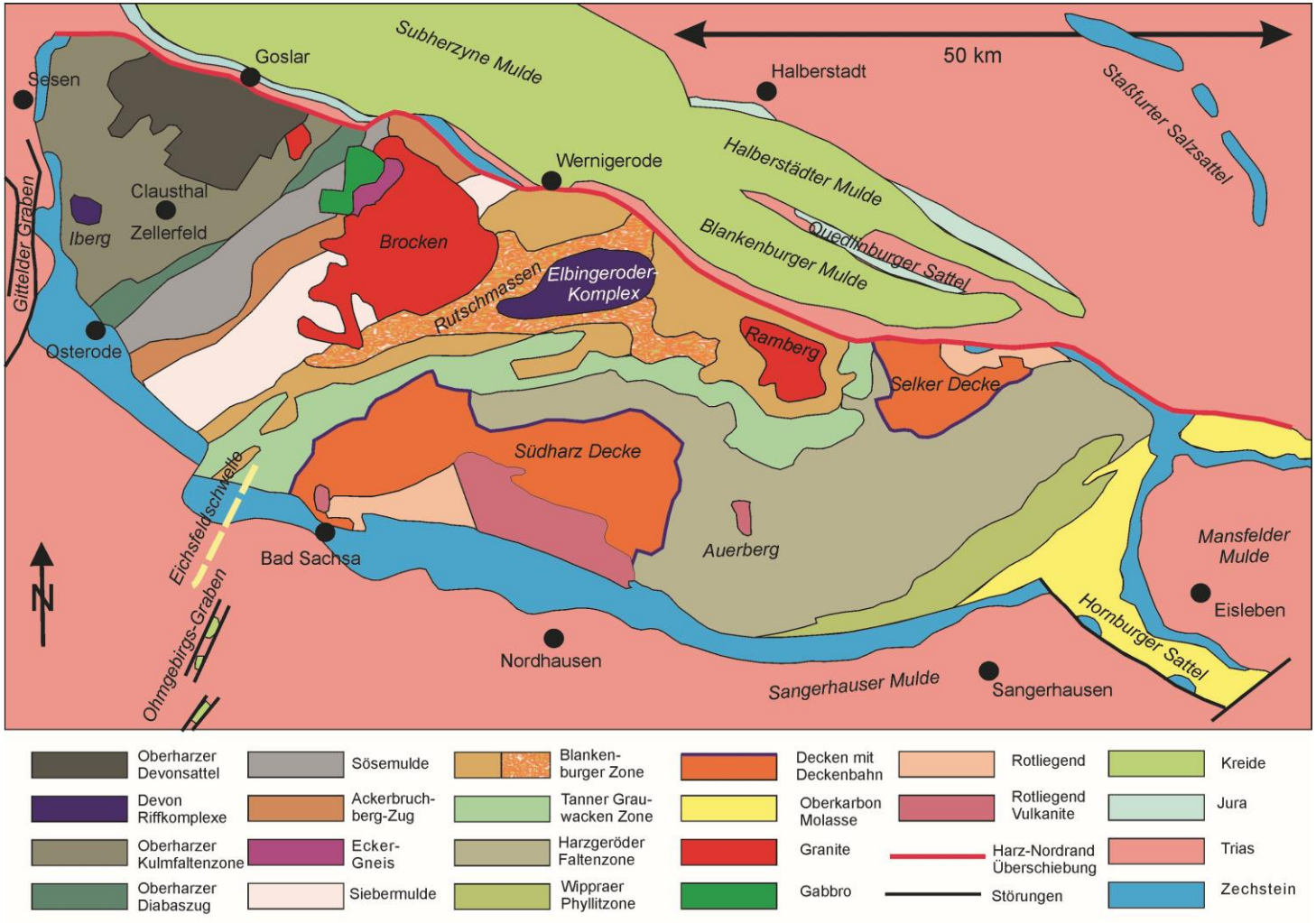


Geology of the South-Harz

Typical for gypsum karst are the white rocks and sinkhole-pitted surfaces

Photos: Firouz Vladi

The upper Perm (Zechstein; blue) surrounds the variscian-folded Harz Mountains



ABHANDLUNGEN ZUR KARST- UND HÖHLENKUNDE

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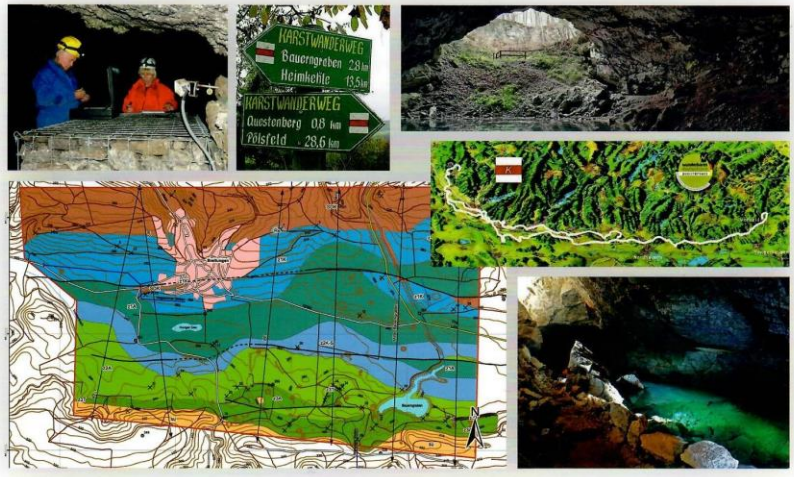
ISSN 0179-3969

Heft 40

Karst und Höhlen des Südharzes

Neue und alte Forschungen in Erinnerung an Reinhard Völker (12.11.1944 – 19.8.2020)



Gemeinsam mit der Arbeitsgemeinschaft für Karstkunde Harz e.V.
ediert von Stephan Kempe und Firouz Vladi

Abh. Karst- u. Höhlenkunde	287 Seiten	Heft 40	München 2022

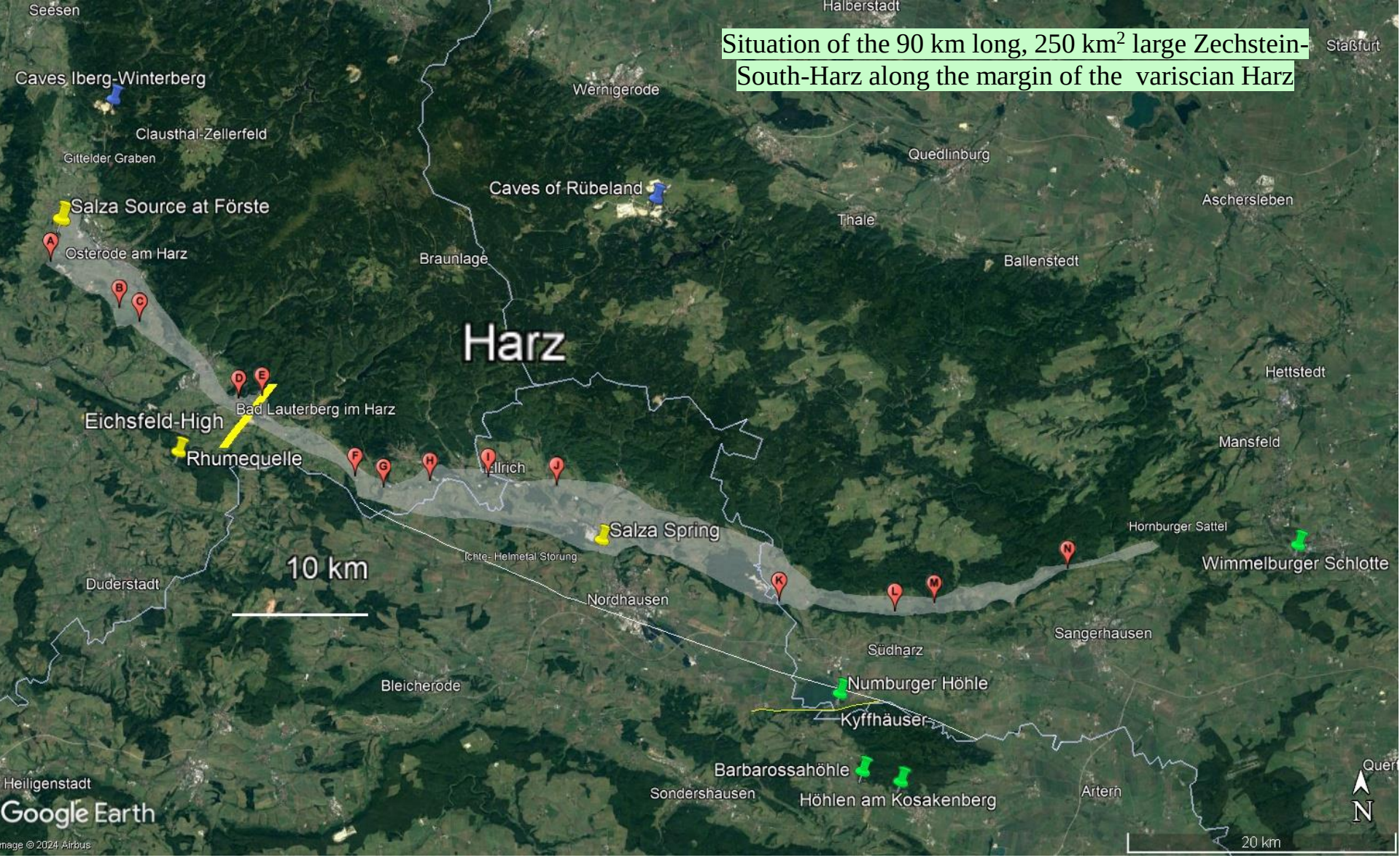
Verband der deutschen Höhlen- und Karstforscher e.V.

Die Mansfelder Schlotten

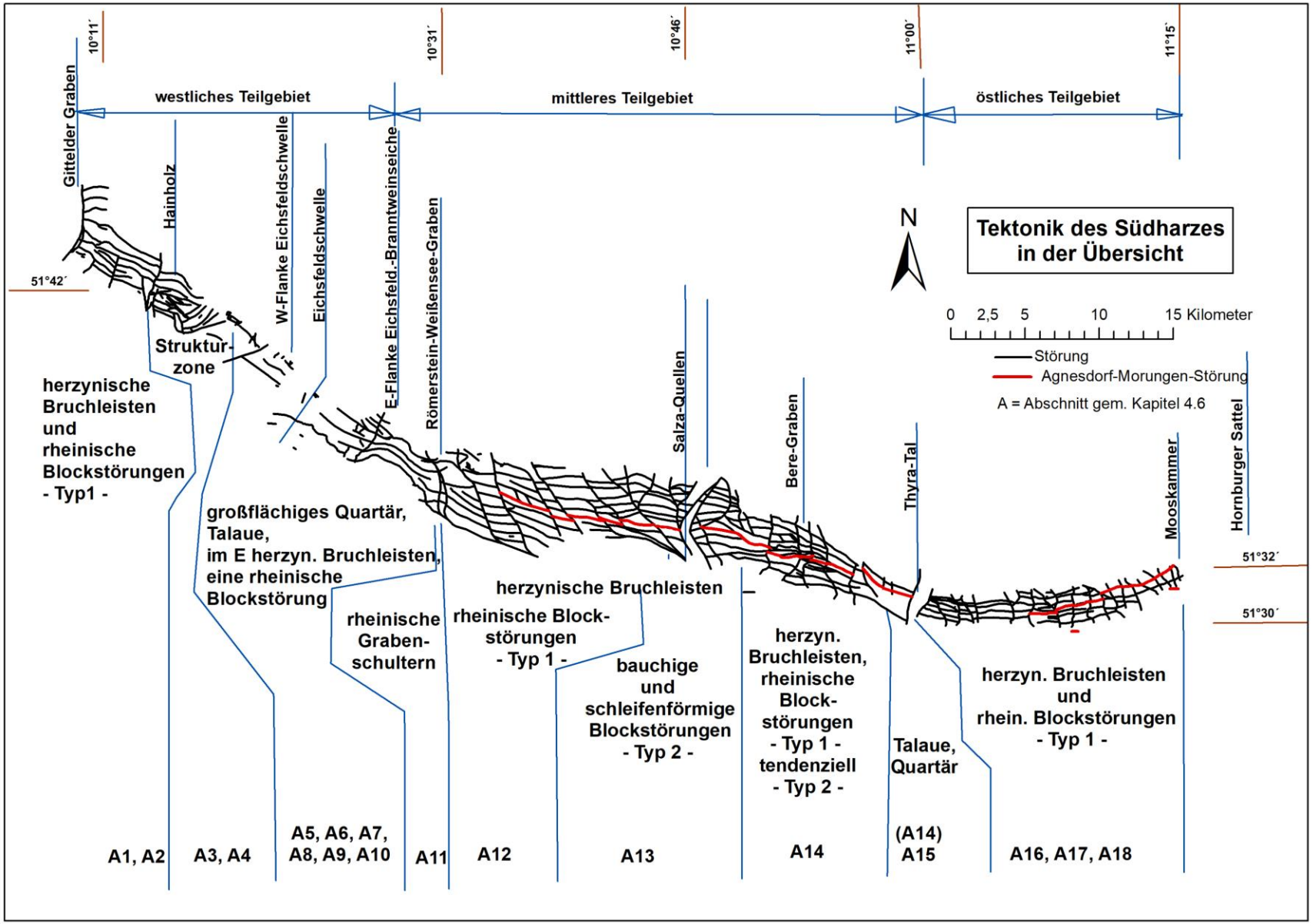
Blick in den Tanzsaal der Wimmelburger Schlotten; Foto Thomas Wäsche

Karst und Höhle 2018 - 2021

ISSN 0342-2062



Caves and cave areas: A) Lichtenstein, B) Beierstein (Klinkerbrunnen), C) Hainholz (Jettenhöhle, Marthahöhle), D) Dolomite caves (Einhornhöhle, Steinkirche), E) Weingartenloch F) Trogstein, G) Priester- u. Sachsenstein, H) Himmelreich, I) Kelle, J) Heimkehle, K) Questenberg, L) Elisabethschächter Schlotte



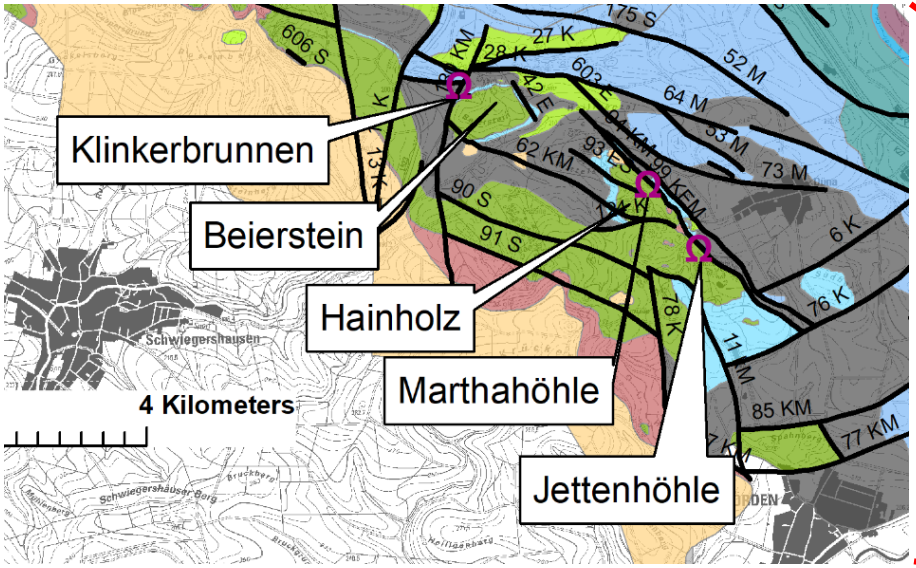
HUBRICH, H.-P. (2020): Aufklärung der tektonischen Struktur des Harz-Südrandes und dessen Genese seit dem Perm nach Erfassung der Geologie des Südharzer Zechsteins im Maßstab 1:10,000. – Dissertation, TU Darmstadt, 150 S., 17 Anl. u. Karten.

