Abris and sandstone caves in southern Lower Saxony

Location: Europe, Germany, Lower Saxony, Goettingen-Northeim region

Andreas Hartwig Juli 2022 (Contact: ah.hartwig.andreas@gmail.com)
With images from the public lecture of the annual general meeting of the Working Group for Karst and Caves Harz e.V. (ArGeKH e.V.) on April 2nd, 2022, created by Andreas Hartwig.

Introduction:

The sandstone area that I want to present in my following article is in Europe, there within Germany in the northern German state of Lower Saxony. Within Lower Saxony in the southernmost part on the border with the states of Thuringia and

Hesse. In terms of local politics, the area is primarily in the district of the city of Göttingen and partly in the southern area of the district of Northeim. The core area is located south of the city of Göttingen, near the rocky town of Reinhausen. This is the “Reinhäuserwald” nature reserve. In the “Reinhäuserwald" there is a multitude of different rock roofs (abris), caves and dry valleys in a very small space. In particular, a large accumulation of early human camp sites under the rock roofs, which have been proven to go back to the Neanderthals. There are also numerous rock carvings from the Stone Age to the Middle Ages and to the present day. To date, more than 1.600 rock roofs (abris) in southern Lower Saxony have been recorded, mapped and, in some cases, randomly excavated by the district archaeologists.
In southern Lower Saxony it is partly a karst landscape in the sense of the nomenclature of classic or genuine karst, but also a landscape that only appears to be karst in the aforementioned sense on the surface of the terrain. In my article I would therefore like to write about special karst, which is actually not karst, but which appears to be karst on the surface of the terrain, the appearance of the caves also partly, but it is not karst. Out of the tradition of the UIS Pseudo-Karst Commission and for the sake of simplicity, I would like to use the nomenclature "pseudo-karst" in my article below, even if some scientists now consider this nomenclature to be outdated and incorrect.

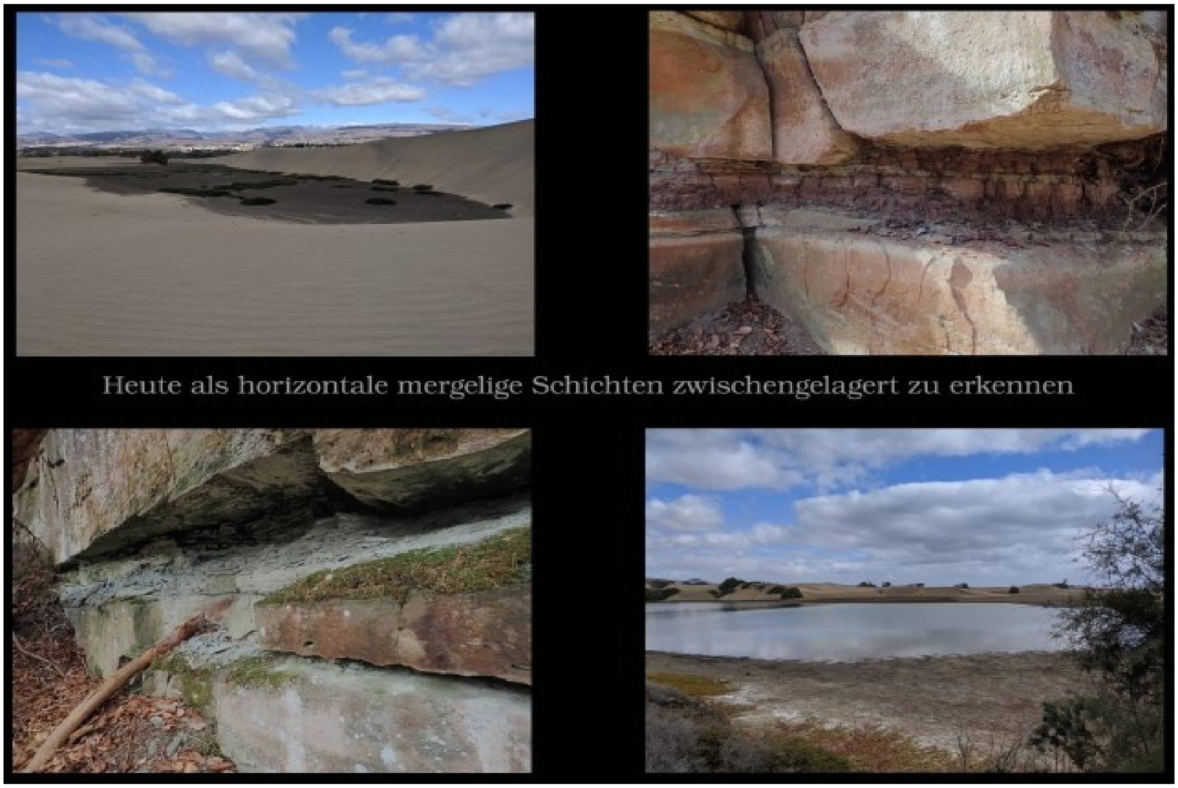
Geological genesis:

A landscape created from desert dunes. Nice to see the diagonal layering and cap-like interlocking.

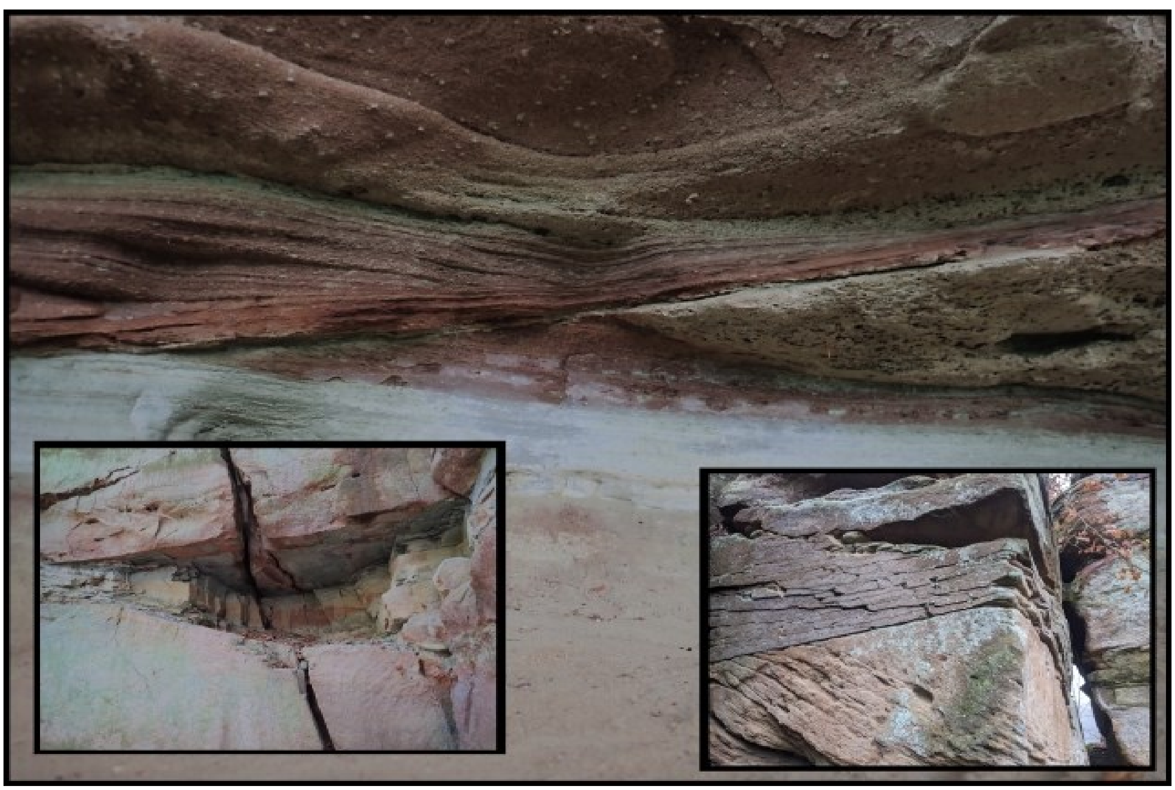
The Middle Buntsandstein (Colored sandstone; red sandstone) was formed in the early Mesozoic, at the beginning of the Mesozoic around 251-214 million years ago. The Triassic, Jurassic and Cretaceous ages are counted towards the Mesozoic Era (approx. 251-190 million years ago). In the Mesozoic era, "Southern Lower Saxony" lay in the middle of a huge central or central European basin within the large continent of Pangea and was relatively close to the equator. The Buntsand-stein (Colored sandstone; red sandstone) originated in a desert-like landscape primarily in the form of desert dunes. The dunes were formed from weathering residues (sand, clay, silt etc.), which were transported by the wind from the distant hinterland mountains and deposited in the Central European basin.