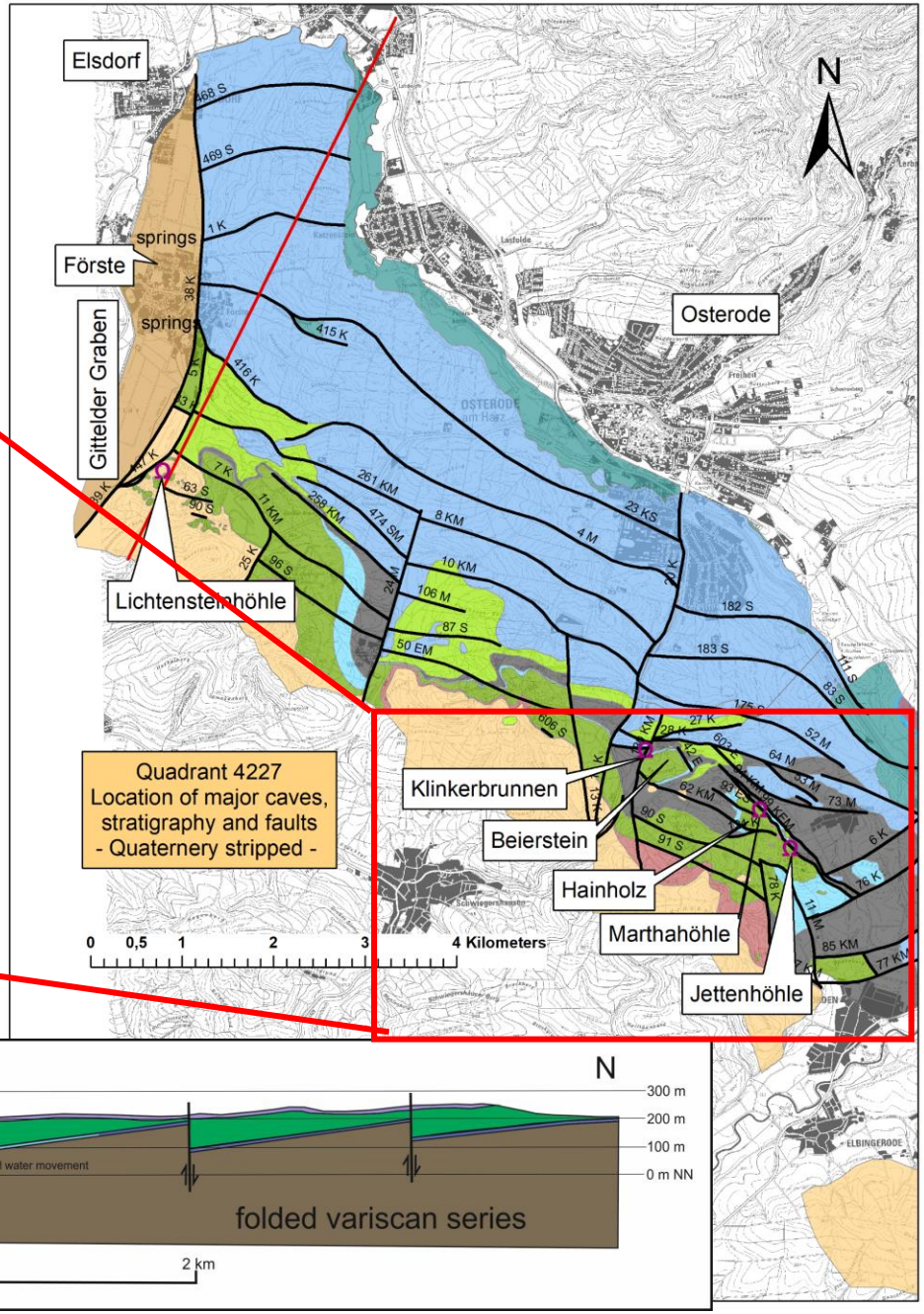
Stratgraphically, the Zechstein of the Harz margins is composed of four salinar cycles

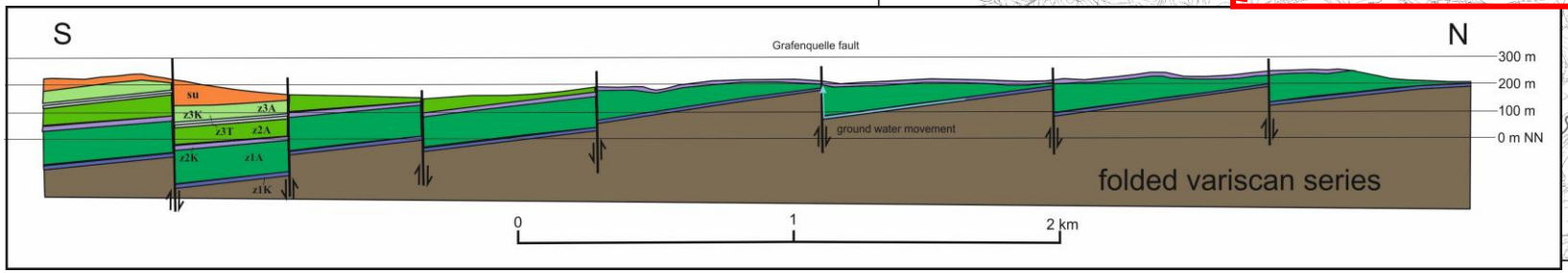
Signature *	Stratigraphy (German Formation Names)	Thickness	Cycles	
su	Lower Buntsandstein (including Bröckelschiefer)	> 200 m	Triassic	
z4A	Aller-anhydrite	< 2 m	Zechstein	Aller-Cycle
z4T	Red salt-clay (roter Salzton)	8 - 10 m		
z3A	Leine-anhydrite (Hauptanhydrit)	35 - 70 m		Leine-Cycle
z3K	Leine-carbonate (Plattendolomit)	2 - 25 m		
z3T	Gray salt-clay (Grauer Salzton)	3 - 10 m		
z2A	Stassfurt-anhydrite (Sangerhausen-Anhydrit and Basal-Anhydrit)	0 - 30 m		Stassfurt-Cycle
z2K	Stassfurt-carbonate (Stinkkarbonat, Stinkschiefer)	0 - 60 m		
z2T	Brown-red salt-clay (Roter Salzton)	0 - 2 m		
z1A	Werra-anhydrite	0 - 250 m		Werra-Cycle
z1K	Werra-carbonate (Zechsteinkalk)	0 - 10 m		
z1T	Copper-shale (Kupferschiefer)	0 - 0,5 m		
z1C	Zechstein-conglomerate	0 - 3 m		
c/d	Discordance: Rotliegend, Upper Carboniferous and Devon		Pre-Zechstein	

Copper-shale was mined until 1989
if >2% Cu, and
rarely > 200g Ag/t

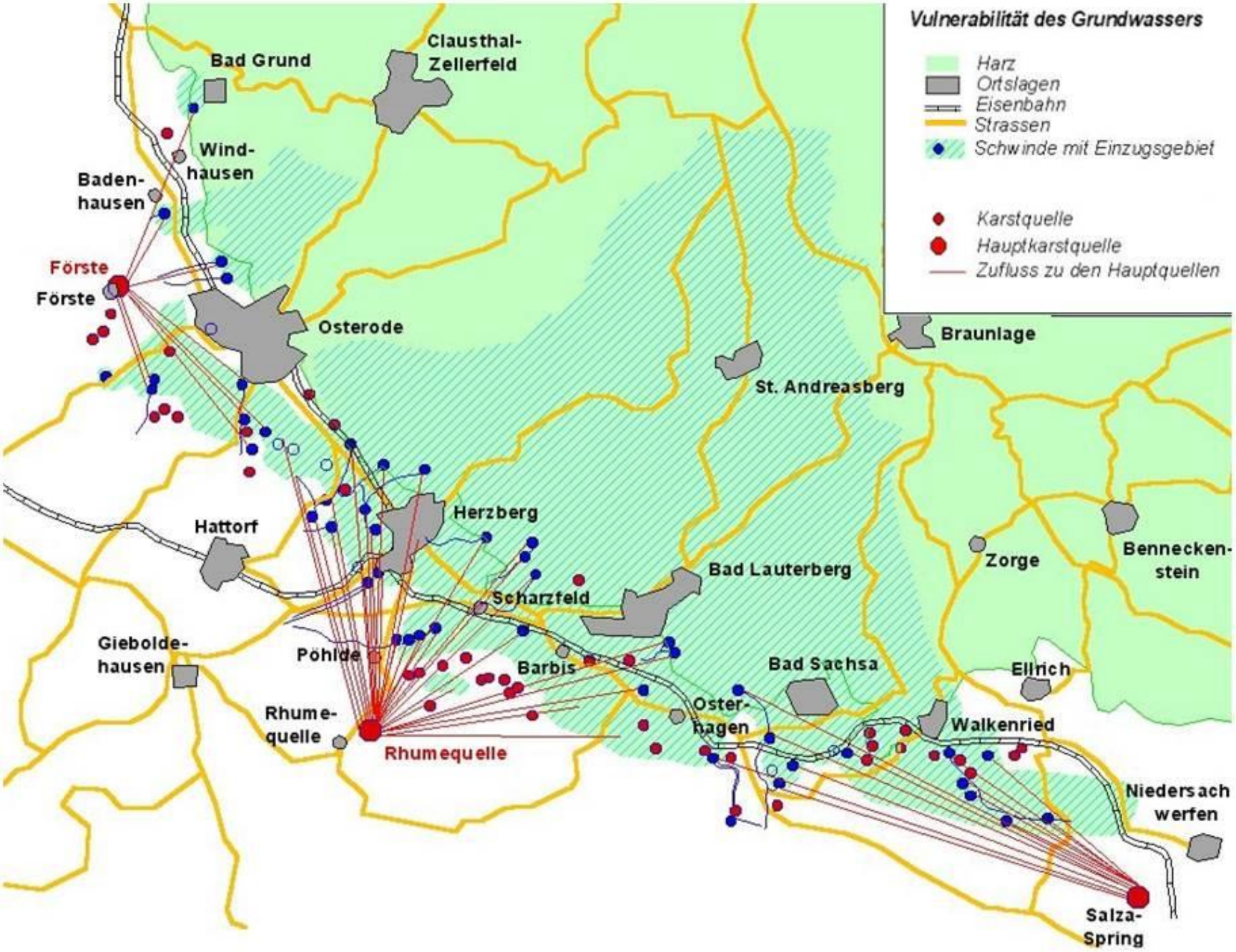
Tectonic Model of the area near Osterode (Hubrich, 2020)





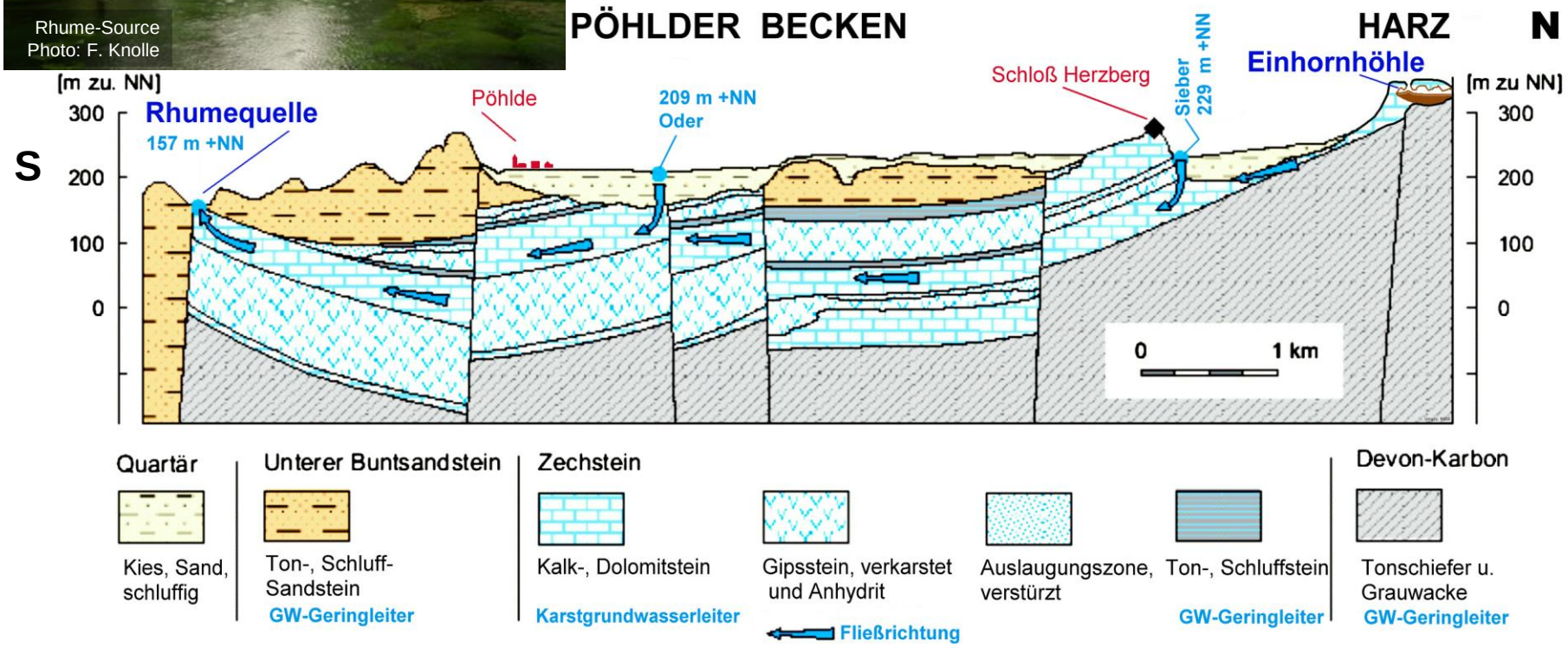


Karstic Springs


Vulnerabilität des Grundwassers
Harz
Ortslagen
Eisenbahn
Strassen
Schwinde mit Einzugsgebiet
Karstquelle
Hauptkarstquelle
Zufluss zu den Hauptquellen
Bad Grund
Clausthal-Zellerfeld
Wind-hausen
Baden-hausen
Förste
Förste
Osterode
Braunlage
St. Andreasberg
Hattorf
Herzberg
Bad Lauterberg
Zorge
Bennecken-stein
Scharzfeld
Giebolde-hausen
Pöhlde
Barbis
Bad Sachsa
Ellrich
Rhume-quelle
Rhumequelle
Oster-hagen
Walkenried
Niedersach werfen
Salza-Spring

The Rhume-Source is fed by the sinking of the rivers Sieber and Oder


Rhume-Source
Photo: F. Knolle



Graphic: Klaus Stedingk

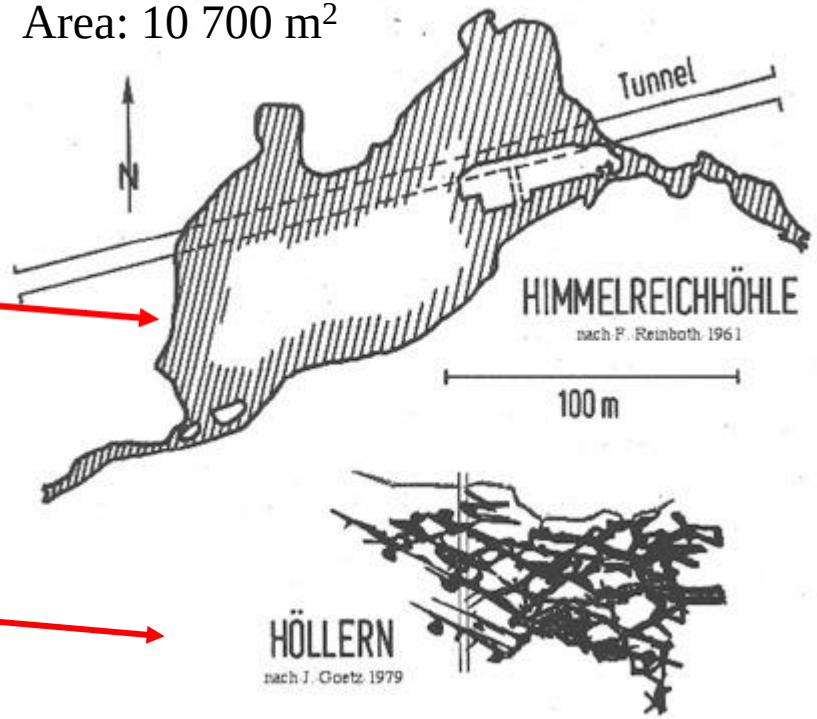
Gypsum and Anhydrite Caves. What we Have in Germany

There is a conflict between large caves and long caves. Long does not mean large and large does not mean long.


Photo: Stephan Kempe


Photo: Jochen Götz

Length: 580 m
Area: 10 700 m²

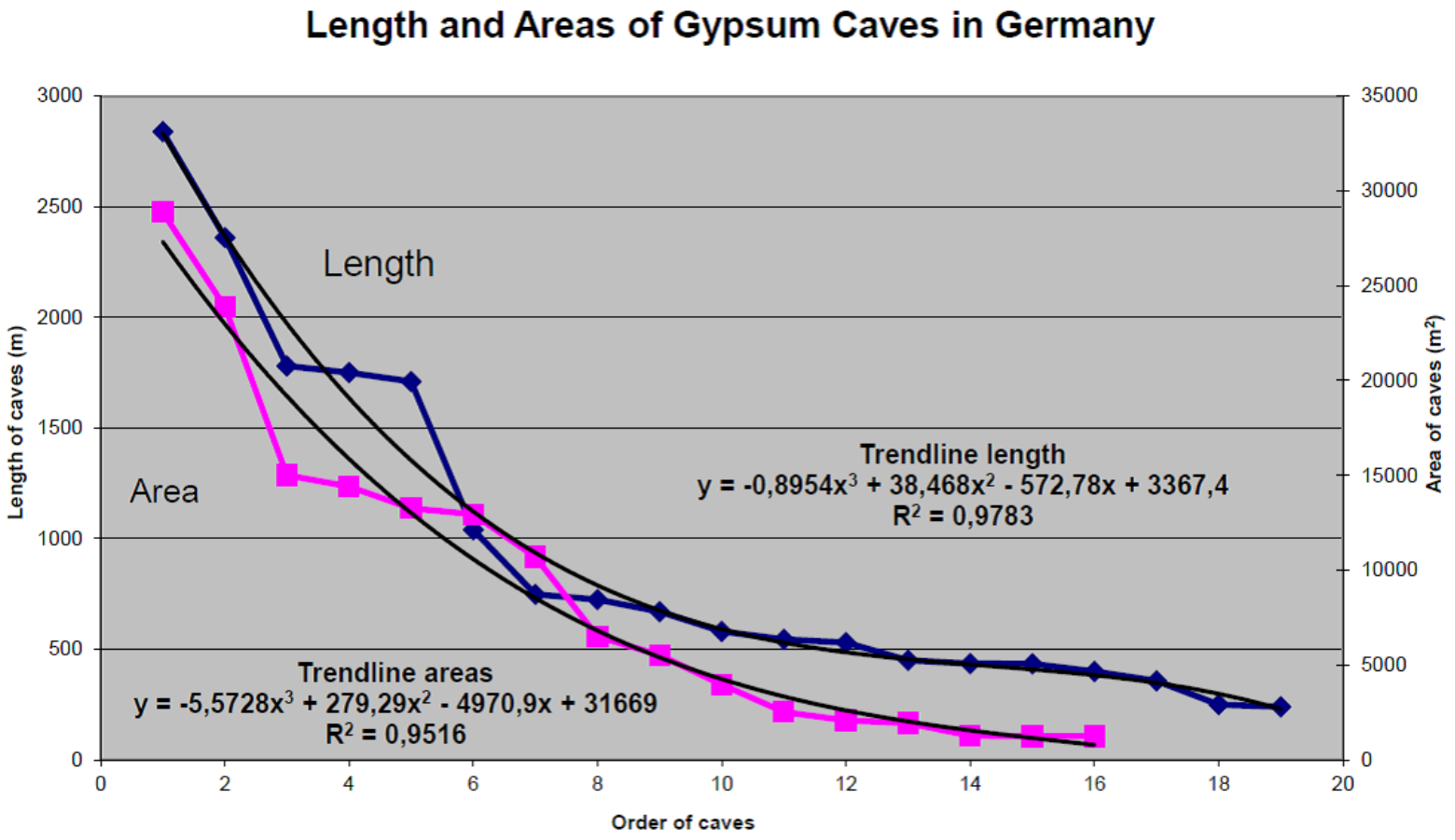


Length: 1040 m
Area: 2400 m²

List of German Sulfate Caves > 200 m in length

Cave Name	Total length[m]	Area [m²]	Average width [m]
Numburghöhle	1 746	28 866	16,53
Wimmelburger Schlotten	2 838	23 866	8,41
Helbraer Schlotten*	2505	20 675	8,25
a)Schlotte am Ottiliaeschacht b) am	1701	ca. 15 000	8,81
Schacht E	725	5 525	7,62
c) Verbindung	70	150	
Brandschächter Schlotte (Schlotte A)	530	13 267	25,03
Ahlsdorfer Schlotte(Große Schlotte)	1 714	15 009	8,76
Heimkehle	1 780	14 407	8,09
Barbarossahöhle	670	12 946	19,32
Himmelreichhöhle	580	10 695	18,44
Segeberger Kalkbeghöhle	2260	6 511	2,88
Marthahöhle	450	3 969	8,82
Höllern	1 040	2 531	2,43
Elisabethschächter Schlotte	358	2 082	5,82
Trogsteinhöhle	435	1 945	4,47
Segen Gottes Stollen	242	1 279	5,29
Fitzmühlen Quellhöhle	545	1 253	2,30
Mathildenhöhle	317	1 250	3,94
Jettenhöhle	748	Ca. 5 000	
Schlotte am Eduardschacht	ca. 400		
Schusterhöhle	434		
Höhle im Grundgips der Kläranlage	250		