Sand blown by the wind in primeval times, petrified in the present.

A subtropical monsoon climate prevailed with heavy rainfall events, which caused rivers to transport debris from the mountains into the basin with the dunes. The rivers often ended in lakes, ponds and swamp ponds. The slanted stratification, which was partly interlocked like a cap and deposited as dunes, or the slanted stratification of the river and lake shore areas, can be found petrified in the sandstone rocks today. The red color of today's sandstone is due to iron oxide (Fe_2O_3) and the discoloration due to water absorption, which resulted in iron hydroxide ($Fe[OH]_3$) with a brown-red colour.



Sediments transported by heavy rain deposited between the dunes. Visible today as horizontal marly interlayers.



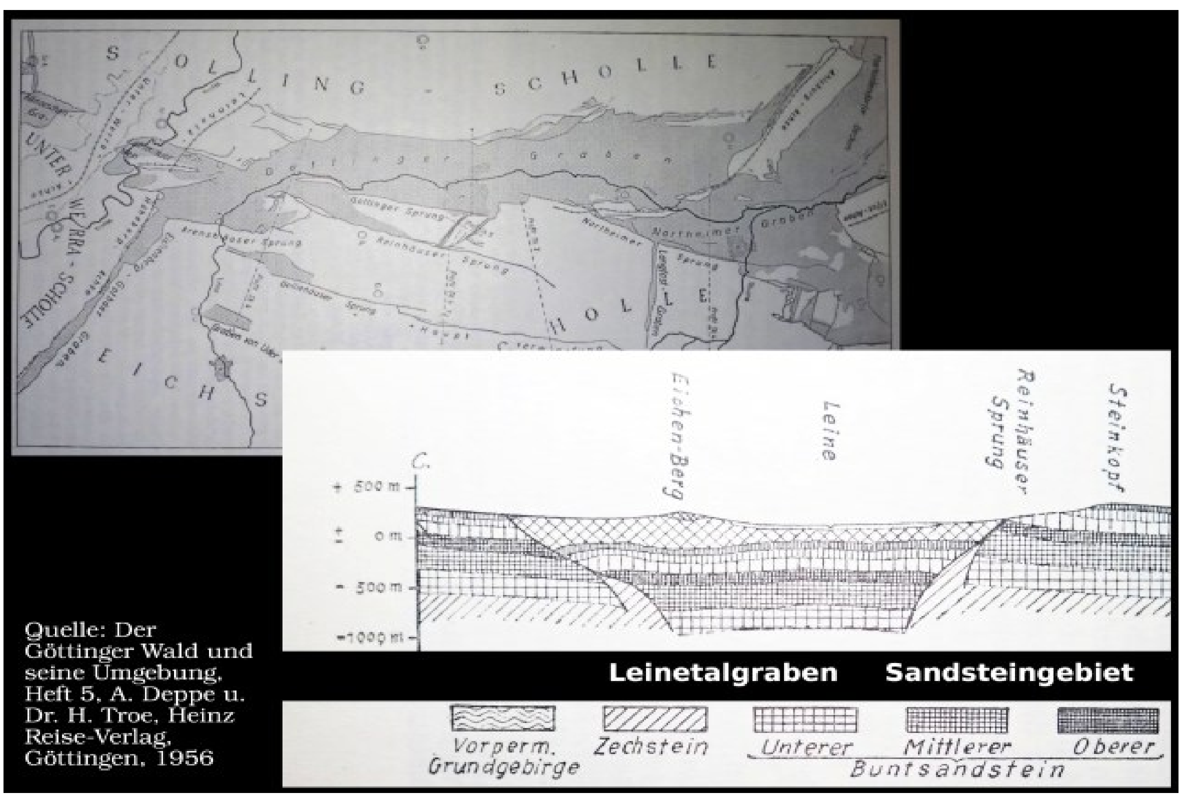
The sloping deposits of the primeval banks (lakes, rivers etc.) are petrified today. At the time the Upper Buntsandstein (Röt) was formed, the central European basin was repeatedly flooded by the sea. In between, the shallow sea dried upseveral times, with rock salt and gypsum being deposited by evaporation in hollows and tidal creeks. After that, the basin flooded completely and today's shell limestone was deposited in the sea as a very calcareous marine sediment.

Upper red sandstone (Oberer Buntsandstein) gypsum rock. formed from evaporated marine deposits.

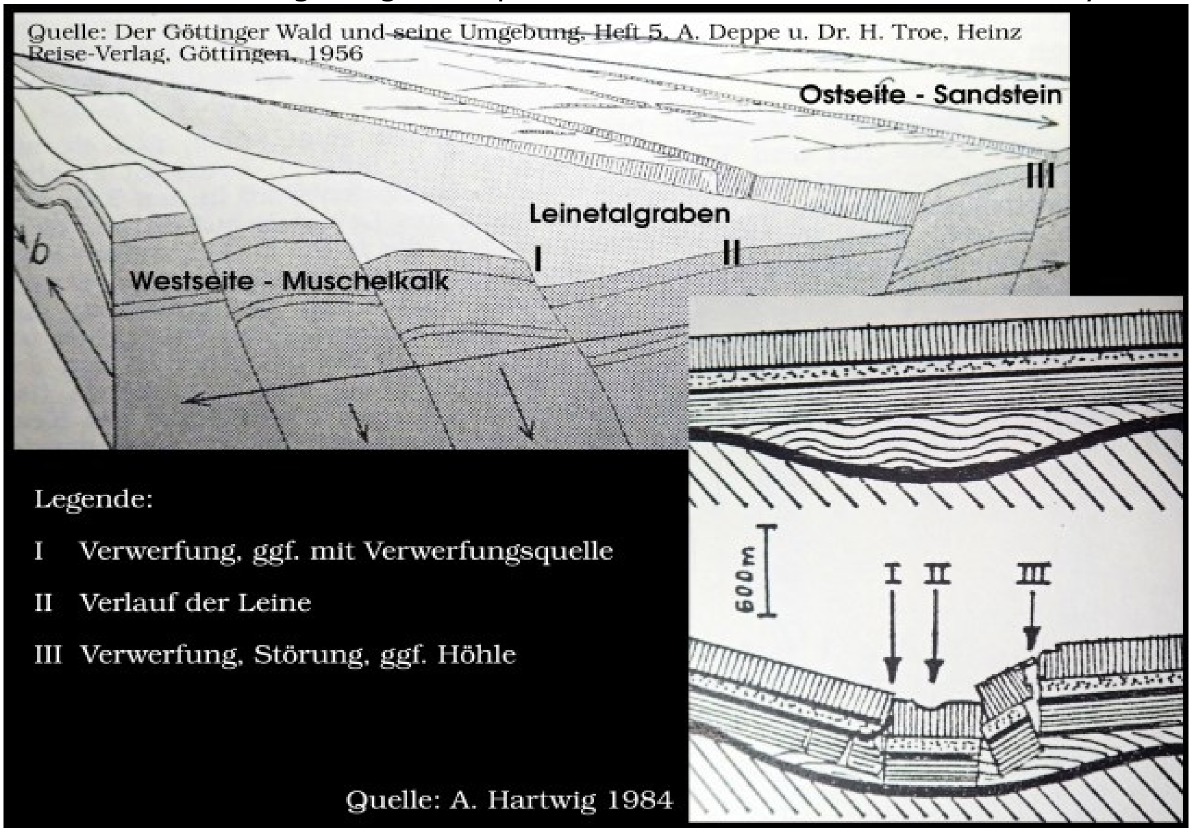
Tectonics:

At the end of the Mesozoic, in the Cretaceous period (approx. 145-66 millionyears ago), a large movement in the earth's crust began and the main features of the „Leinetal" Rift Valley with its edge, tear and fault fissures developed. The Leinetalgraben is said to represent a marginal element of the Central European expansion field. In more recent work, the Leinetalgraben is assigned to the Central European graben system as a part of the Lower Saxony Basin. Lateral shifts, strains and compression occurred in the Central European graben system, which resulted in faults (height jumps) between the geological layers. As a result of these faults (height jumps), rock strata now lie next to each other at the same height as they were not originally next to each other. For us, the eastern edge faults with jump heights of several 100 m offset are the most interesting for the landscape and tectonic cave formation in the Buntsandstein (Colored sandstone; red sandstone).

View of the Leine valley and the sometimes wild course of the river.



Tectonic and geological representation of the Leinetal rift valley.



Schematic representation of the Leinetal rift valley. In the west primarily shell limestone on the surface of the terrain, in the east the red sandstone.

Legend:
I: tectonic rift, possibly with fault source
II: course of the river Leine
III: Tectonic rift, possibly with accessible cave (large rift, rift cave)

The formation of today's Leinetalgraben is to be regarded as very complex overall. An essential question was and still is the influence of the Zechstein salts, their flow movement (halotectonics) or dissolution (corrosion, consequence: subrosion) combined with collapse and fracture structures (subrosion lowering). In addition to the continental rift tectonics, which certainly initially influenced the salinar participation, the salinar processes were certainly involved in shaping the structure of today's landscape with great certainty.

Corrosion / possible low-grade karstification:

Fissures are always fault zones in the otherwise compact rock through which water can penetrate and then become chemically effective. It is possible that the tectonically widened fissures, fracture zones, strain and disruption cracks in the sandstone vados (seepage and flowing water etc.), shallow phreatic (groundwater fluctuation area) and deep phreatic (permanent groundwater body) have been expanding corrosively for around 145 million years. This corrosive process would have been possible in particular in the Tertiary period (approx. 66-2.6 million years ago), which was climatically significantly warmer and wetter than today (Quarterary). The age of the Tertiary is now divided by geologists into Paleogene and the younger Neogene. The main corrosive expansion of the fissures thus probably occurred in the subtropical Tertiary epoch, presumably primarily through hydrolysis along the fissures and bedding joints in the tectonically disturbed rock structure. $SiO2$ and $H2O$ become $H2SiO4$ and this is then water-soluble, which can contribute to the corrosive expansion of the primarily tectonic widened fissures. This would be a corrosive (chemical) and not an erosive (physical) process, which is generally understood as a karstification process, only much slower than in limestone, gypsum or salt rock. As noted above, this process occurs much faster under tropical conditions. It can therefore be assumed that this type of corrosive expansion (karstification process), if it took place here (southern Lower Saxony) in what is now more moderate latitudes, probably made a contribution to the expansion of the tectonically primarily widened fissures mainly in the Tertiary age.

Genesis of the caves, rock shelters and dry valleys in southern Lower Saxony:

The caves, semi-caves, grottos and shelters (abris) were very likely formed when the valleys were cut into the rock walls and rocks that formed, mainly due to erosion (strong water flows, partly in the permafrost soil without vegetation), frost cracking and weathering along the crevasses and layer joints in the sandstone (smSS / Solling sandstone-formation) created after the tectonics (cracks; faults, fractures, etc.) and outflow conditions (rivers, groundwater, etc.) had changed again seriously due to the Leine valley depression (Leine valley rift valley). The greatest rift valley subsidence happened about 2.58 million years ago, when the Pleistocene age began. The Pleistocene was a time in which cold or ice (erosion and corrosion) and warm periods (erosion, corrosion and corrasion) alternated. The Pleistocene began about 2.588 million years ago and ended about 11,700 years ago with the start of the Holocene (the present epoch). As a result of the subsidence, the outfall (Leine) was relatively quickly shifted deeper, which probably caused the gorge valleys to cut into the sandstone along tectonic fault zones through erosion, mainly in the Pleistocene era. Many of these canyon valleys are now the dry valleys typical of southern Lower Saxony (e.g. Reinhäuser Wald), since drainage most likely occurs underground along the tectonic clefts, fracture zones, and fractures and fractures (for example: underground tributary of the "Mariaspring" spring). The tectonic fissures may have been widened over millions of years by the corrosive processes described above (karstification process), which certainly made them even more water-transportable (low-grade karstification process) than they were tectonic previously.