There are 19 caves exceeding 200 m in length



In Germany, about 300 sulfate caves are registered

No of caves	Area	Longest cave
180	South Harz*	Heimkehle, 1.93 km
61	Kyffhäuser*	Numburger Cave, 1.75 km
17	Eastern Harz*	Wimmelburger Schlotten, 2.8 km
26	Northern Germany*	Segeberger Kalkberghöhle, 2.26 km
> 5	Southern Germany**	Höllern, 1.0 km

* Cadastre, Uwe Fricke, Henning Harzer and Michael Brust of Arge Karstkunde Harz and Thuringia Caving Club, May 2024

** Estimated

The „Schlotten“:
A World-Wide Class of its own

„Schlotten“, intercepted by historic mining for “Copper-Shale”, finally discontinued in 1989

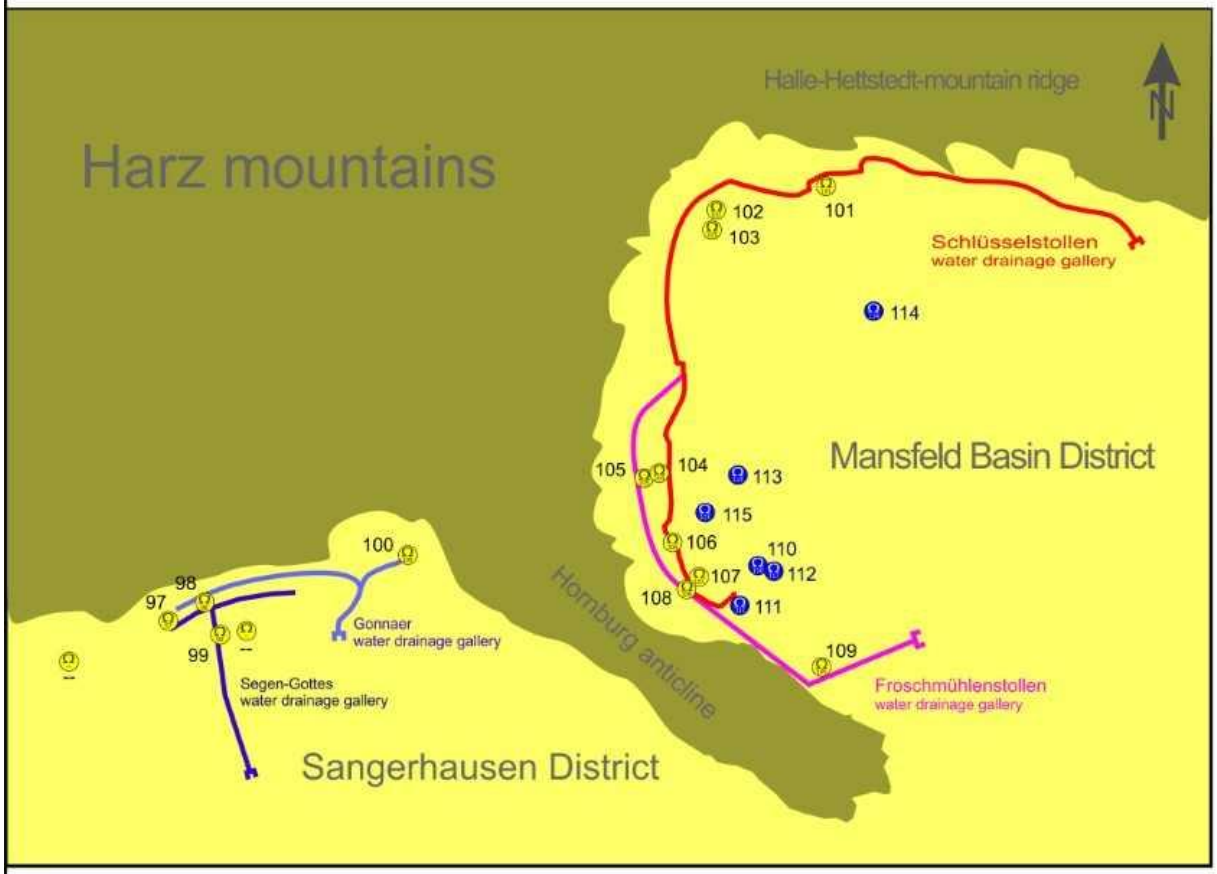
Graphic: Spilker, 2021

Anhydrite of the Stassfurt-Cycle
with alabaster-spheres

Elisabethschächter Schlotte.
Photo: Siegfried Wieler

„Schlotten“, intercepted by historic mining, are hypogenic, deep phreatic cavities, mostly inaccessible

Schlotten in the Copper-Shale Mining Districts of Sangerhausen and the Mansfeld Basin

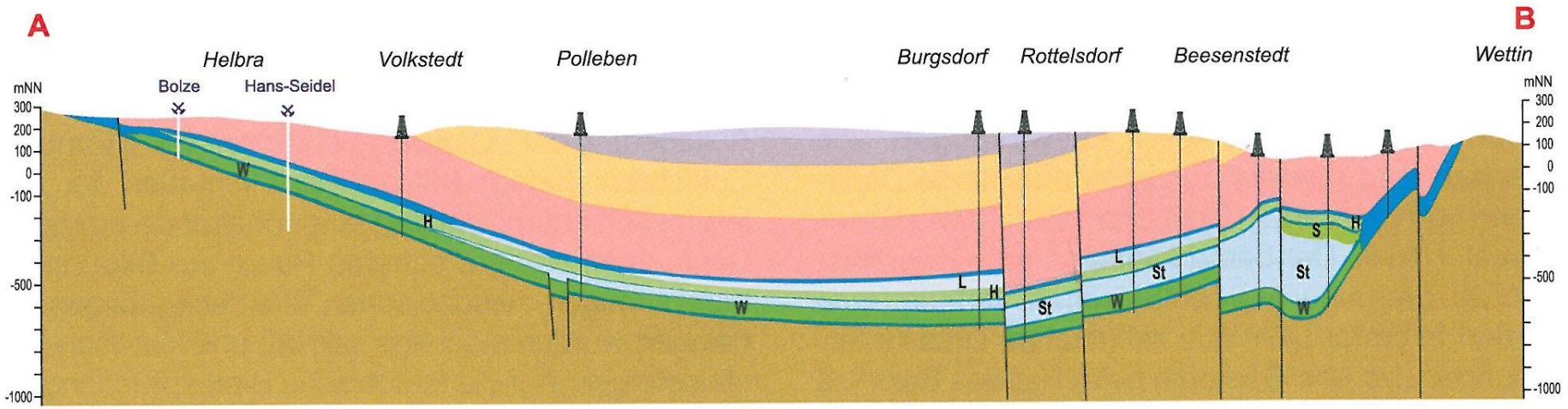


Signatures and Schlotten-designations
after the STOLBERG' Cave cadastre(1942/43) and 1984;
with supplements (italics), synonyms in brackets

-- *Hainröder Schlotte*
-- *Schlotte unter Lengefeld*
97 Schlotten im Hohe[n]warter Revier
(Hasenwinkler Schlotte, Zwergenloch)
98 Schlotte am Elisabethschacht im Heiligenborner Revier
(*Elisabethschächter Schlotte*)
99 Schlotte im Segengottesstolln
(Segen-Gottes-Schlotte, *Marienglasschlotte*)
100 Schlotte im Kupferberger Revier bei Pölsfeld
(Brandschächter Schlotte, *in total four Schlotten*)
101 Schlotte bei Welfesholz
102 Schlotte bei Burgörner
103 Schlotte im Eduardschacht
104 Schlotte am Schacht E bei Helbra *(Helbraer Schlotten)*
105 Schlotte am Schacht Ottiliae bei Helbra *(Helbraer Schl.)*
106 Schlotte bei Creisfeld *(Glückaufer Schlotten)*
107 Schlotte am Schacht W bei Wimmelburg
(Wimmelburger Schlotten)
108 Schlotte am Froschmühlenstollen-Querschlag
bei Wimmelburg *(Wimmelburger Schlotten)*
109 Schlotte im Hermannschacht
110 Schlotte in der II. Tiefbausohle Eisleben
111 Schlotte am Ottoschacht (Ottoschächter Schlotte)
112 Schlotte am Umfahrungsquerschlag der IV. Tiefbausohle
113 Schlotte am Graf Hohenthalschacht
114 Schlotte am Paulschacht *(in total four Schlotten, opened up in transverse adits in the 5. and 7. underground level)*
115 Schlotte im Eikendorf (109 a)

outside of map:
Buchholzer Schlotte, east of Nordhausen

Geological cross-section through the Mansfeld Basin



B - Tertiär, *B2* - Eozän, *B1* - Paläozän / Kreide, *Kms* - Maastricht

Unterer Muschelkalk (Wellenkalk-Folge)

Oberer Buntsandstein (Salinarröt- bis Myophorien-Folge

Mittlerer Buntsandstein (Volpriehausen- bis Solling-Folge)

Unterer Buntsandstein

Zechstein (ungegliedert)

L Zechstein / Leinesteinsalz

St Zechstein / Staßfurtsteinsalz

H Zechstein / Hauptanhydrit

S Zechstein / Sangerhäuser Anhydrit

W Zechstein / Werra-Anhydrit

Permokarbon

Tektonische Störung (oberflächennah)

Tektonische Störung (vermutet)

Schacht

Erkundungsbohrung

Strobel, 1984

Anhydrite of the Werra-Cycle

„Dancing-Hall“ Schlotte at Froschmühlenstollen, Wimmelburg,
Photo: Holger Lander

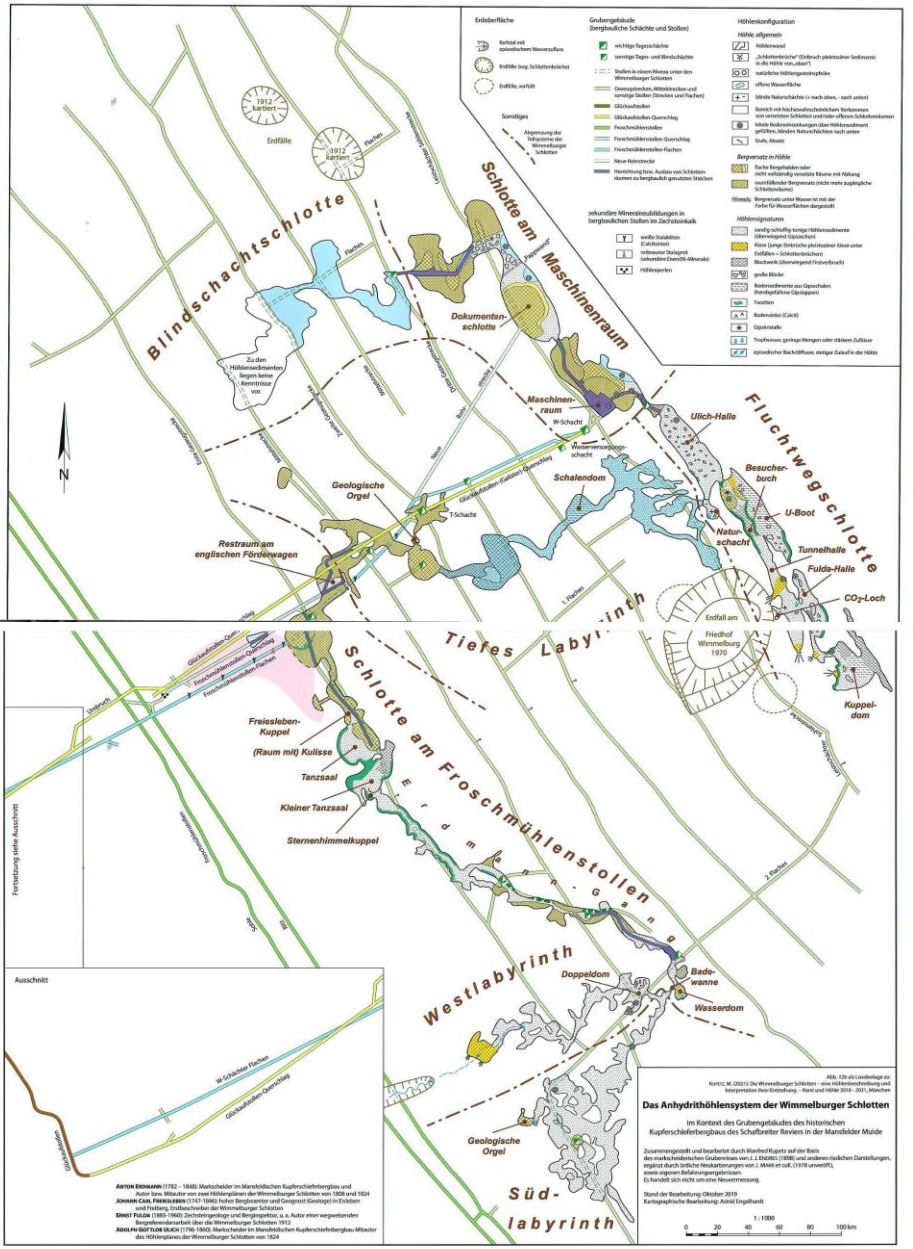
The Wimmelburger Schlotten near Mansfeld, East-Harz

Length: 2840 m
Area: 23 900 m^2

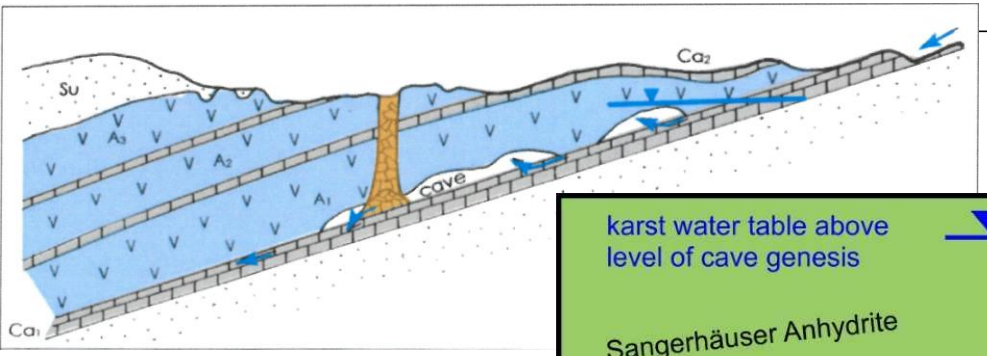
Discovered by mining beginning of 19th century.
Access through a mine-shaft.
Drained artificially to control kast water level.
Threatened by closure.