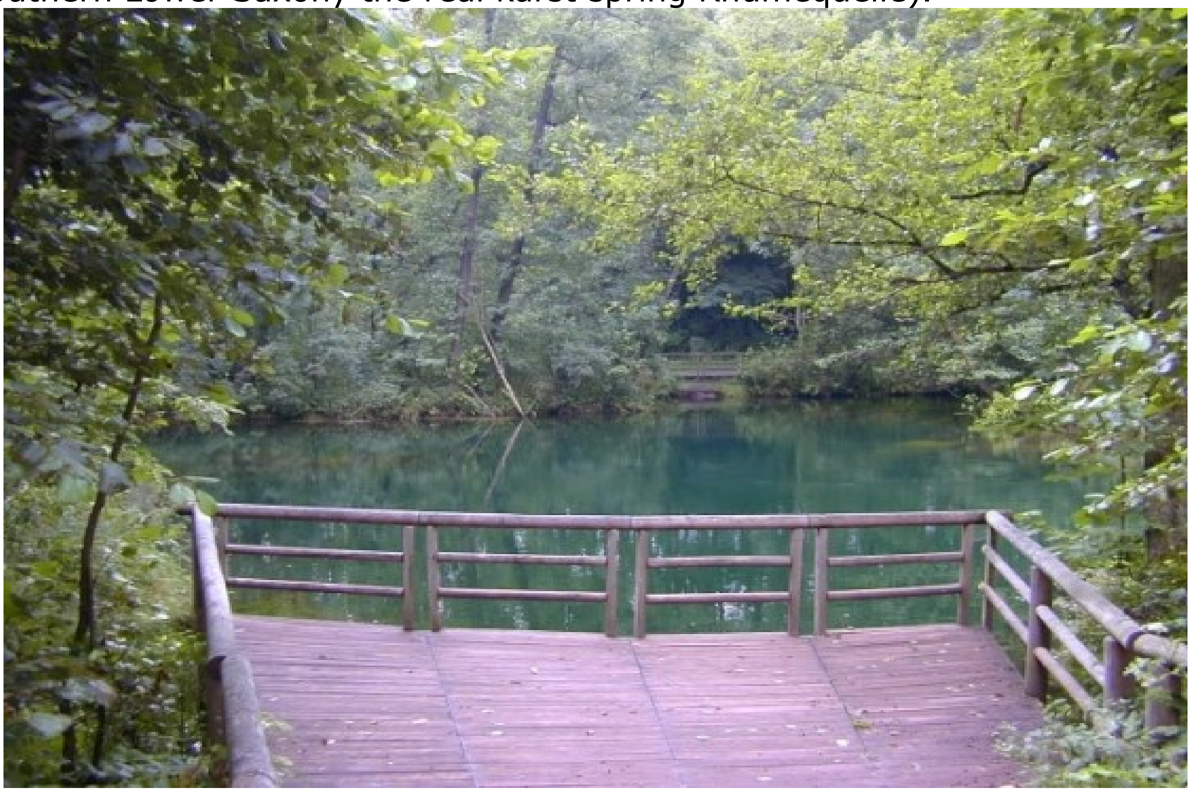
Typical dry valley in southern Lower Saxony, of which there are a few.
In southern Lower Saxony it is partly a karst landscape in the sense of the nomenclature of classic or genuine karst, but also a landscape that only appears to be karst in the aforementioned sense on the surface of the terrain. I want to traditionally call this landscape pseudo-karst (special karst).

Discussion of "real" karst or "pseudo" karst (special karst):

But whether one should therefore speak of sandstone karst in southern Lower Saxony - as some geologists argue - is an open question. The author (A. Hartwig) is more of the opinion that one should speak of pseudokarst in southern Lower Saxony in the Middle and Lower Buntsandstein - the reasoning is given below.
I rely on the karst type classification, which is presented in tabular form at ARGE Bad Cannstatt (2022), for example - see web links below.

Real-Karst:

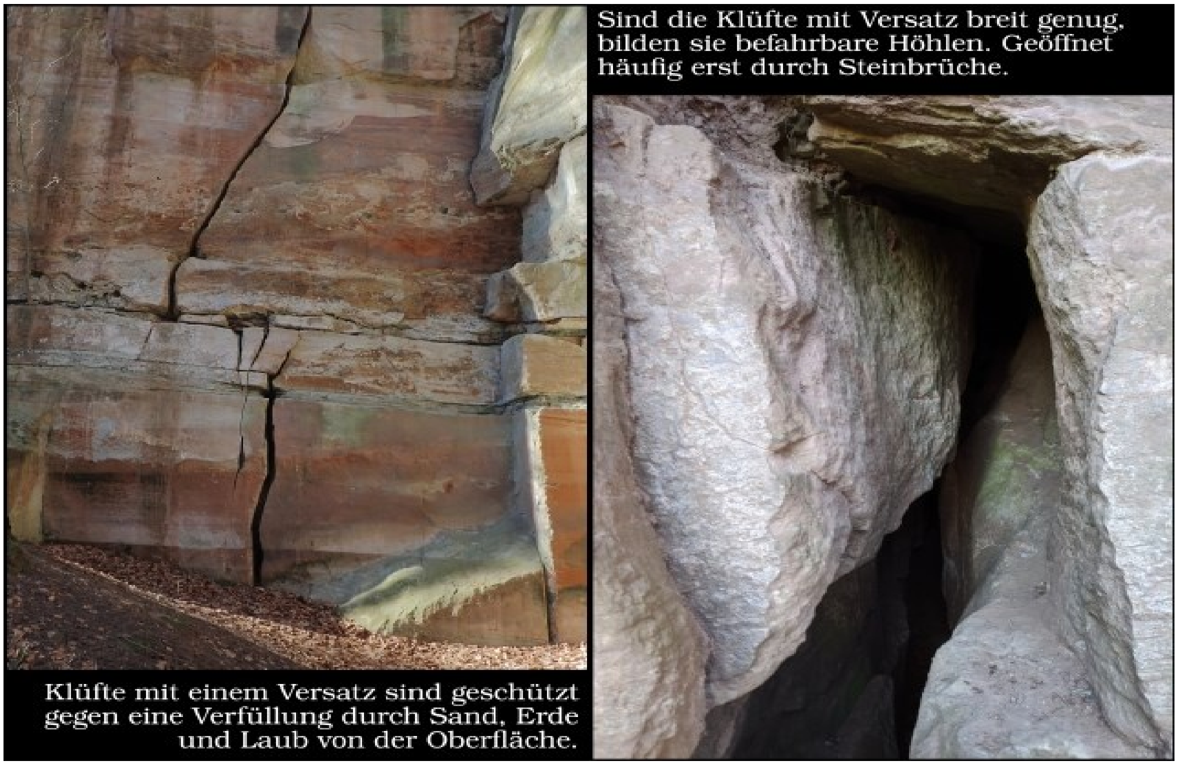
Drainage mainly underground, characterized by sinkholes (sinkholes, etc.), ponors (sinkholes, etc.), dry plateaus and dry valleys. The initial formation is mainly tied to very narrow fissures in the rock (vertical, horizontal, etc.). The water essentially seeps in through the capillaries and then usually chemically expands (> 5 % shere) them at crossing points (result: mixed corrosion) into cavities. Through the primarily chemically formed caves, the water can then move freely (vados, shallow phreatic and/or deep phreatic) in the direction of real karst springs (For example in southern Lower Saxony the real karst spring Rhumequelle).



One of the largest springs in Germany in real karst, the Rhume spring.

The author (A. Hartwig) after a research dive in the source of Rhume.
Pseudo-Karst:

Primarily tectonically widened fissures in which the water can move freely in the direction of springs from the outset. This is not real karst, but pseudo karst. Often protected from backfilling by cleft offset.

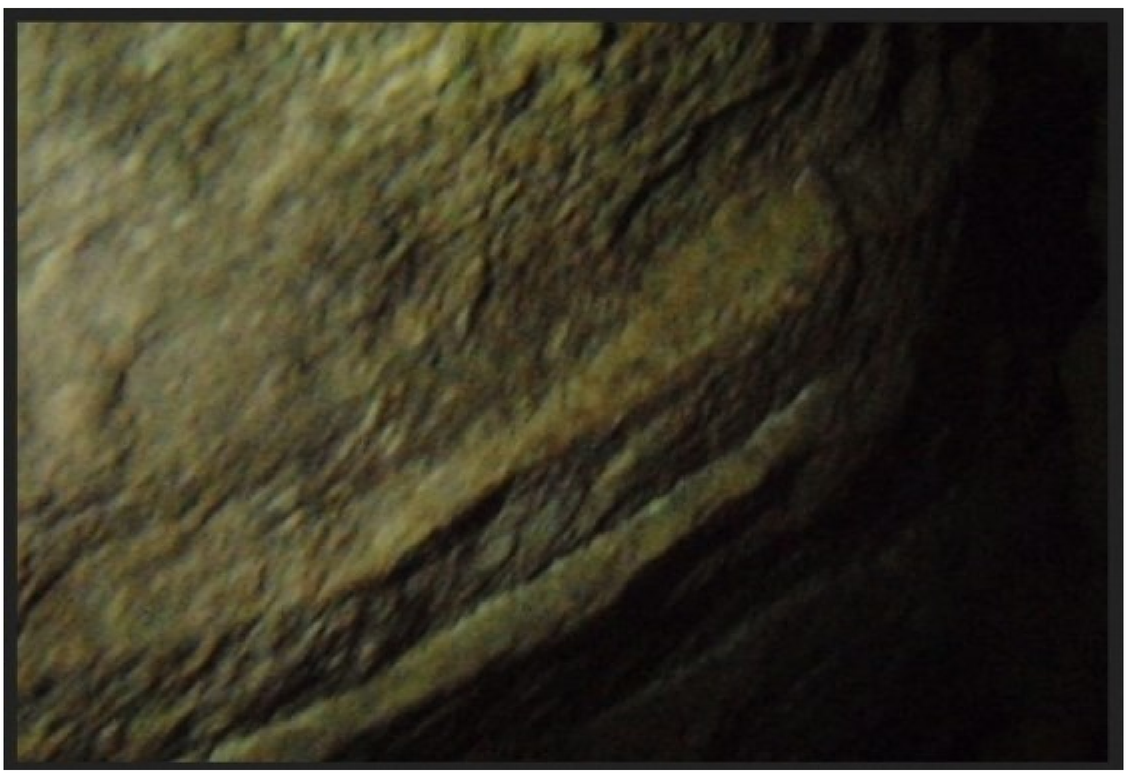


Drainage mainly underground, characterized by dry plateaus or dry valleys or both. Sinkholes and ponors are rarer or only sporadically encountered. Formation initially primarily through tectonically widened fissures or as primarycaves (e.g. volcanic tubes etc.) in which the water can move freely from the outset in the direction of bedding joints or tectonic sources (for example: underground tributary of the tectonic source "Mariaspring"). The rockwalls in the caves (tectonically widened fissures) are only overstated chemically (corrosion) and the primary cavity is usually only slightly expanded as a result. The corrosion (karstification process) has only a very small share in the formation of caves or expansion in the rock (< 5 % shere).

The only diveable sandstone pseudo-karst fissure spring cave Mariaspring on a Rift Valley fault. So far the only access to the groundwater of the pseudo-karst on the eastern slope of the Leintalgraben.

Of course, there will always be mixed forms of "real karst" and "pseudo-karst" if the environmental conditions last for a long time - subtropical or tropical, there may be moors on the surface that greatly change the pH value of precipitation or seepage water (e.g. a pH between 3,5 and 4,7). Such as with the up to 3000 meter high table mountains made of sandstone (Tepuis) in the areas of Venezuela, Guyana and Brazil. There, the longest known cave system in sandstone is over 20 km long. But even there, the experts (geologists, mineralogists, karst researchers, etc.) still do not agree whether it is "real karst" (chemical solution, karst formation) or "pseudo-karst" (clearing of loose sand layers, erosion).

To see minor corrosion (< 5 %) we have to dive into Mariaspring.



The corrosion (karstification process) has only a very small share in the formation of caves or expansion in the rock (< 5% shear). The actual sharp-edged rock fracture edges were probably only slightly rounded off by corrosion. Possibly only through a physical effect, e.g. similar to cavitation corrosion.

The photo could indeed be flow facets, in a fossil spring dike. This would possibly speak for corrosion. However, there could be traces of core weathering, although it would then be a rather atypical form of core weathering honeycomb structure (alveoli-tafoni). But it could also be flow facets due to wind abrasion (corrasion), who knows? Is this low-grade karstification (< 5% corrosion / “pseudo-karst”) or “real karst” (> 5% corrosion)? Or mixed forms of "real karst" and "pseudo-karst"? Or erosion and corrosion? Or erosion (e.g. Cavitation corrasion effect) and wind abrasion (corrasion)? Or a mix of everything?

Summary:

In southern Lower Saxony there is "genuine" karst, which was primarily formed corrosively in the shell limestone that was deposited above the Buntsandstein sequence as marine sedimentary rock from deposited from Klak mud. Around Göttingen and on the western and eastern slopes of the Leinetalgraben (Leinetal rift valley) there are some large shell limestone karst springs that pour out very heavily. such as the Weendesprig (drinking water), Gronespring (drinking water) or the Rasequelle (drinking water). Furthermore, the Buntsandstein in the east is underlain by Zechstein anhydrite and gypsum, which is also strongly corrosive karstified. One of the largest karst springs in Germany, the Rhumequelle (drinking water use), also emerges from this real karst horizon. Furthermore, one can still find primarily corrosive “real” karst in the Upper Buntsandstein, in which large connected gypsum inclusions occur in some cases, which have actively corrosively karsified to the present day.

Example of a shell limestone karst spring, the Gronespring (Gronespring).

Another example of a shell limestone karst spring, the Rase Spring (Rasequelle).

Real karst in the upper Buntsandstein (red sandstone), in the Röt gypsum. Using the example of a ponor cave in Röt gips.

Earth depressions (dolines) and sinkholes (collaps dolines) in the Upper red sandstone (Buntsandstein) mark the subterranean course of the real karst waters.

Parallel to the Leinetalgraben, a landscape with dry valleys has formed in the Middle and Lower Buntsandstein, which appears to be "real" karst. There, however, the subterranean drainage does not take place on primarilycorrosive drainage channels, but rather along fissures that were primarily widened by rift tectonics (Leinetal rift valley).

Typical dry valleys in southern Lower Saxony in the Middle red Sandstone

(Buntsandstein). They give the appearance of real karst.