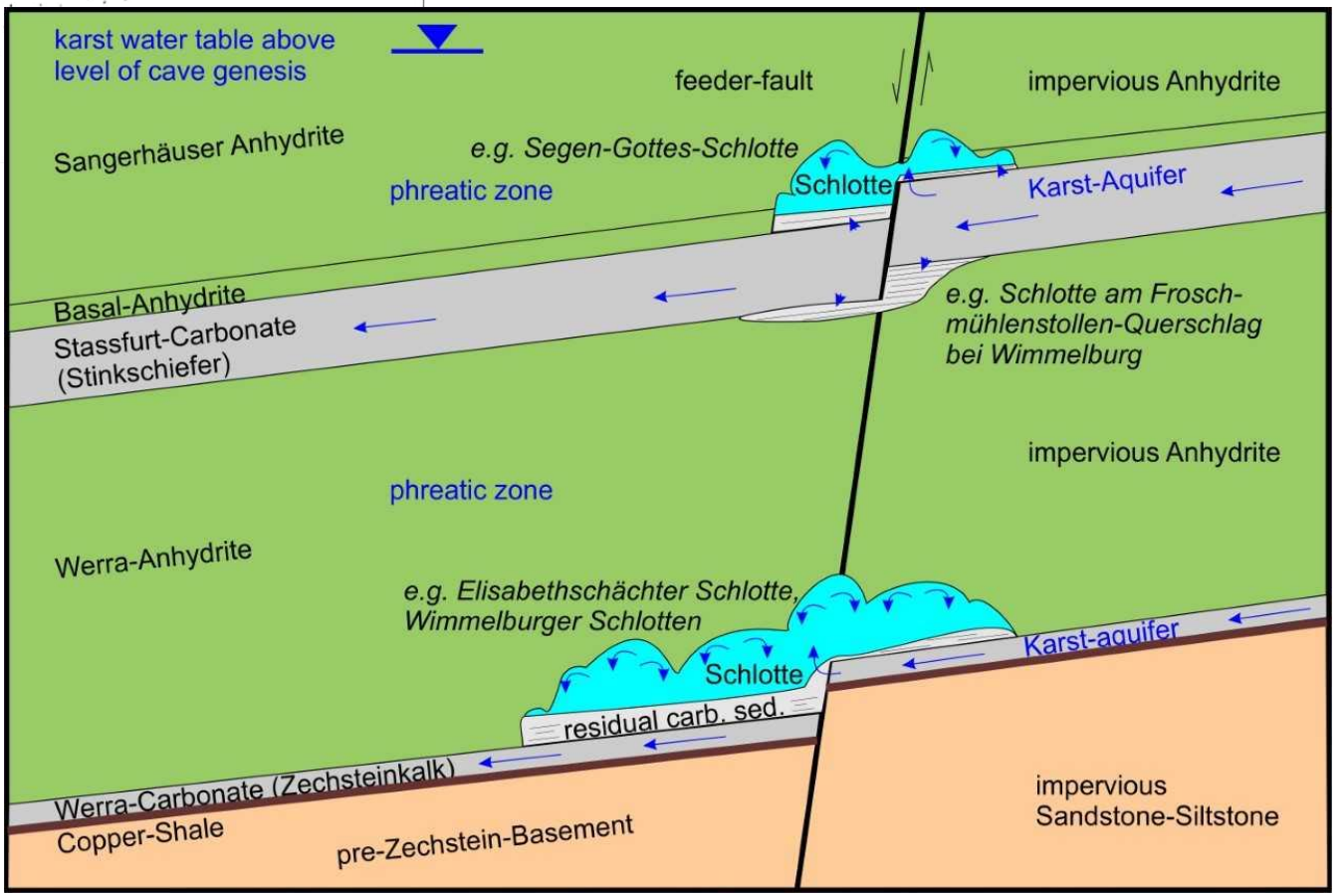
Photos: Stephan Kempe

Kupetz, 2021



„Schlotten“ are deep-phreatic, hypogen cavities, fed by water from carbonate aquifers



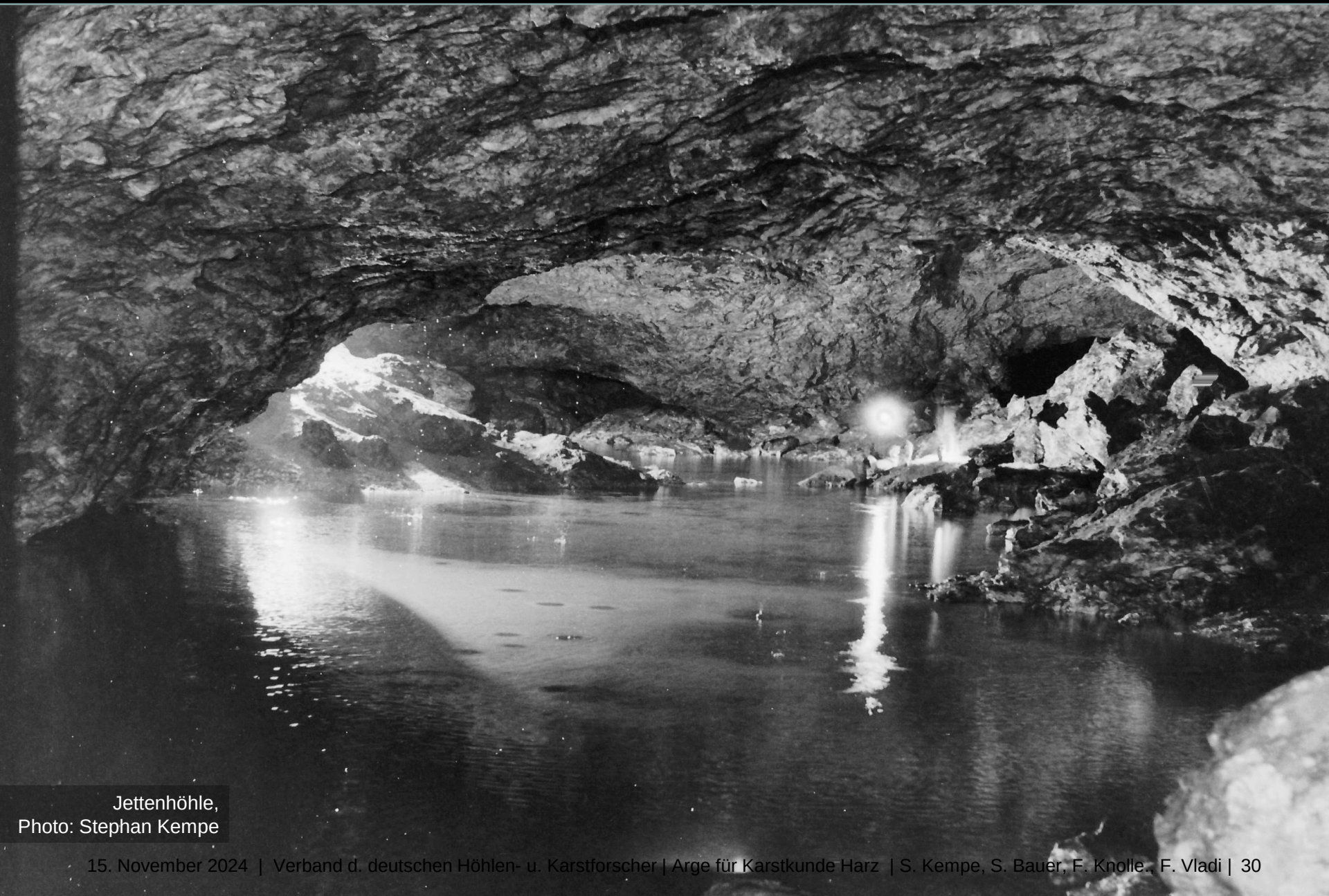


Collapse of „Schlotten“ cause large sinkholes

Sinkhole near Nordhausen,
Photo: Sven Bauer

Near-Surface Gypsum Caves: Hypogenic or Epigenic (or both?)

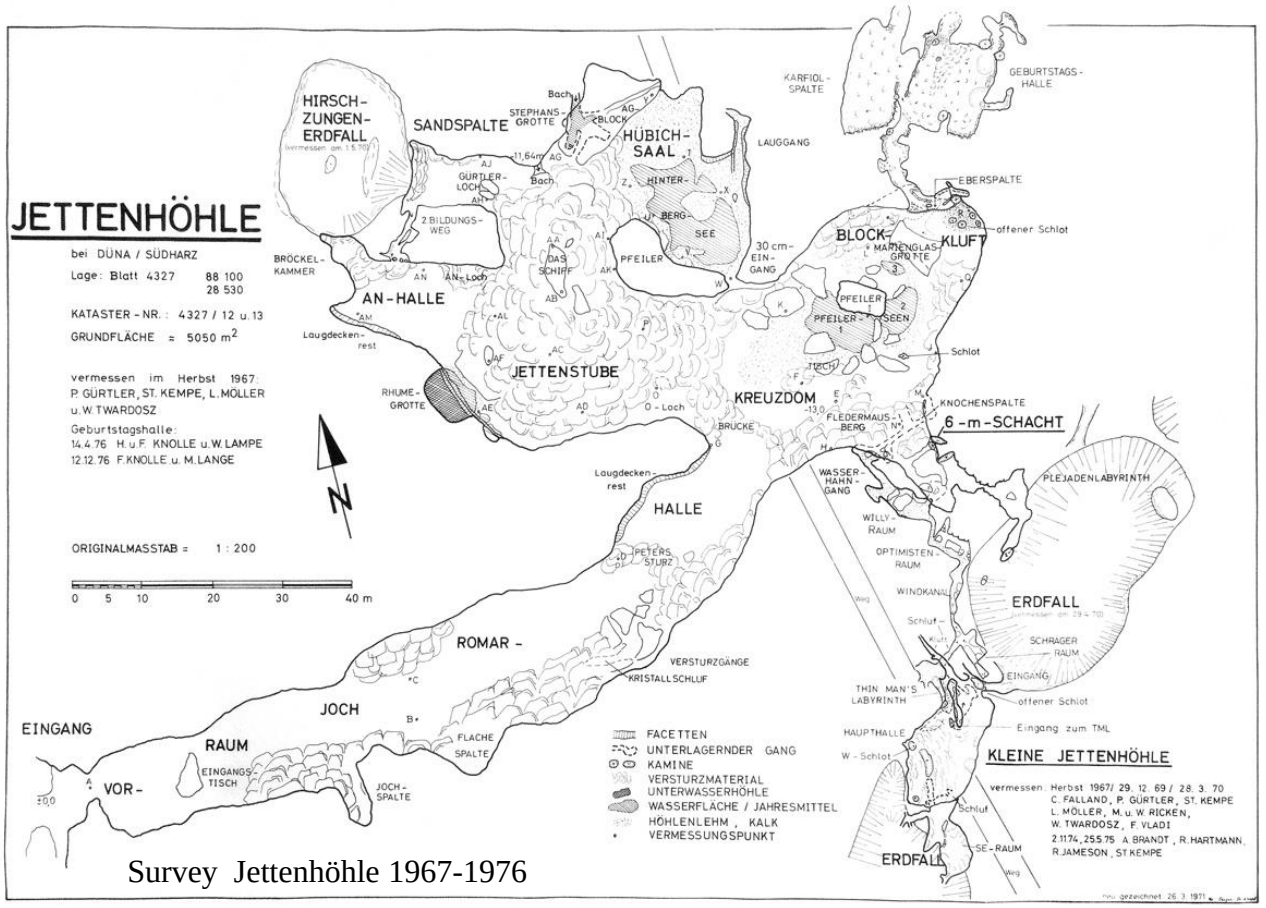
View into the Kreuzdom of the Jettenhöhle a shallow hypogenic cave at high water



Jettenhöhle,
Photo: Stephan Kempe

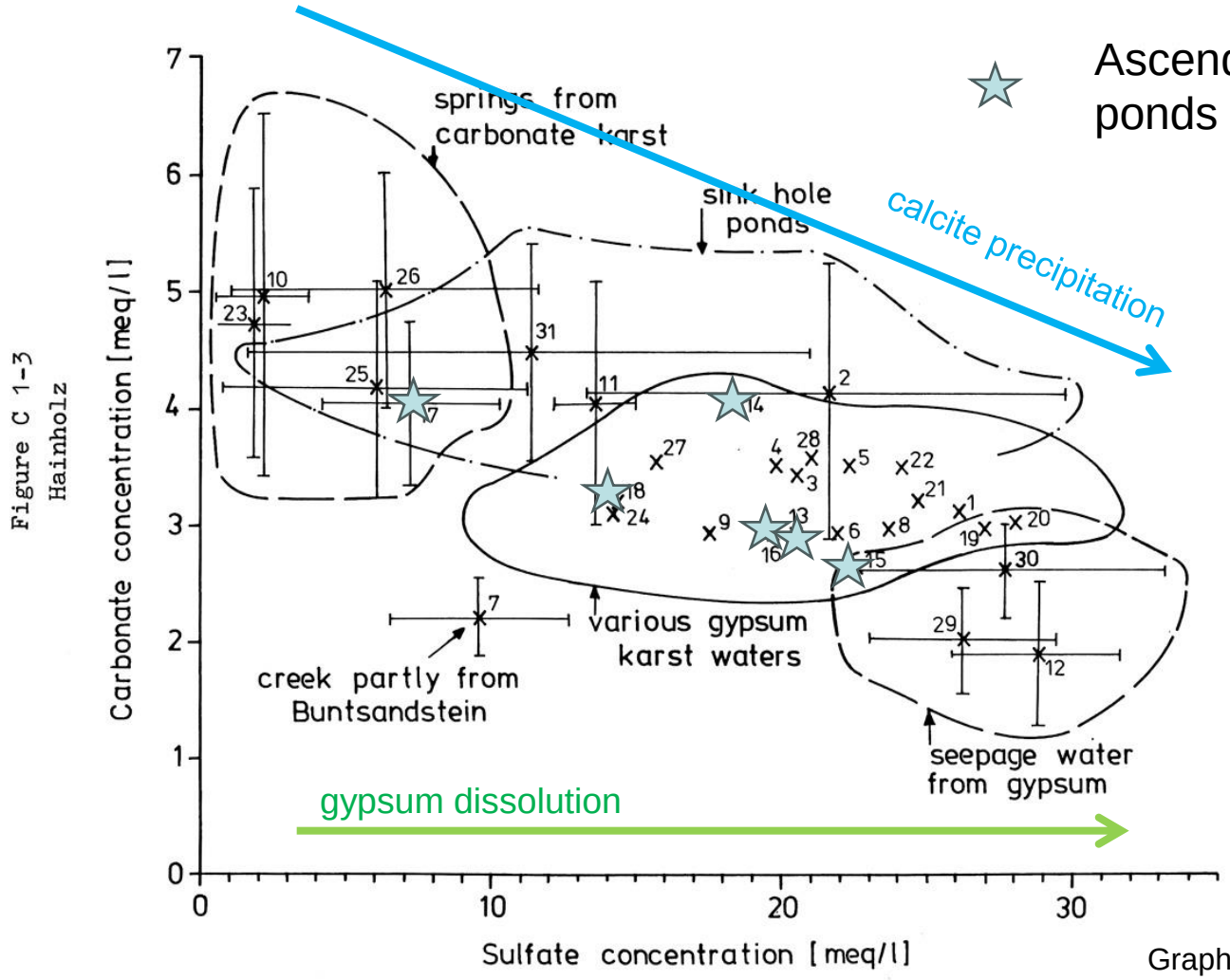
The Jettenhöhle is hypogenic, fed by water rising from below into ponds, but grew above the watertable by breakdown and its consecutive dissolution

1967-68: **KEMPE, S., GÜRTLER, P., MÖLLER, L. & TWARDOSZ, W.**: Eine speläologische Übersicht der Jettenhöhle. – Jugend forscht, Hamburg.



Survey Jettenhöhle 1967-1976

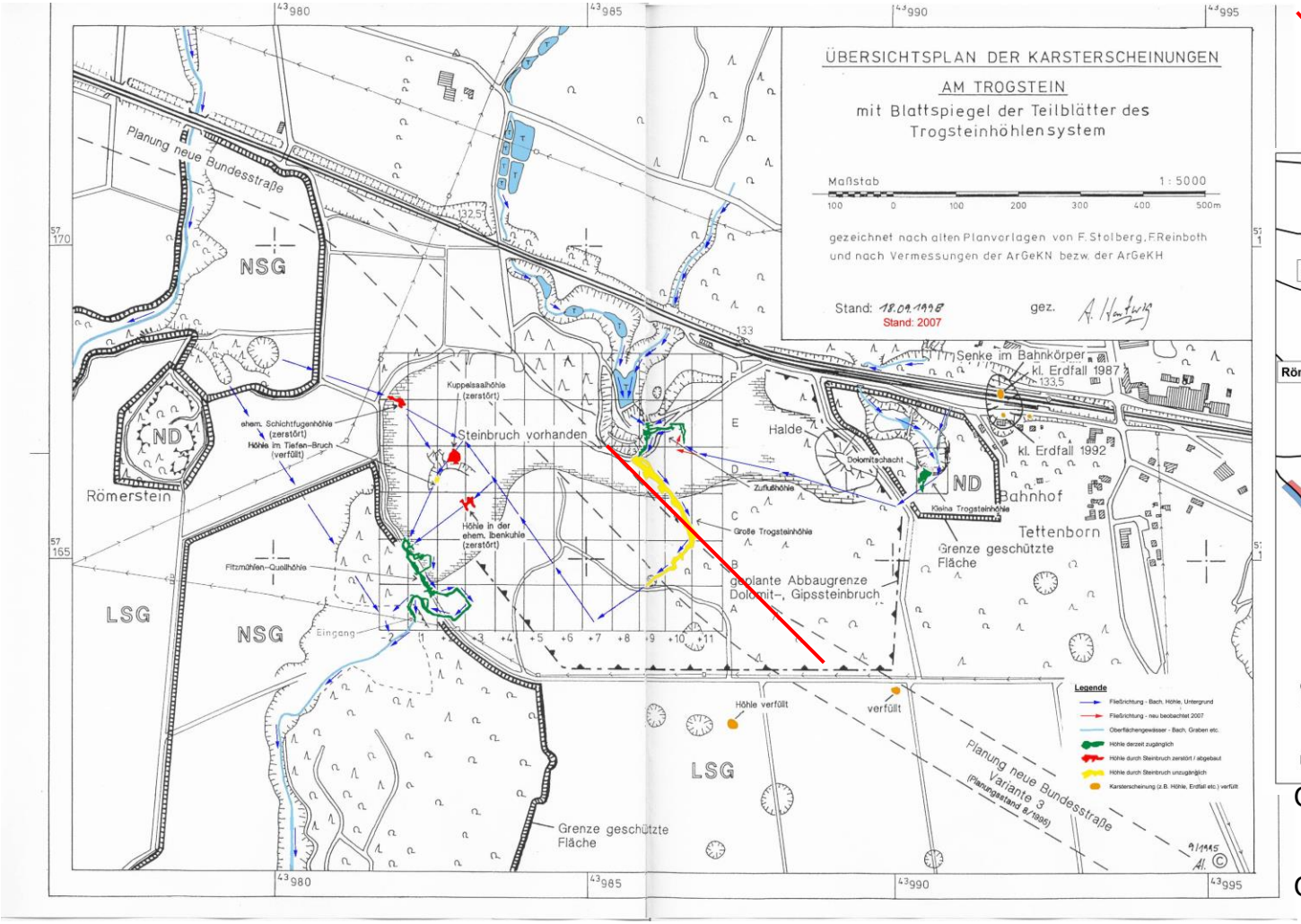
The Hainholz/Beierstein Gypsum Landscape Preserve, known for its complex hydrochemistry