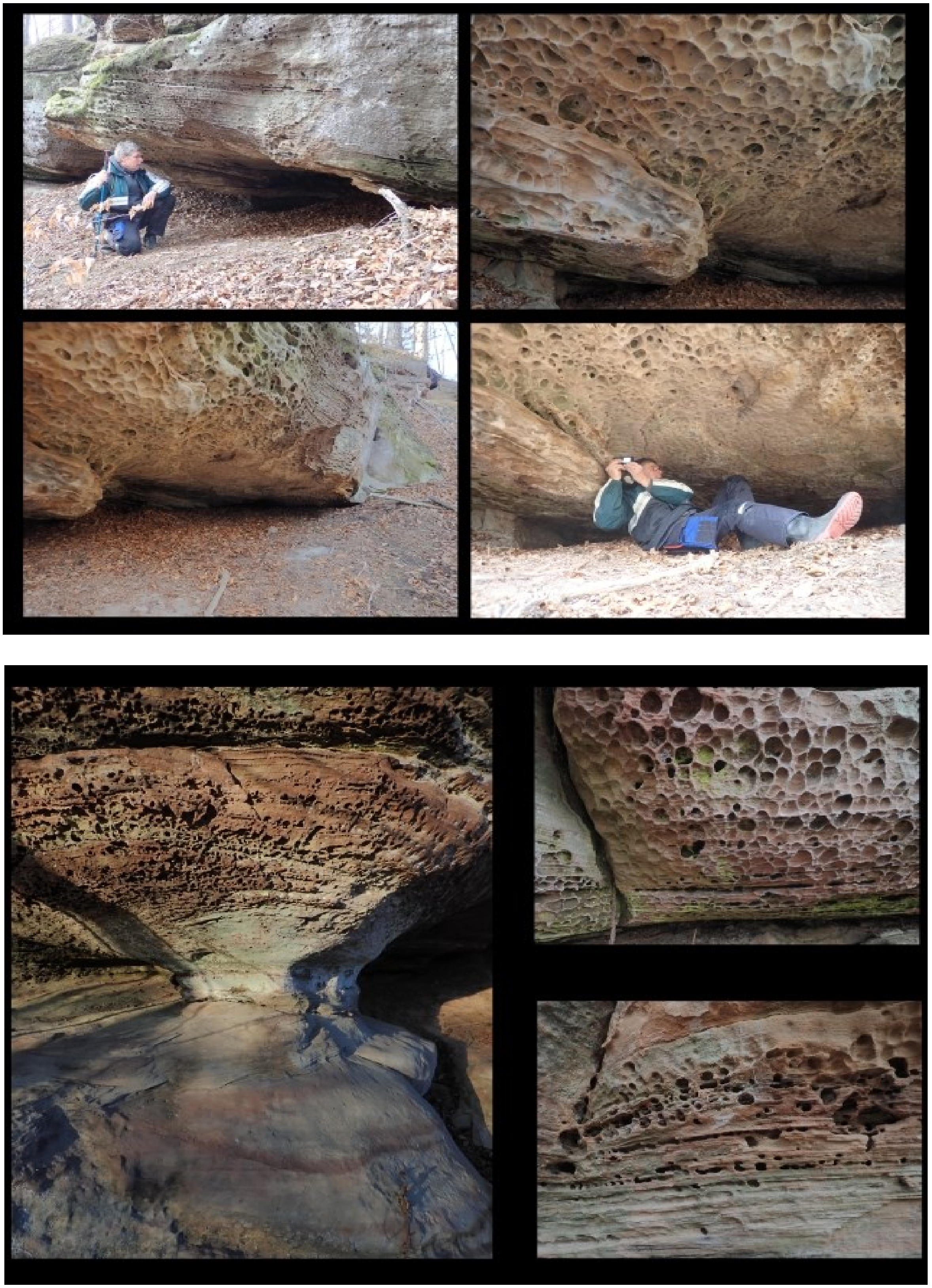
So far, no evidence has been found there, either in the fossil, shallow phreatic or deep phreatic horizon, that corrosion has made a decisive contribution to cave formation. That is why it is difficult for the author (A. Hartwig) to speak of "real" karst in this landscape. Since the fissures (cavities) were only slightly corrosively overprinted or widened, if at all, I would like to continue to use the nomenclature “pseudo” karst for here.

Stroke luck: rift valley tectonics cave, open through quarry. Partly dynamic air draft, which may result in core weathering.

In front of the spring outlets there are sometimes thick calcareous tuff beds (duckstone, meadow marl etc.) and sinter terraces (travertine etc.), but the deposited limestone usually comes from the overlying shell limestone and Upper red sandstone (Röt-gypsum). Due to the dry valleys, the sometimes heavy pouringsprings (e.g. Mariaspring) and the sometimes thick limestone deposits, the viewer is easily tempted to speak of a "real" karst landscape. In fact, however, it is not a "real" karst, but a very special landscape with underground linear drainage channels. Therefore I (A. Hartwig) would like to continue to use the nomenclature “pseudo” karst.

Impressive calcareous tuff terraces in red sandstone notched valleys.

The primary formation of the near-surface grottoes, semi-caves, small caves and rock shelters (rock roofs, abris) are most likely primarily objects of erosion. In addition to erosion, the chemical SiO_2-H_2O process certainly played a role in its formation and expansion. Other polygenetic corrosive processes were also very likely involved, such as e.g. Fe, Ca or biological corrosion (bacteria, lichens, mosses, roots and humic acid or pH-related etc.). The objects were then overstated by wind abrasion (corrasion) in the dry epochs and/or and through further erosion and core weathering (honeycomb structures; tafoni, alveoli-tafoni, etc.) in the wetter and frostier (cold periods, ice age) epochs up to and including today (present).



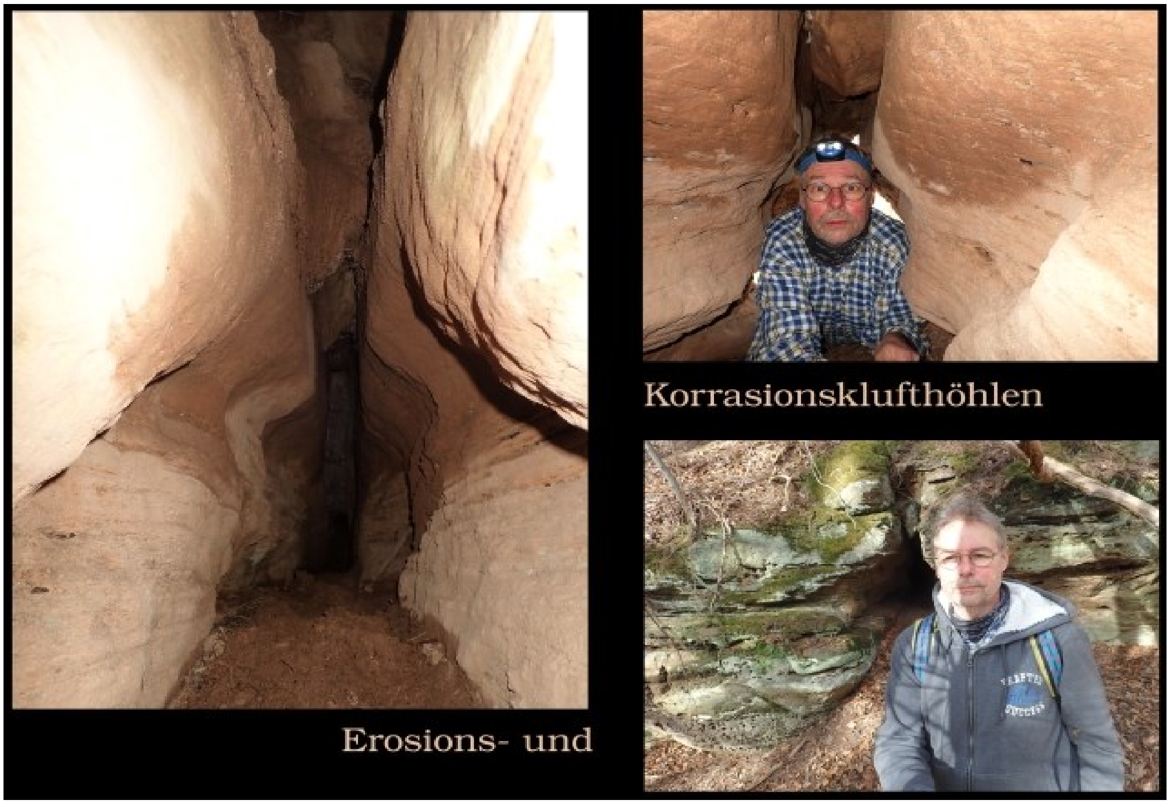
Example of objects that were expanded and overprinted in the entrance area by wind abrasion (corrasion) and core weathering (honeycomb structures; tafoni, alveolus tafoni, etc.).

Examples of typical core weathering structures (honeycomb structures; tafoni, alveolar tafoni, etc.) in the red sandstone (Buntsandstein) of southern Lower

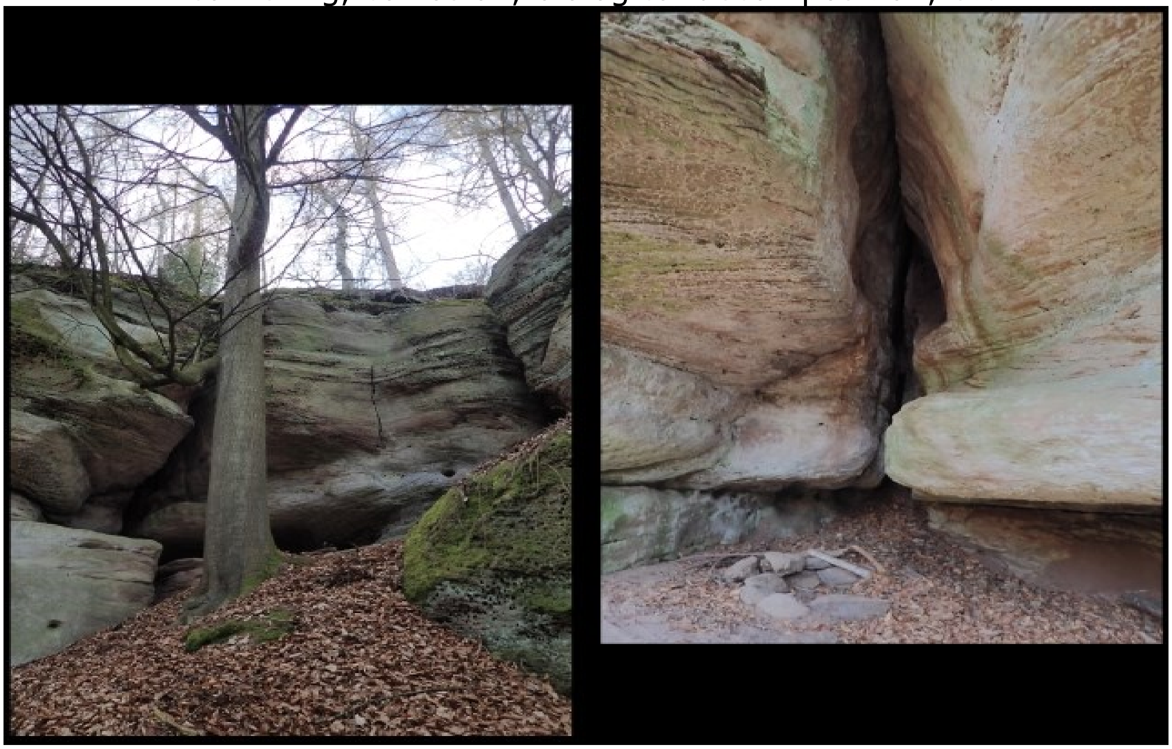
Saxony.

Typical examples of rock roofs (abris) from southern Lower Saxony, which were primarily formed by erosion, but were then heavily overstated by wind abrasion (corrasion). But you can also see from the ubiquitous honeycomb structures that they also play a role in the expansion of the objects.

In southern Lower Saxony, in some deeper, wind-protected valleys, rock roofs can also be found, most of which probably got their present form from erosion.



Mixed form of polygenetic formation: erosion, wind abrasion (corrasion), core weathering, corrosion, biological decomposition, etc.



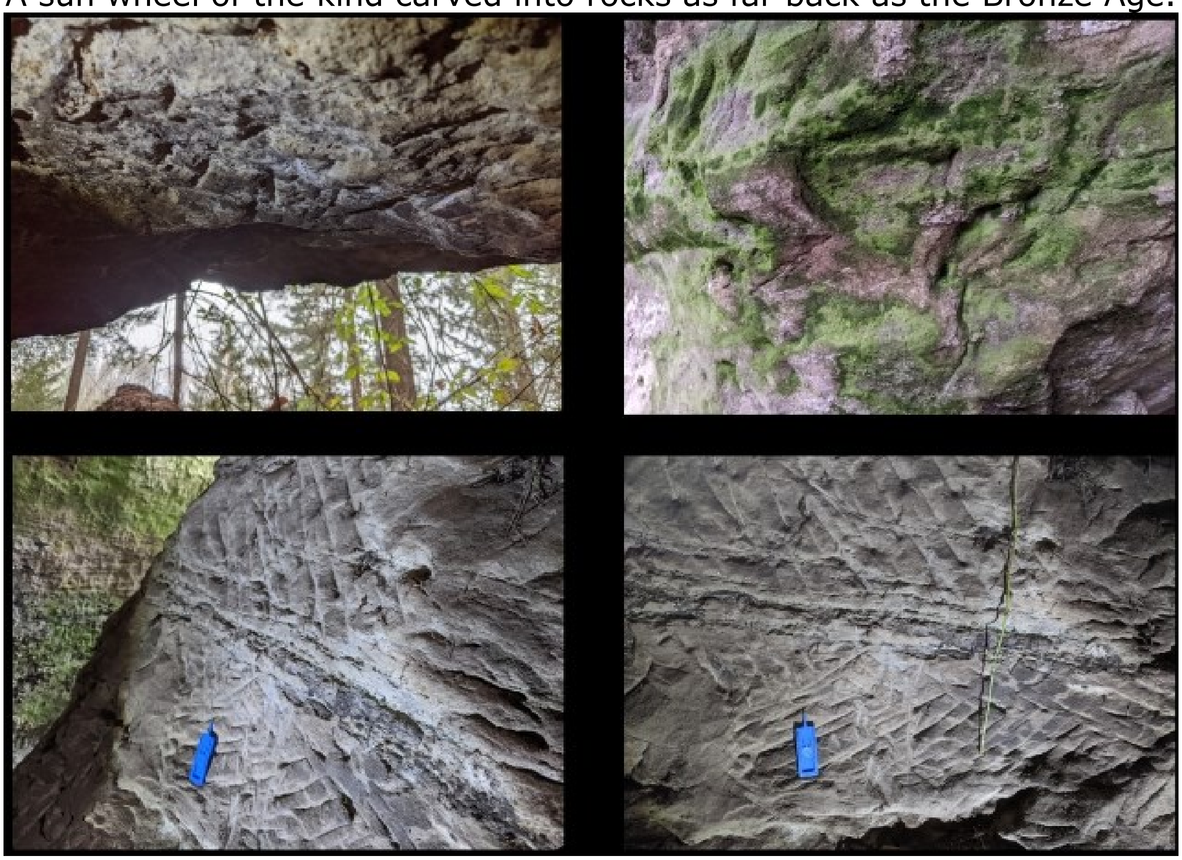
Other examples from southern Lower Saxony of polygenetic origin: erosion, wind abrasion (corrasion), core weathering, corrosion, biological degradation, etc.