Ascending water in the ponds of the Jettenhöhle

Graphic: S. Kempe, 1982, 2022

In contrast, the Trogstein-System, is an epigenic creek-cave threatened by quarrying



Trogstein-fault, south lifting

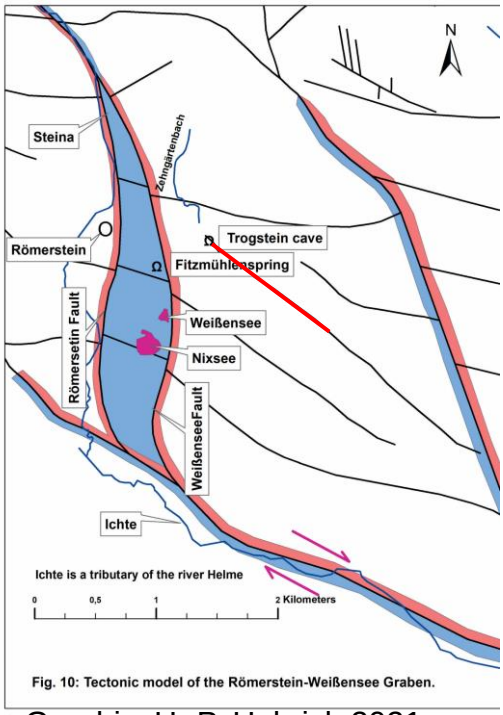
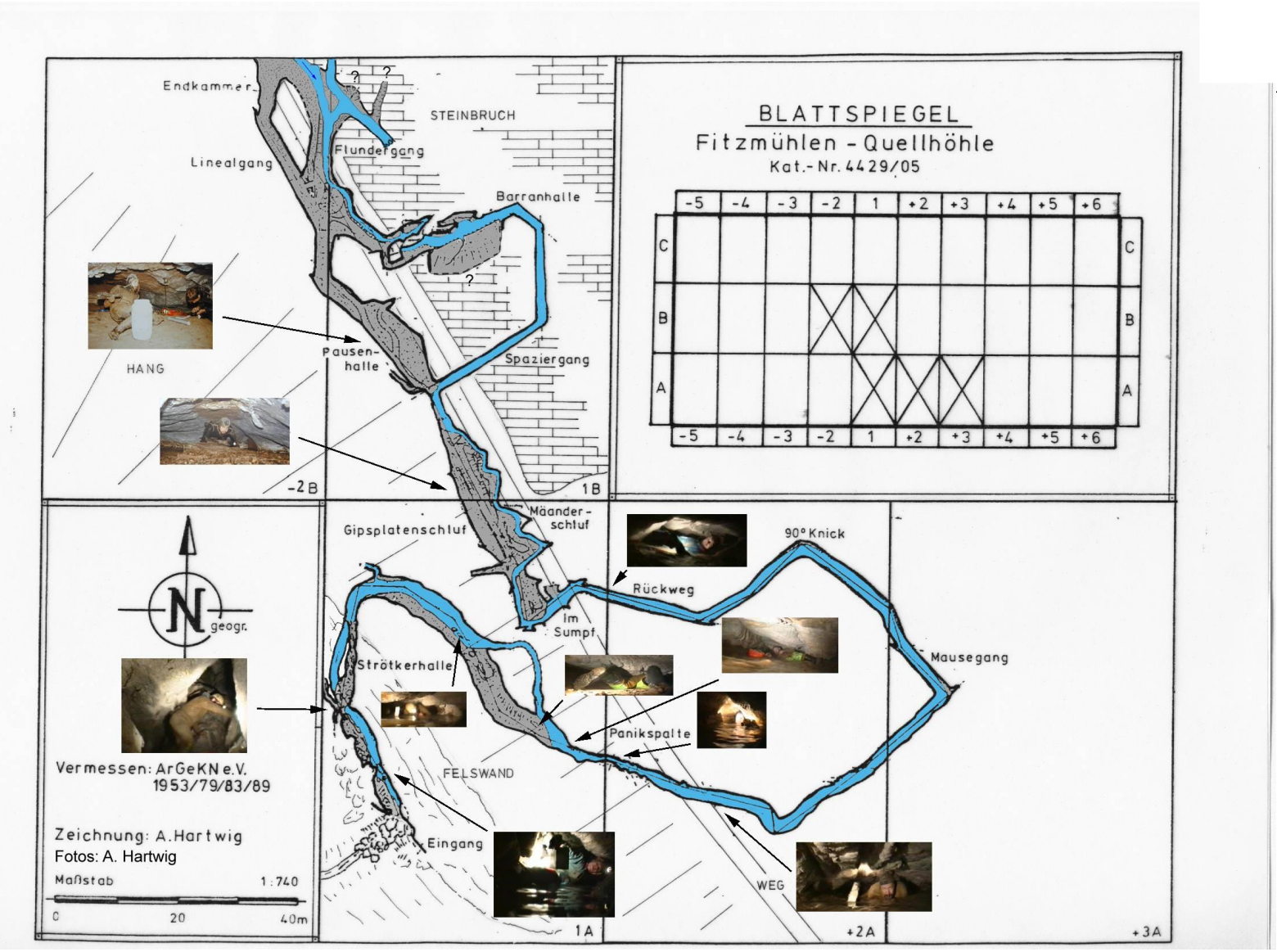


Fig. 10: Tectonic model of the Römerstein-Weißensee Graben.

Graphic: H.-P. Hubrich 2021

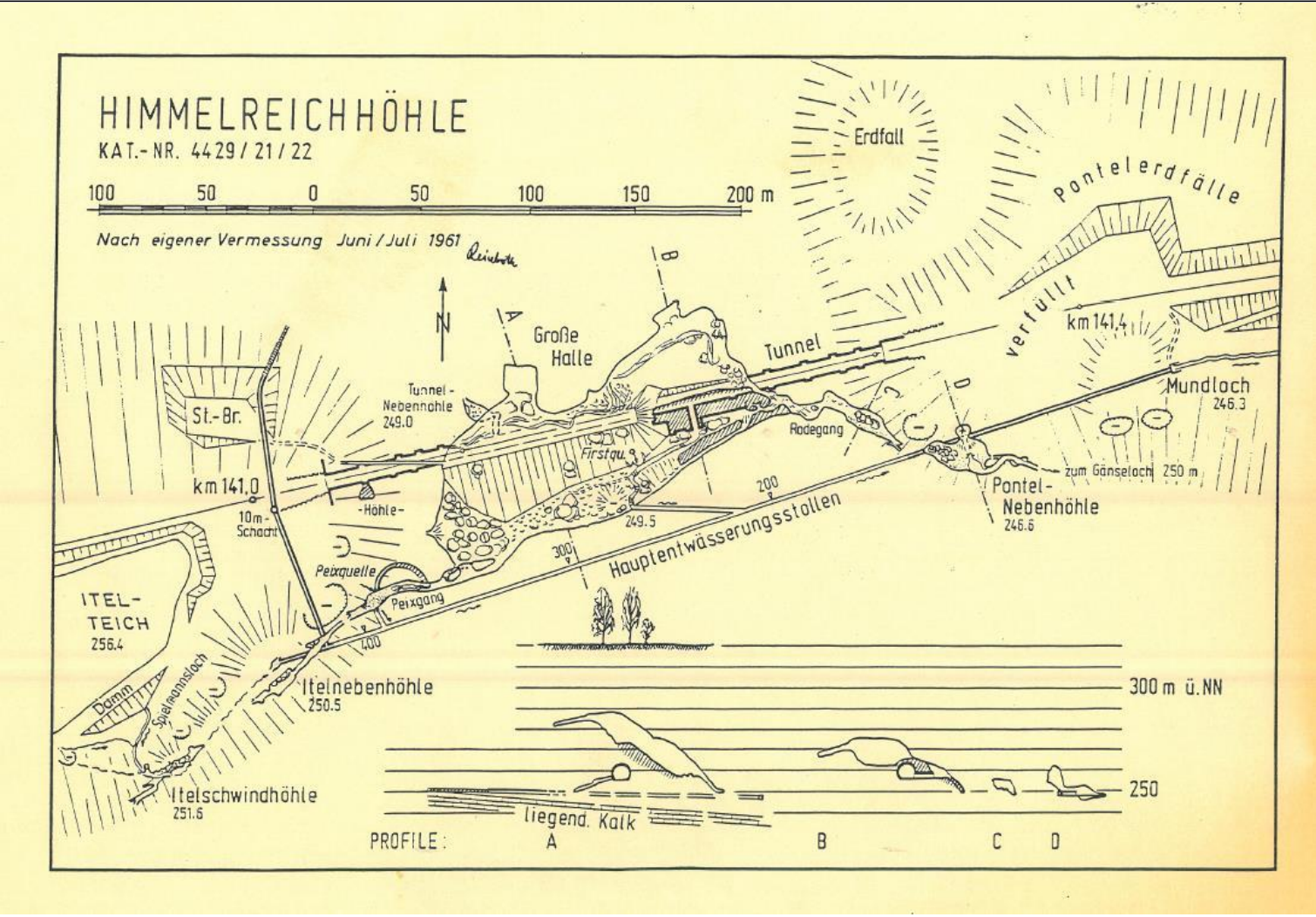
Graphic: A. Hartwig (unpubl.)

The Fitzmühle (545 m), an extremely low epigenic cave

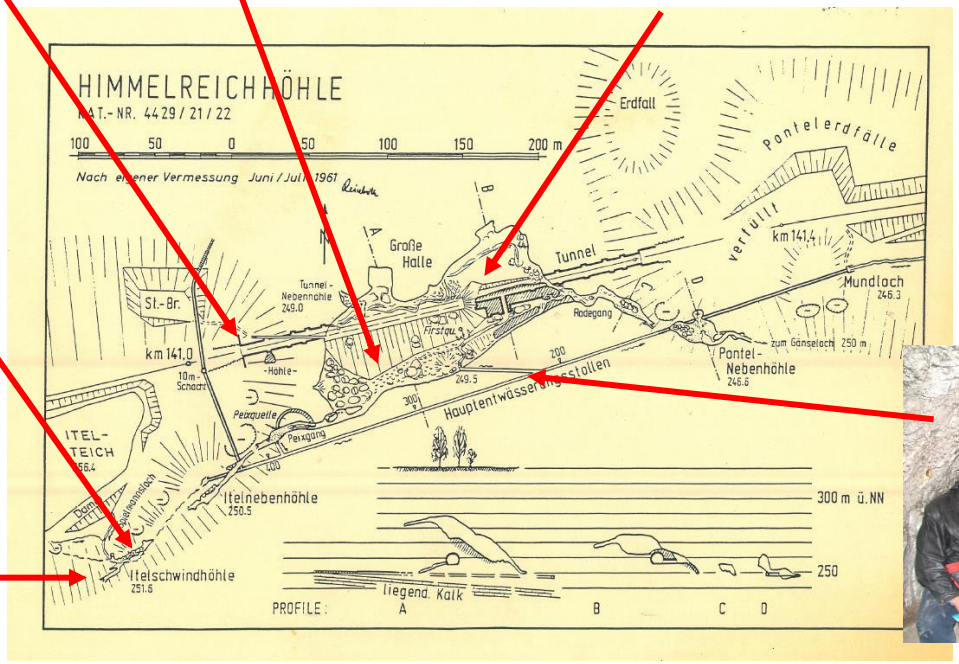


Graphic: A. Hartwig (unpubl.)

One of the curious caves is Himmelreichhöhle, above a train tunnel from the 1860‘ies



Himmelreichhöhle („Heaven‘s Cave“)



Itel Ponor Cave (Photos: S. Meyer)

The Höllern, > 1000 m long) is the only one in Middle Keuper (Grundgips) to speak of. It does look large….

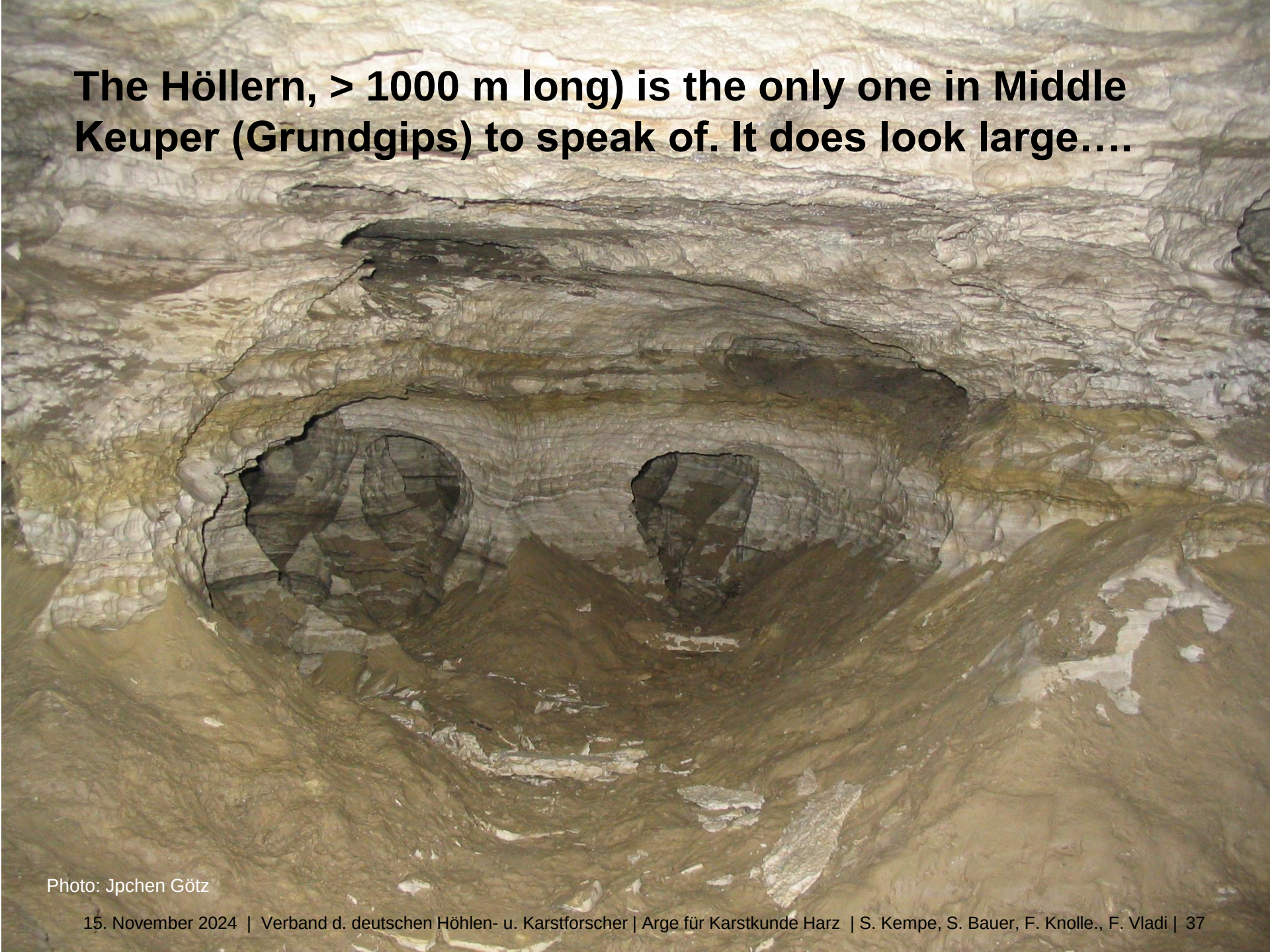
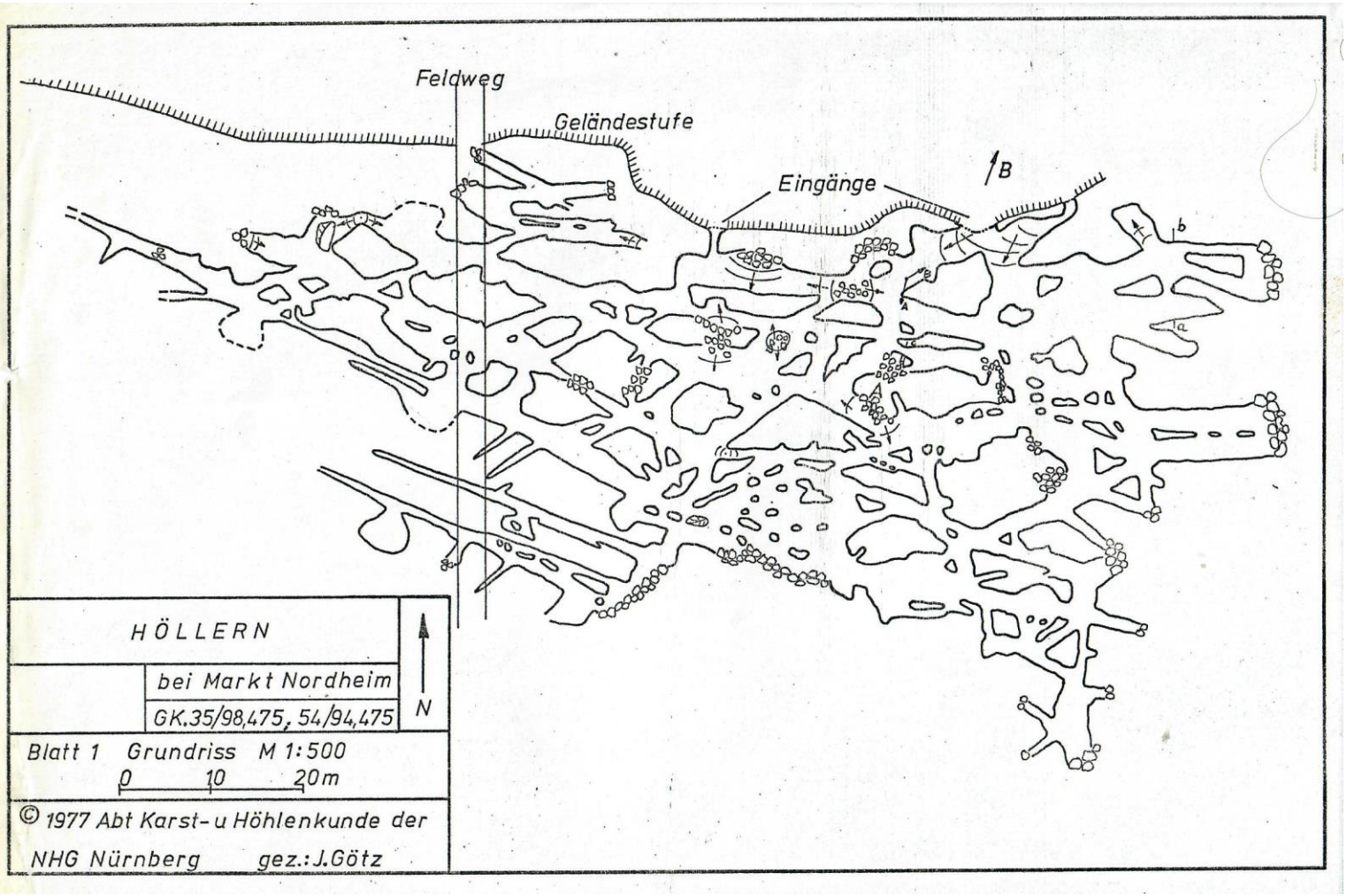