I do not want to go into detail about the archaeological finds, excavations and investigations in my article, I would like to refer here in particular to investigations by the Goettingen district archeology department. However, I would like to note that from the point of view of karst and cave research, only objects (rock roofs, abris etc.) with a span > 5 meters were and are recorded. There are also no sloping rock overhangs in the cave cadastre. Also, only caves with a total corridor length of > 5 meters are recorded. Exceptions are only made in the cave cadastral register for smaller objects that have special features or are unique. This results in a discrepancy in southern Lower Saxony to the > 1.600 mapped archeological objects, which also include rocky sloping overhangs and also significantly smaller objects (< 5m) because they can always potentially represent an archaeological site.
For example, you can read the following on Wikipedia.org on the subject ofdemolitions in southern Lower Saxony: …] *In the red sandstone area of the southern Leine* mountain country *(Leinebergland) between the towns of Nörten-Hardenberg (Lower Saxony), Heiligenstadt (Thuringia) and Göttingen (Lower Saxony) is the largest group of rock formations in Central Europe. They can often be found in the narrowest of spaces in the canyon-like rocky valleys between the Leine and the Eichsfeld. Around 1600 abris have been recorded in an area around 30 km long and 6 to 10 km wide.* [...

Lower Saxony cadastre of the Working Group for Karstkund Harz.
Only caves with a total corridor length of > 5 m and rock roofs (rock shelters, abris etc.) with a span of > 5 meters were and are recorded. No sloping rock overhangs, just real rock roofs.

Example of various medieval rock carvings from southern Lower Saxony.

A sun wheel of the kind carved into rocks as far back as the Bronze Age.



A few examples of various probably early historical rock carvings from southern Lower Saxony. Among other things, different forms of pubic triangles and colors.

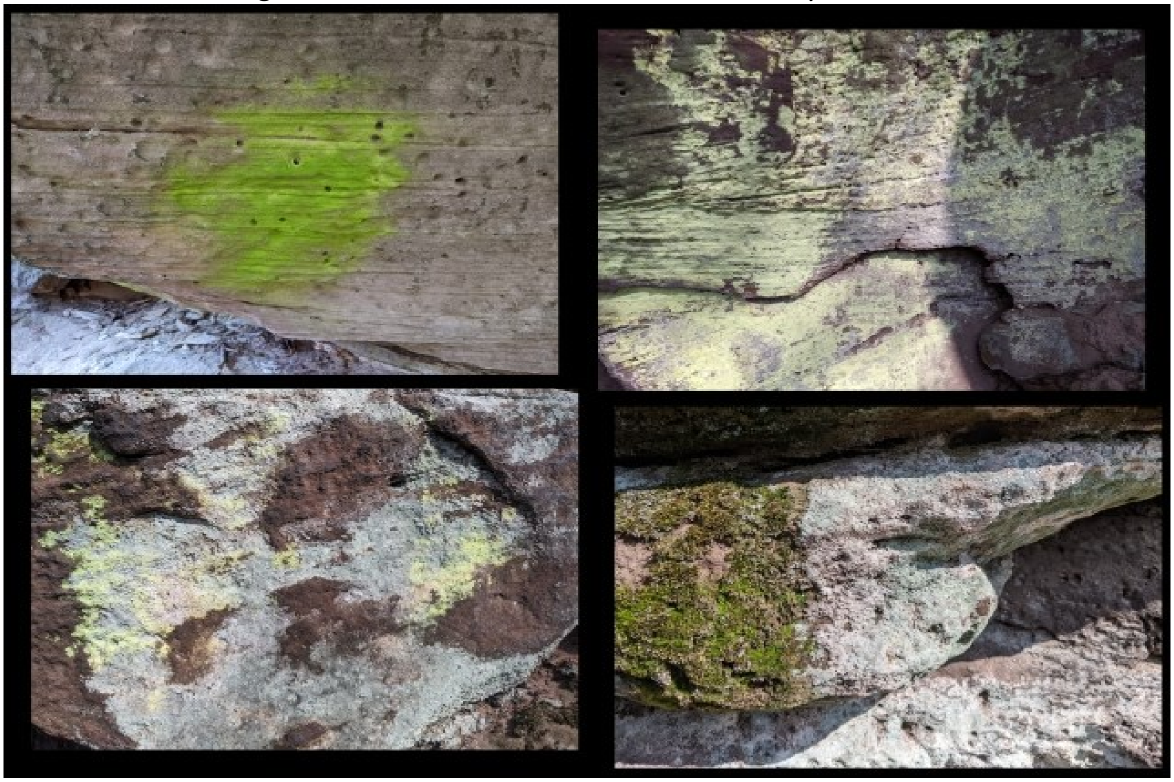
In terms of biology, or fauna and flora in the "Reinhäuser Wald" landscape protection area, I would like to refer to the "Lower Saxony State Office for Water Management, Coastal Protection and Nature Conservation" („Niedersächsische Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz" / NLWKN). The following can be read about the Reinhäuser forest landscape protection area on their website: …] The red sandstone rocks have significant moss, lichen and fern vegetation and are home to the largest population of the magnificent thin fern (Trichomanes speciosum) in Lower Saxony. The area has large and representative stands of woodruff beech forest and grove beech forest for the natural area of Göttingen-Northeimer forest. In addition, there are streams with floodplain and oak-hornbeam forests as well as very small areas of moist tall herb corridors, grassland and still waters with diving and floating leaf plants. [...

Below are a few example photos of the fauna and flora under and on the rockroofs and in the sandstone caves of southern Lower Saxony.

Various insects, such as spiders, mosquitoes, butterflies, isopods, ants, etc.

Breeding and nursery of various insects and animals ...

The shelters and caves are also often used as protection against the weather and as a nursery for higher animals, such as wild boar, martens, lynxes, etc.



The red sandstone cliffs have a significant population of moss, lichen and fern vegetation. A few examples are shown in the photos.

They are certainly involved in the chemical decomposition of the sandstone rocks through their roots and the humic acid and the resulting changed pH value.

To get to the slide show, please click on the red field!

Public slide show from the annual general meeting of the Working Group for Karst and Caves Harz e.V. (ArGeKH e.V.) on April 2nd, 2022, compiled by Andreas Hartwig.

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