Photo: Jpchen Götz

but it isn‘t

Photo: Jpchen Götz

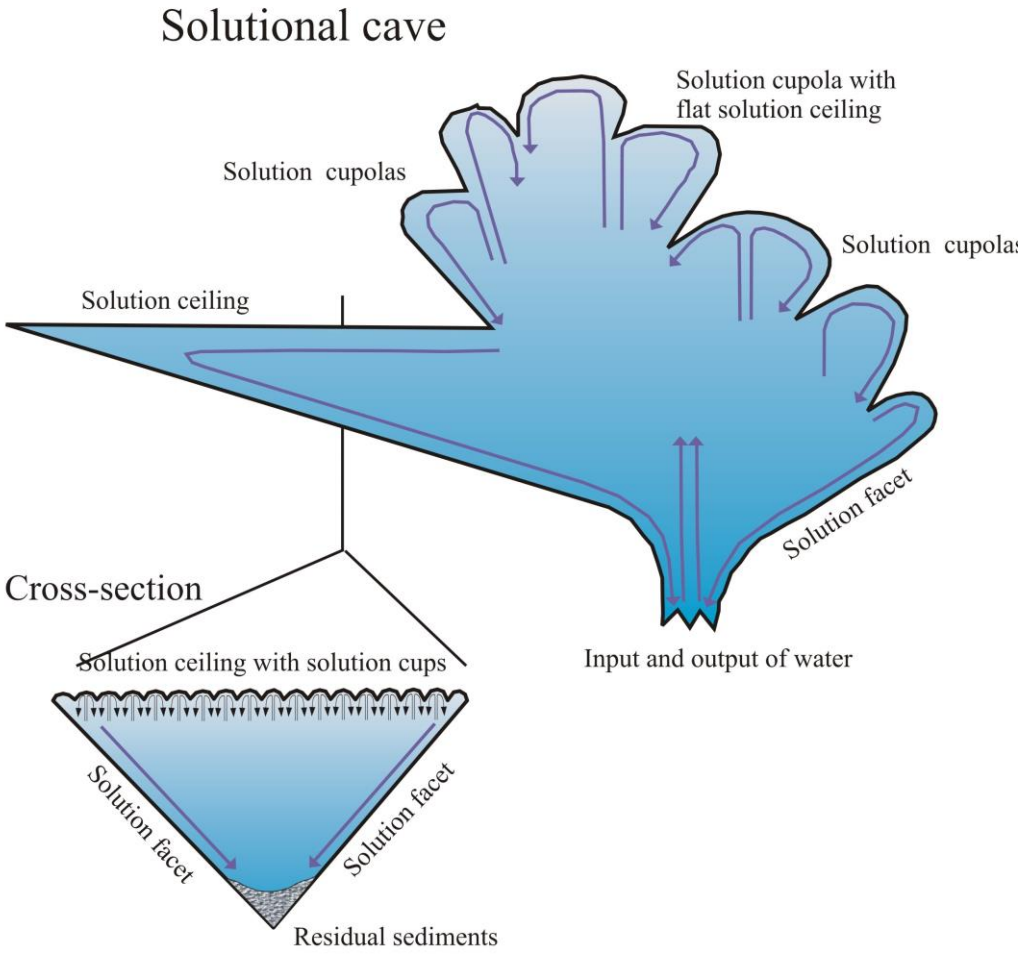
Höllern, a typical low, solutional maze-cave



Sulfate Caves:
Each has its Genetic Singularity

Most of the Harz sulfate caves are convective in origin either at or far below the water-table

The morphological elements of these caves are solutional ceilings, sloping sidewalls („facets“) and solutional cupolas. Cupolas have a fractal pattern, starting with cm-sized solution cups and ending in 10 m-sized halls.



The often observed semi-triagonal cross-section is a consequence of solutional convection

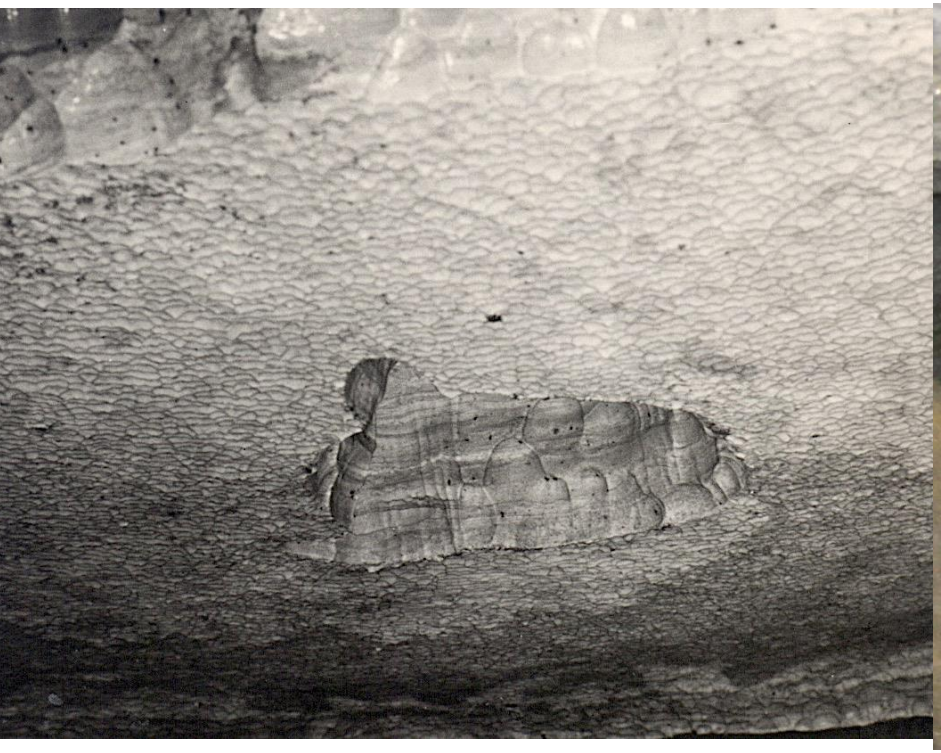
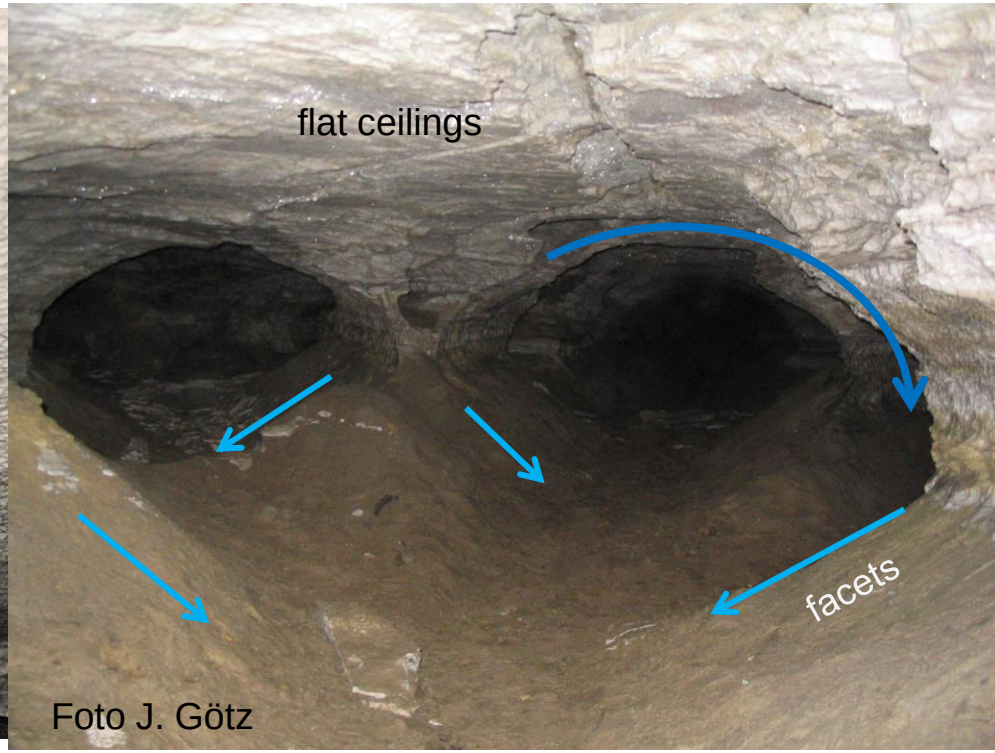


Foto F. Reinboth

Flat solutional ceiling with solutional cups and larger cupolas (fractal convection structure)

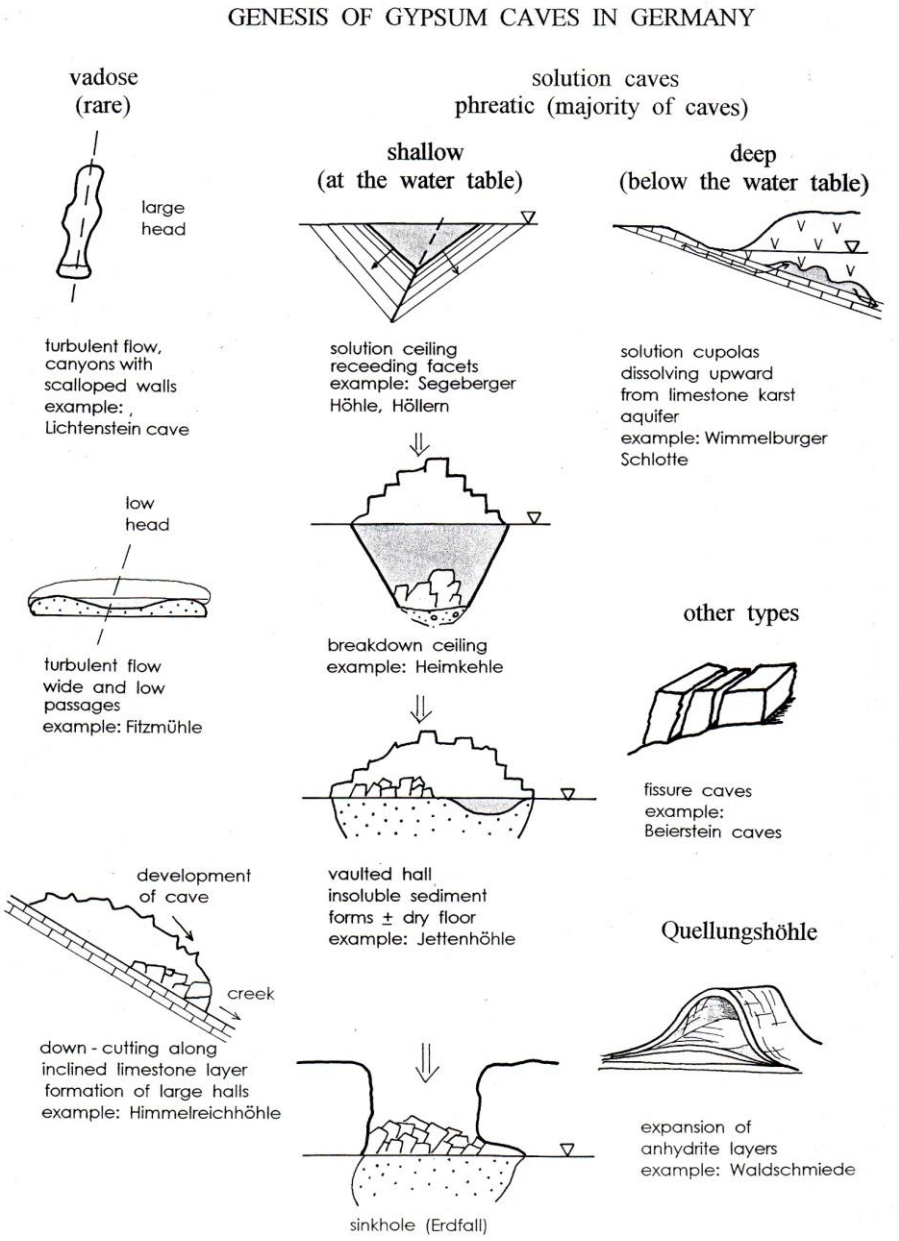


Convection forms flat ceilings, concave sides and flat sidewalls (facets).

Sulfate caves have a high genetic diversity!

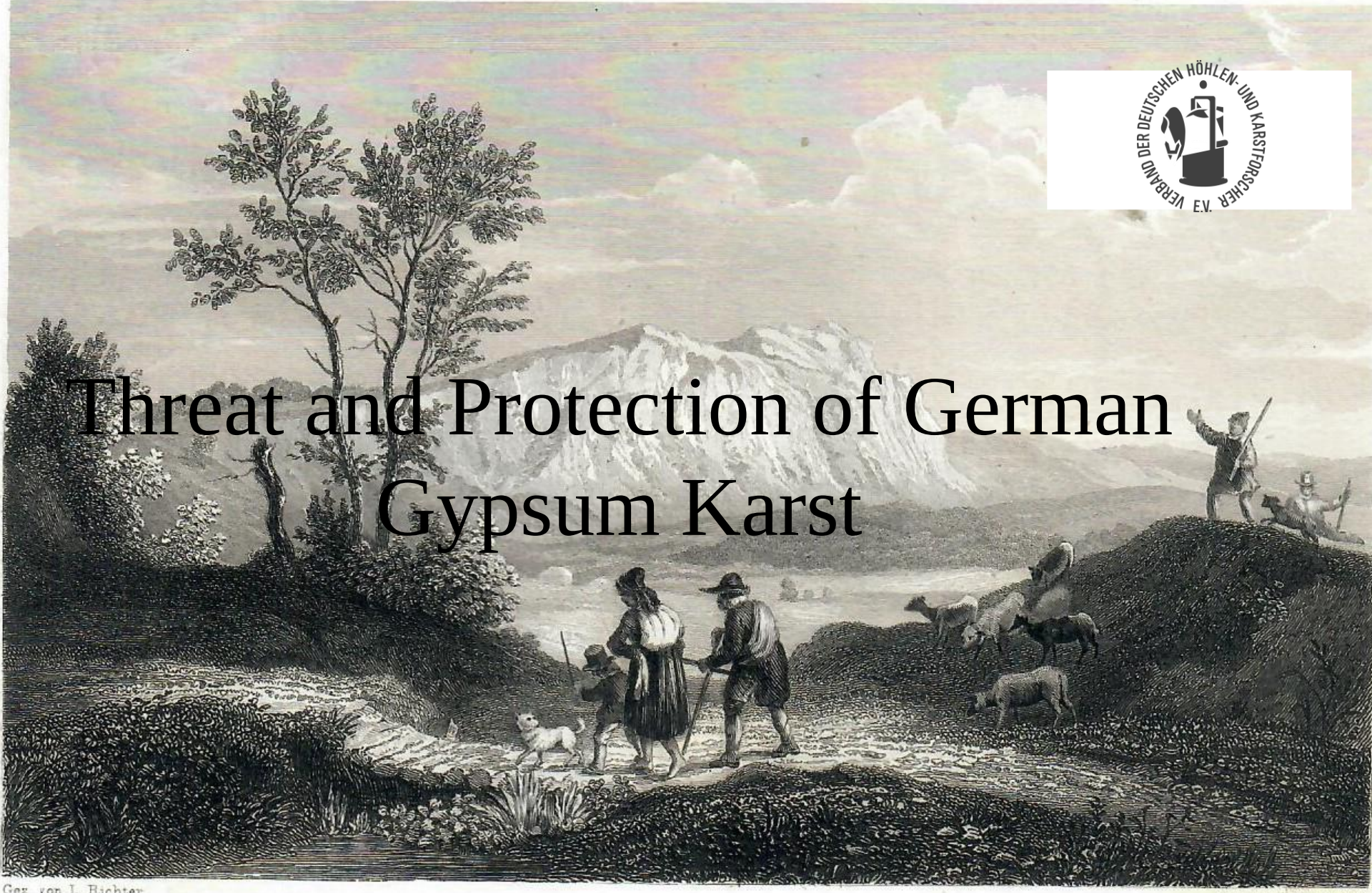
With the exceptions of the Himmelreich Höhle, the large caves are shallow or deep hypogene (“Schlotten” caves), formed by less dense water rising from carbonate aquifers from below, which in turn is saturated with gypsum by slow convective dissolution.

Additionally, we have caves created by creeks. Among them narrow canyon caves (Lichtenstein Cave), very low but wide active caves (Trogstein-System) and a very large cave created by the downcutting of the creek along a sloping aquiclude (Himmelreich Cave).
There are also a few tectonic caves and the “strange” Quellungshöhlen.



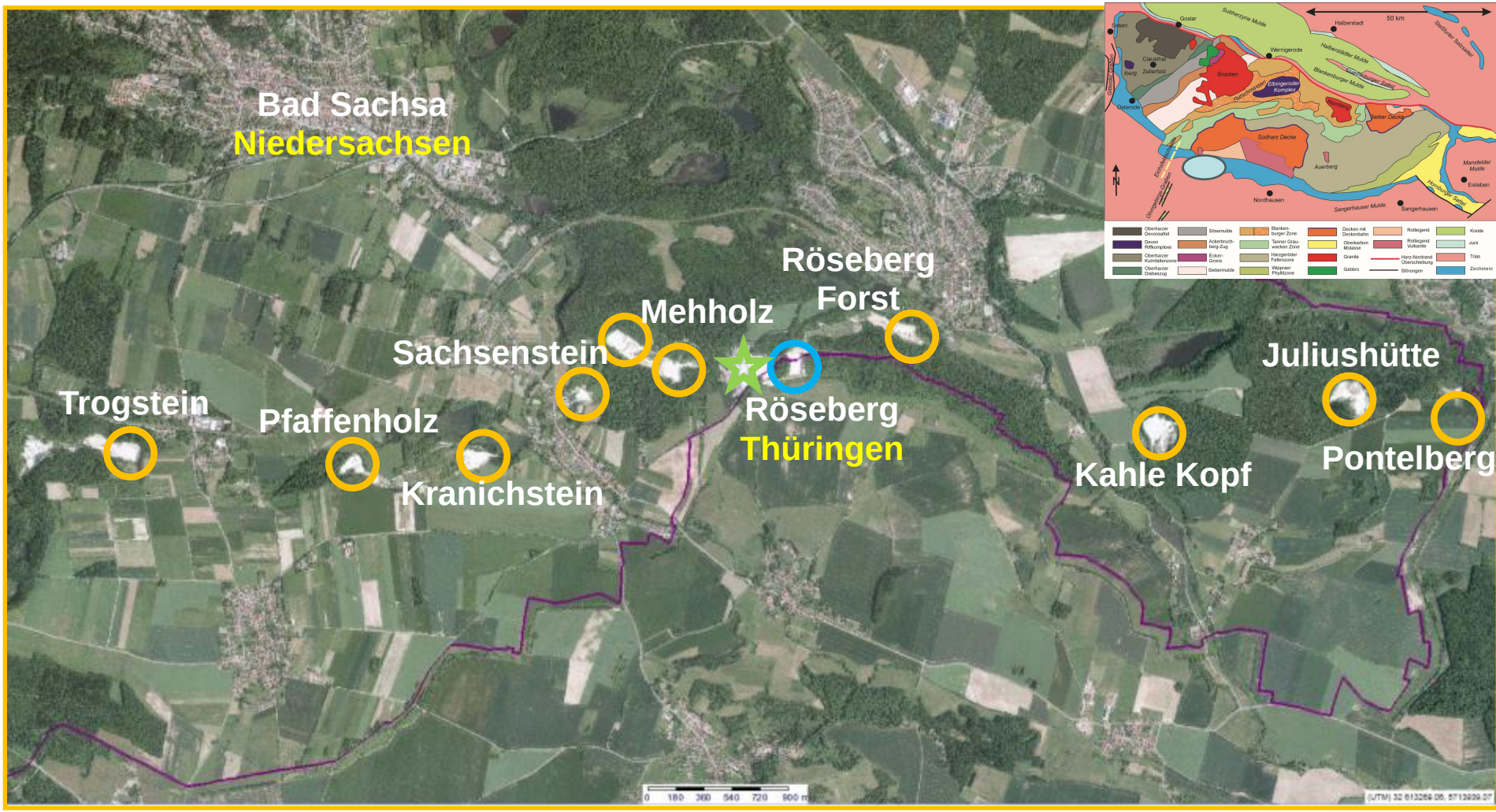
The Sachsenstein in the South-Harz is famous for its “dwarf holes”, Quellungshöhlen, swelling- or hydration-caves, caused by the recrystallization of anhydrite to gypsum.

Threat and Protection of German Gypsum Karst



The main threat of gypsum karst is quarrying

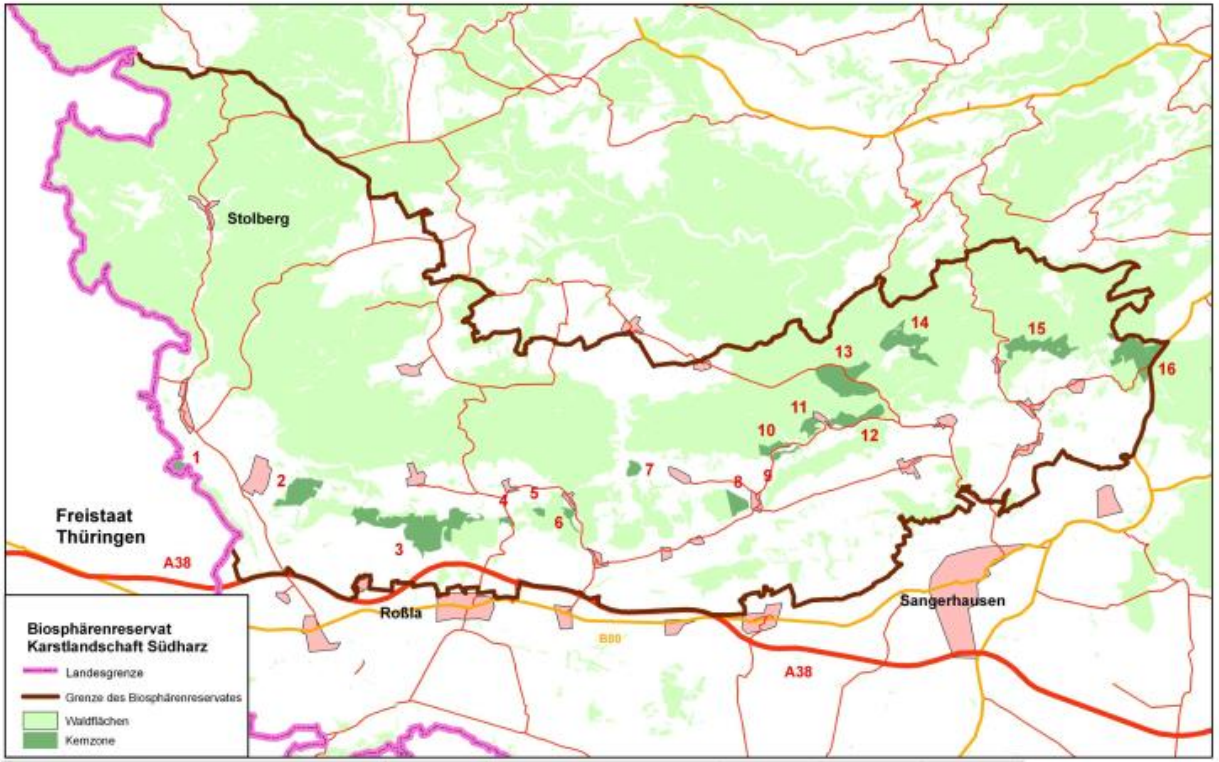
A long string of quarries serves just one factory



With the decrease of gypsum from REA scrubbers, karst destruction rate even increases

- South-German and South-Harz Gypsum karst is only protected to a small extent.
- Gypsum cave Höllern (N-Bavaria) was protected after fierce legal disputes and public pressure.
- Similarly, the South-Harz is under constant pressure from gypsum industry.
- Only the State of Saxony-Anhalt (Sachsen-Anhalt), established a Biosphere Reserve (BR), the largest on sulfate karst, world-wide (www.biosphaerenreservat-karstlandschaft-suedharz.de), excluding, so far, quarrying. The BR includes Fauna-Flora-Habitats (FFH) according to EU and German law and is aiming for UNESCO status.
- In the States of Thuringia (Thüringen) and Lower Saxony (Niedersachsen), the FFH-Areas largely (deliberately) exclude industrial interests, some being established after long-lasting legal fights, such as the 600 ha-large *Hainholz-Beierstein Gypsum-Landscape* in Lower Saxony.
- So far, „Schlotten“ caves are protected; however, their access mine shafts may see shut-down for reason of cost, according to actual State plans.
- Alternatives to natural gypsum exist, thus, quarrying should be terminated and remaining karst areas protected according to Guidelines 4 and 9 (IUCN 1997) + Recommendation 4 (IUCN 2008): *“States Parties whose territories include karst terrains situated on evaporite rocks should consider the potential of their sites for natural World Heritage recognition.”*

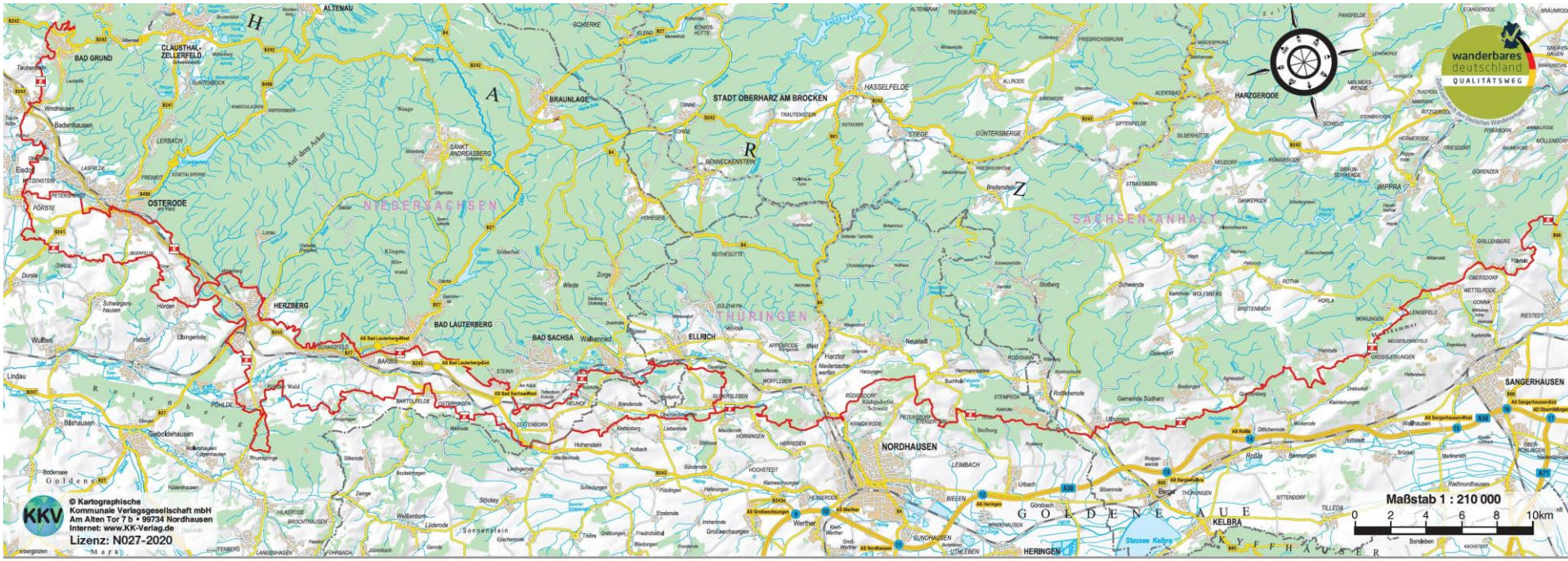
The Biosphere Reserve in Saxony-Anhalt is the largest on gypsum karst world-wide



Teilgebietsnahmen

1	Heimkehle	2	Seeberge	3	Vorberge/Bauerngrabe
4	Thomaslehden	5	Roter Kopf	6	Uhufelsen
7	Kleine Haardt	8	Ankenberg	9	Öhmischer Berg
10	Eichenberg	11	Morungskopf	12	Kuhberge
13	Knüll	14	Rehhagen/Käseberg	15	Hohe Linde
16	Ritterplätze				

In order to increase public awareness, a system of hiking paths was created



The 265 km long paths are not only suitable for long-distance hiking, but include also 30 round-courses, highlighting specific outcrops, karst areas, ecological or heritage features. Numerous billboards provide explanations on-site (www.karstwanderweg.de).


Scolopendrium sink hole, once part of the Jettenhöhle
Thank you for your attention!

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Photo: Jochen Götz

Reserven

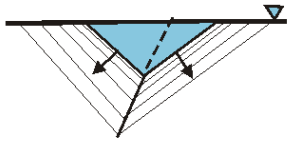
Reserven

Laughöhlen
phreatisch (Mehrheit der Höhlen)

vados (selten)

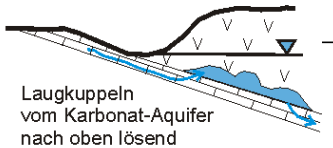
turbulentes Fließen,
Canyons mit Fließfacetten
Beispiel: Lichtensteinhöhle

flachphreatisch (am Grundwasserspiegel)

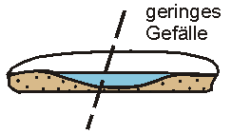


Laugdecke; Rückwärts-verlagerung der Facetten
Beispiele: Segeberger Höhle, Höllern

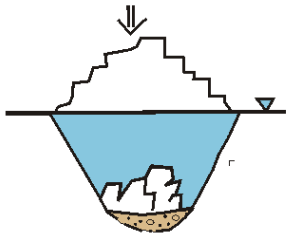
tiefphreatisch (Unterhalb des Grund-wasserspiegels)



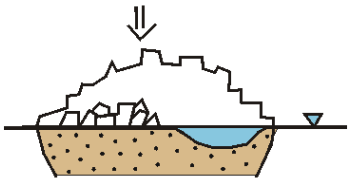
Laugkuppeln
vom Karbonat-Aquifer
nach oben lösend
Beispiel: Wimmelburger Schlotte



turbulentes Fließen,
breite und niedrige Passagen
Beispiel:Fitzmühle

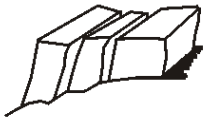


Versturzdecken
Beispiel: Heimkehle

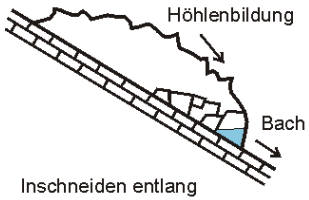


Gewölbte Halle
unlösliche Sedimente
bilden einen trockenen Boden
Beispiel: Jettenhöhle

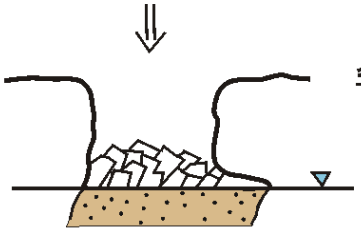
andere Typen



Spaltenhöhlen
Beispiel: Beierstein-höhlen



Inschneiden entlang geneigter Kalkstein-schichten, Bildung großer Hallen
Beispiel:Himmelreich-höhle



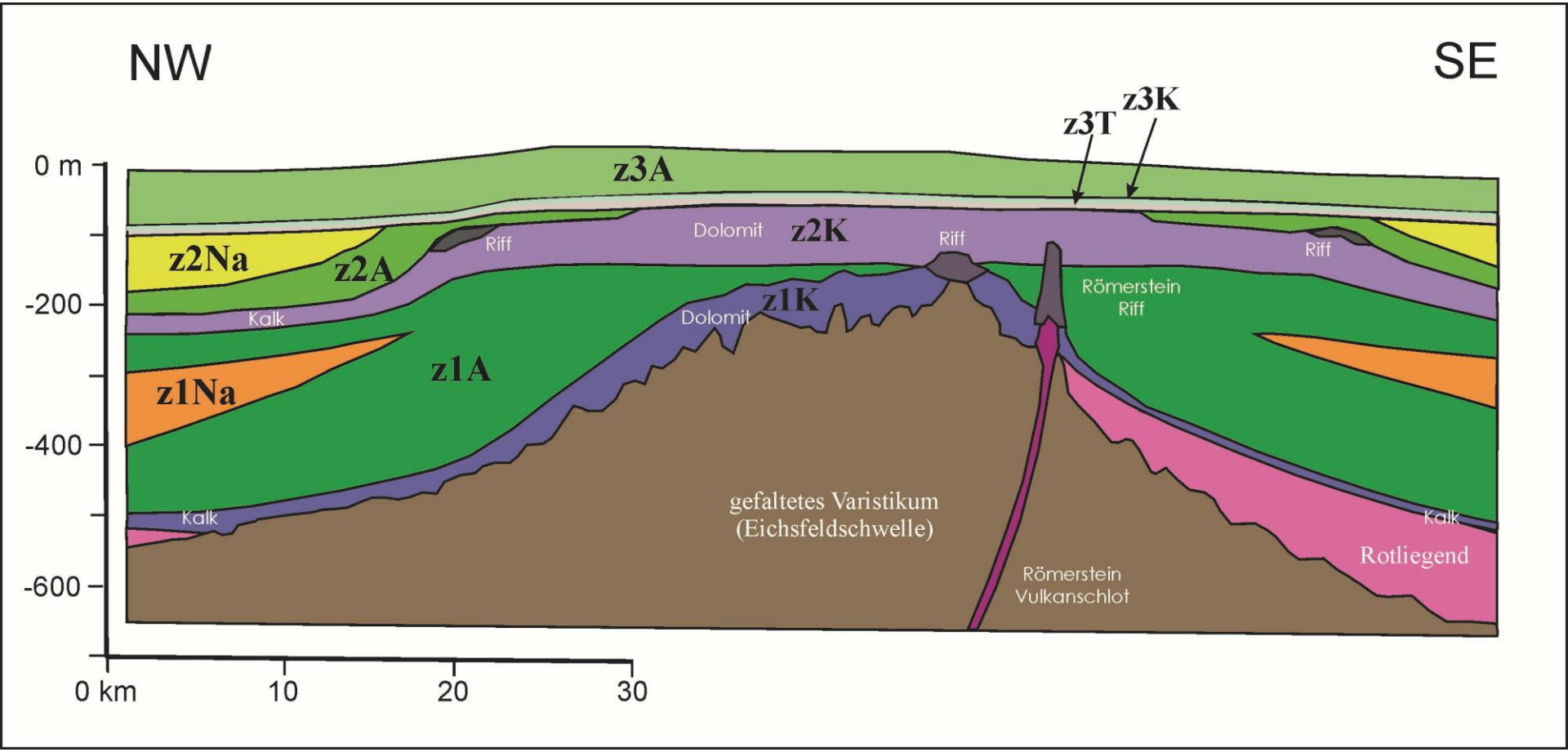
Erdfall

Quellungshöhlen

Quellung von Anhydrit-schichten
Beispiel: Waldschmiede

Die paläogeographische Eichsfeldschwelle teilt das Zechsteinbecken des Südharzes in W und E

TECHNISCHE UNIVERSITÄT DARMSTADT



Nach Herrmann, A. (1956): Der Zechstein am südwestlichen Harzrand (seine Stratigraphie, Fazies, Paläogeografie und Tektonik). – Geol. Jb. 72: 1-72.

Der eigentliche Südharz-Schatz ist der Kupferschiefer, der seit dem Mittelalter verstärkt bis 1989 abgebaut wur

Der Kupferbergbau prägte nicht nur den Namen Zechstein, und machte seine Fossilien bekannt, sondern er fuhr auch viele hypogene Höhlen an, die „Schlotten“.

Der Kupferschiefer, ein Metall-„Flöz“ berühmt für den Ganoid-Fisch *Palaeoniscum freieslebeni*

Fig. 1: The Zechstein Belt along the South Harz (bold blue line) with the most important karst areas and springs (Google Earth): A) Lichtenstein, B) Beierstein/Klinkerbrunnen, C) Hainholz/Martha- and Jettenhöhle, D) Steinberg, E) Einhornhöhle, F) Weingartenloch, G) Trogstein, H) Sachsenstein, I) Himmelreich, J) Kelle, K) Heimkehle, L) Bauerngraben, M) Questenberg, N) Schlotten. Thin blue lines: borders of Federal States.

„Schlotten“

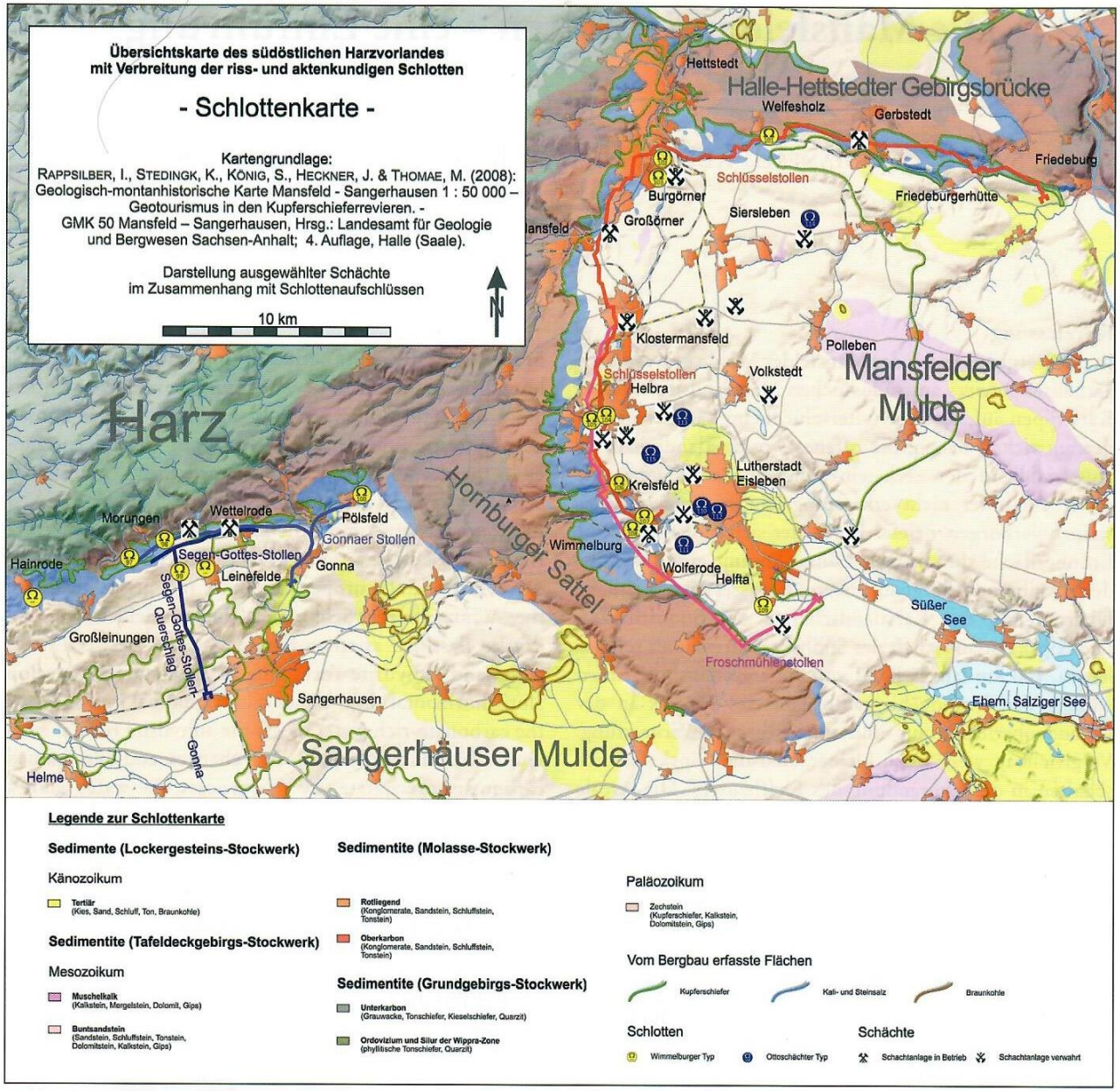
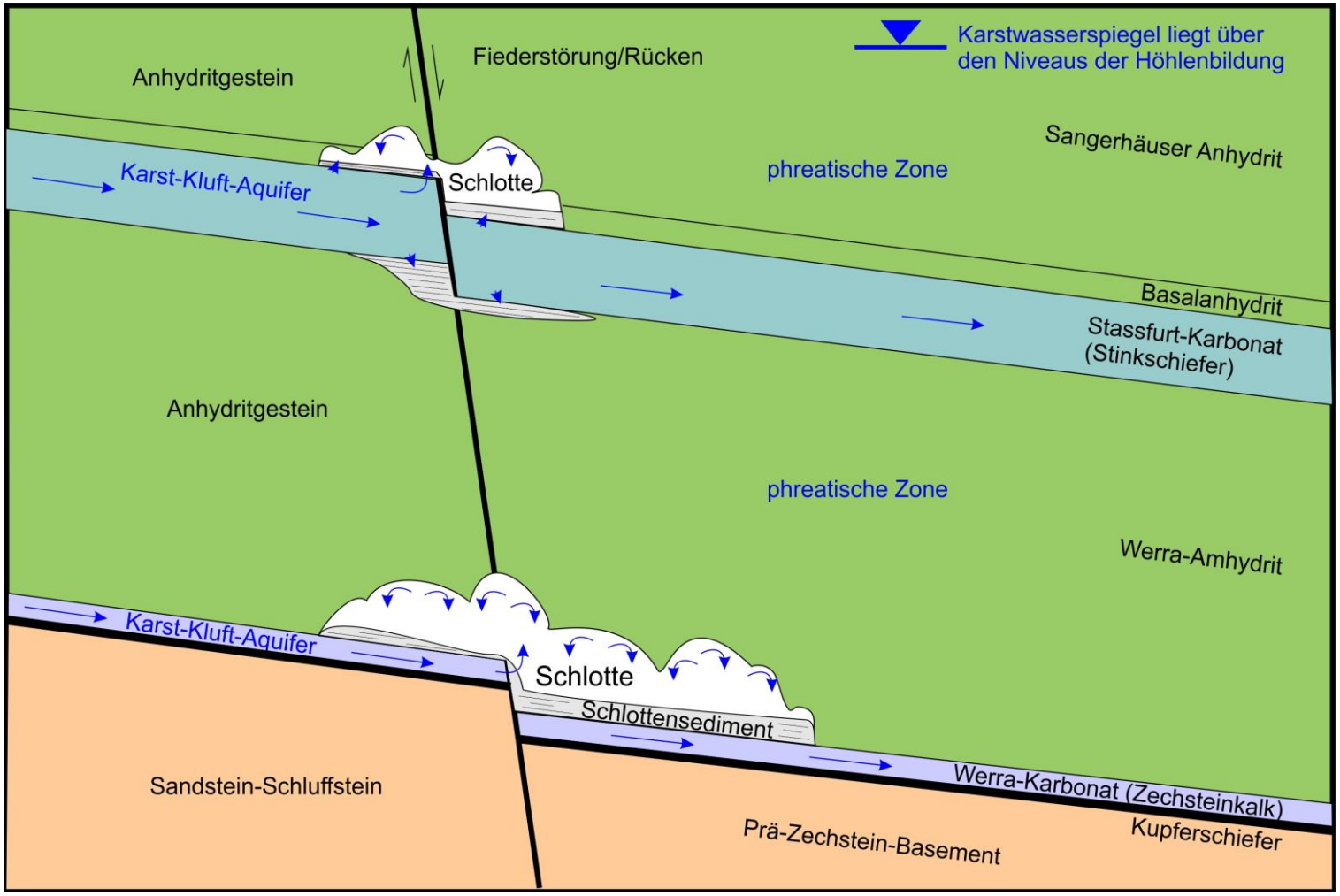
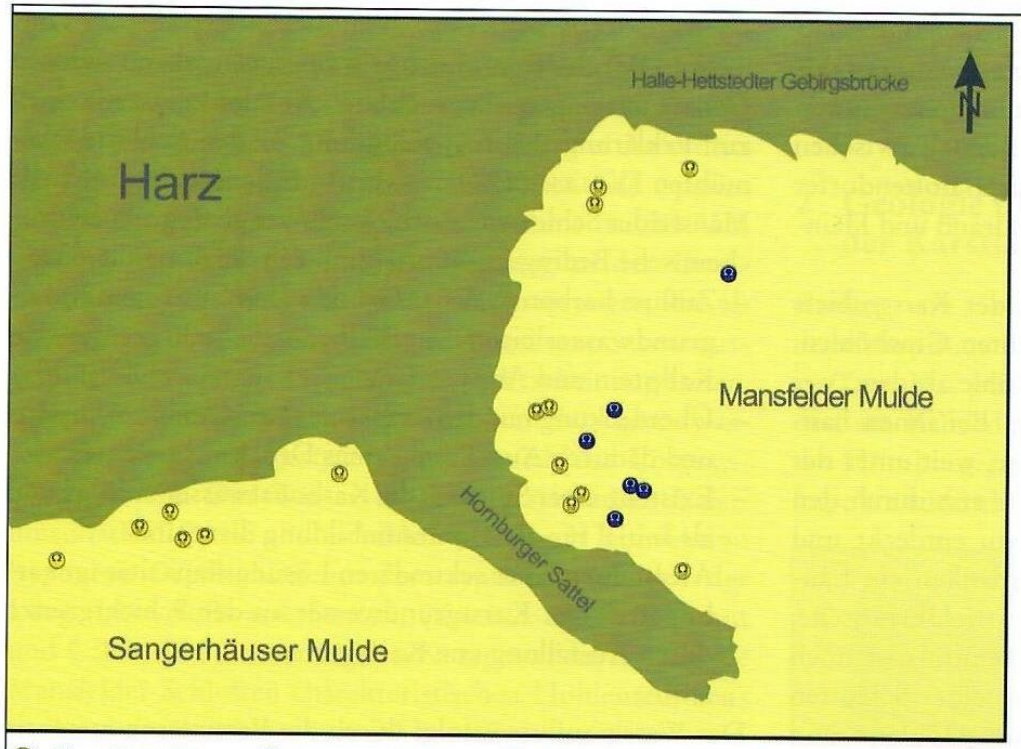


Abb. 1b: Übersichtskarte des südöstlichen Harzvorlands mit Verbreitung der riss- und aktenkundigen Mansfelder Schlotten; Grafik: Sven Bauer & Michael K. Brust.

Bauer, S. et al., 2021


Karstwasserspiegel liegt über den Niveaus der Höhlenbildung
Anhydritgestein
Fiederstörung/Rücken
Sangerhäuser Anhydrit
phreatische Zone
Karst-Kluft-Aquifer
Schlotte
Basalanhydrit
Stassfurt-Karbonat (Stinkschiefer)
Anhydritgestein
phreatische Zone
Werra-Amhydrit
Karst-Kluft-Aquifer
Schlotte
Schlottensediment
Sandstein-Schluffstein
Werra-Karbonat (Zechsteinkalk)
Kupferschiefer
Prä-Zechstein-Basement

„Schlotten“, intercepted by historic mining, are hypogenic, deep phreatic cavities, mostly inaccessible



Signaturnummern und Schlottenbezeichnungen nach dem STOLBERG'schen Harzkataster (1943/1984) mit *Ergänzungen* (kursiv), Synonyme in Klammern:

-- *Hainröder Schlotte*
-- *Schlotte unter Lengefeld*
97 Schlotten im Hohe[n]warter Revier *(Hasenwinkler Schlotte, Zwergenloch)*
98 Schlotte am Elisabethschacht im Heiligenborner Revier *(Elisabethschächter Schlotte)*
99 Schlotte im Segengottesstolln (Segen-Gottes-Schlotte, *Marienglasschlotte*)
100 Schlotte im Kupferberger Revier bei Pölsfeld (Brandschächter Schlotte, *insges. vier Schlotten*)
101 Schlotte bei Welfesholz
102 Schlotte bei Burgörner
103 Schlotte im Eduardschacht
104 Schlotte am Schacht E bei Helbra *(Helbraer Schlotten)*
105 Schlotte am Schacht Ottiliae bei Helbra *(Helbraer Schl.)*
106 Schlotte bei Creisfeld *(Glückaufer Schlotten)*
107 Schlotte am Schacht W bei Wimmelburg *(Wimmelburger Schlotten)*
108 Schlotte am Froschmühlenstollen-Querschlag bei Wimmelburg *(Wimmelburger Schlotten)*
109 Schlotte im Hermannschacht
110 Schlotte in der II. Tiefbausohle Eisleben
111 Schlotte am Ottoschacht (Ottoschächter Schlotte)
112 Schlotte am Umfahrungsquerschlag der IV. Tiefbausohle
113 Schlotte am Graf Hohenthalschacht
114 Schlotte am Paulschacht *(insges. vier Schlotten, aufgefahren in Querschlägen der 5. und 7. Sohle)*
115 Schlotte im Eikendorf (109 a)

nicht in der Karte:
Buchholzer Schlotte (bei Buchholz östlich Nordhausen)

Vgl. hierzu auch den Beitrag BRUST & IRMSCHER in diesem Band.

Schachtanlagen im Zusammenhang mit Schlotten (vgl. auch Abb. 1b)

Schachtanlagen in Betrieb (Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft mbH, Bereich Kali-Spat-Erz):
A - Schacht Junger Adolph, B - Röhrig, C - Schächte W und T, D - Freiesleben II, E - Lichtloch 20 Z

Schachtanlagen verwahrt: F - Hermann, G - Erdmann, H - Otto, I - Segen-Gottes (Otto-Helm), J - Martins, K - Clotilde (Max-Lademann), L - Schmid, M - Ernst (Walter-Schneider), N - Graf Hohenthal (Hans-Seidel), O - Lichtloch 81, P - Zirkel, Q - Vitzthum (Ernst-Thälmann), R - Eduard, S - Zimmermann, T - Paul (Otto-Brosowski), U - Wolf (Fortschritt I, V - Dittrich (Fortschritt II)

Abb. 1c: Schlotten im Sangerhäuser Revier und in der Mansfelder Mulde, Grafik: Sven Bauer & Michael K. Brust.

Bauer, S. et al., 2021

With the decrease of gypsum from REA scrubbers, the destruction rate even increases

- The South-Harz Gypsum-karst is only protected to a small extent.
- A 600 ha-large area is preserved as *Hainholz-Beierstein Gypsum-Landscape* in Lower Saxony (State of Niedersachsen).
- FFH-Areas are protected in all three respective Federal States.
- In the same State, a Biosphere-Reserve was founded, the only one on sulfate karst, world-wide (www.bioreskarstsuedharz.de).
- In Thuringia (State of Thüringen) the gypsum karst has the least protective status.
- Supposedly, State and Federal Administrations assume that the „Schlotten“ are under protection (UNB, UDB, Hydrological and Geological Surveys).
- What about World-Heritage: Guidelines 4 and 9 (IUCN 1997) + Recommendation 4 (IUCN 2008): *“States Parties whose territories include karst terrains situated on evaporite rocks should consider the potential of their sites for natural World Heritage recognition.”*