GEOPARK RIES
Europe's Giant Meteorite Crater

# Windows into the Earth

with excursion tips

Windows into the Earth

## Adventure Geotopes

unesco Global Geopark Ries

www.geopark-ries.de

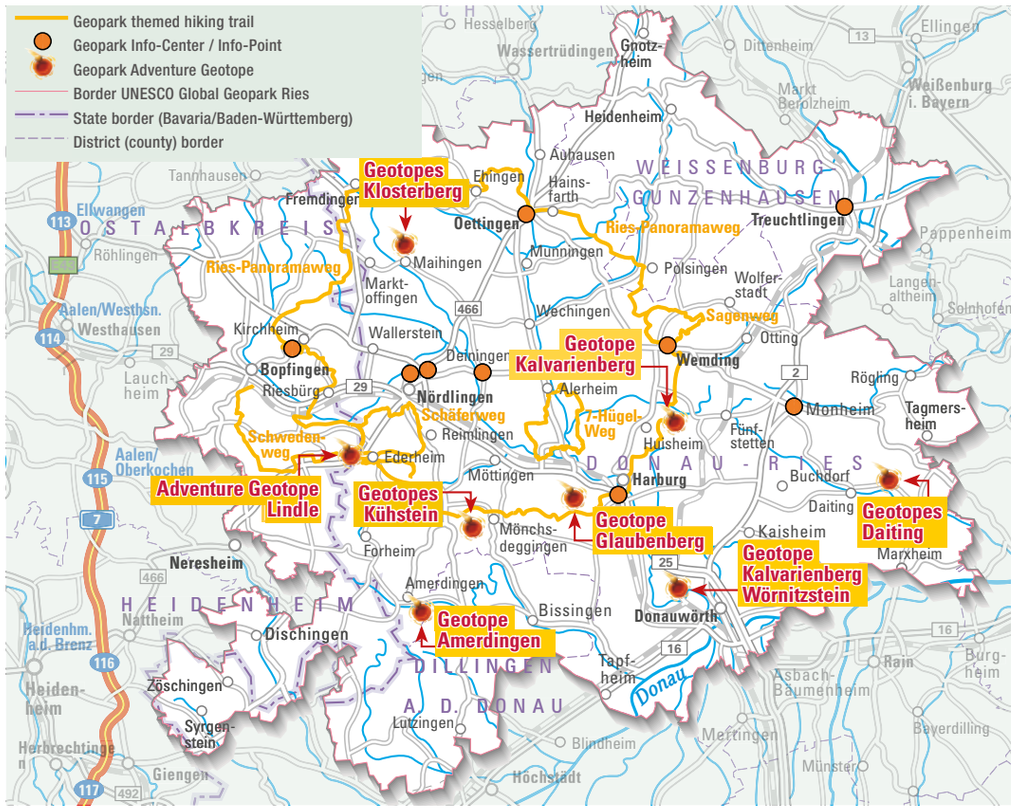
# Overview map

## UNESCO Global Geopark Ries with Adventure Geotopes, themed Hiking Trails, Info-Centers and Info-Points

The UNESCO Global Geopark Ries has an area of about **1,750 km²**. The impact crater Nördlinger Ries is the best preserved crater in Europe. The flat, largely unwooded and densely populated crater basin with its **25-kilometer diameter** and up to 150-meter-high outer crater rim is extremely visible in the landscape.

There are about 175 mapped geosites in the UNESCO Global Geopark Ries. Sixteen geological features have been made accessible by the Geopark Ries on eight nature trails. Five of the 100 most beautiful geotopes in Bavaria are also located in the Geopark Ries.

The outline map of the Geopark Ries e. V. shows the locations of the Adventure Geotopes with nature trails as well as the Geopark Ries themed hiking trails and all Geopark Info-Centers and Info-Points. The Geotopes are “Windows into the Earth”—excursion destinations offering learning experiences.





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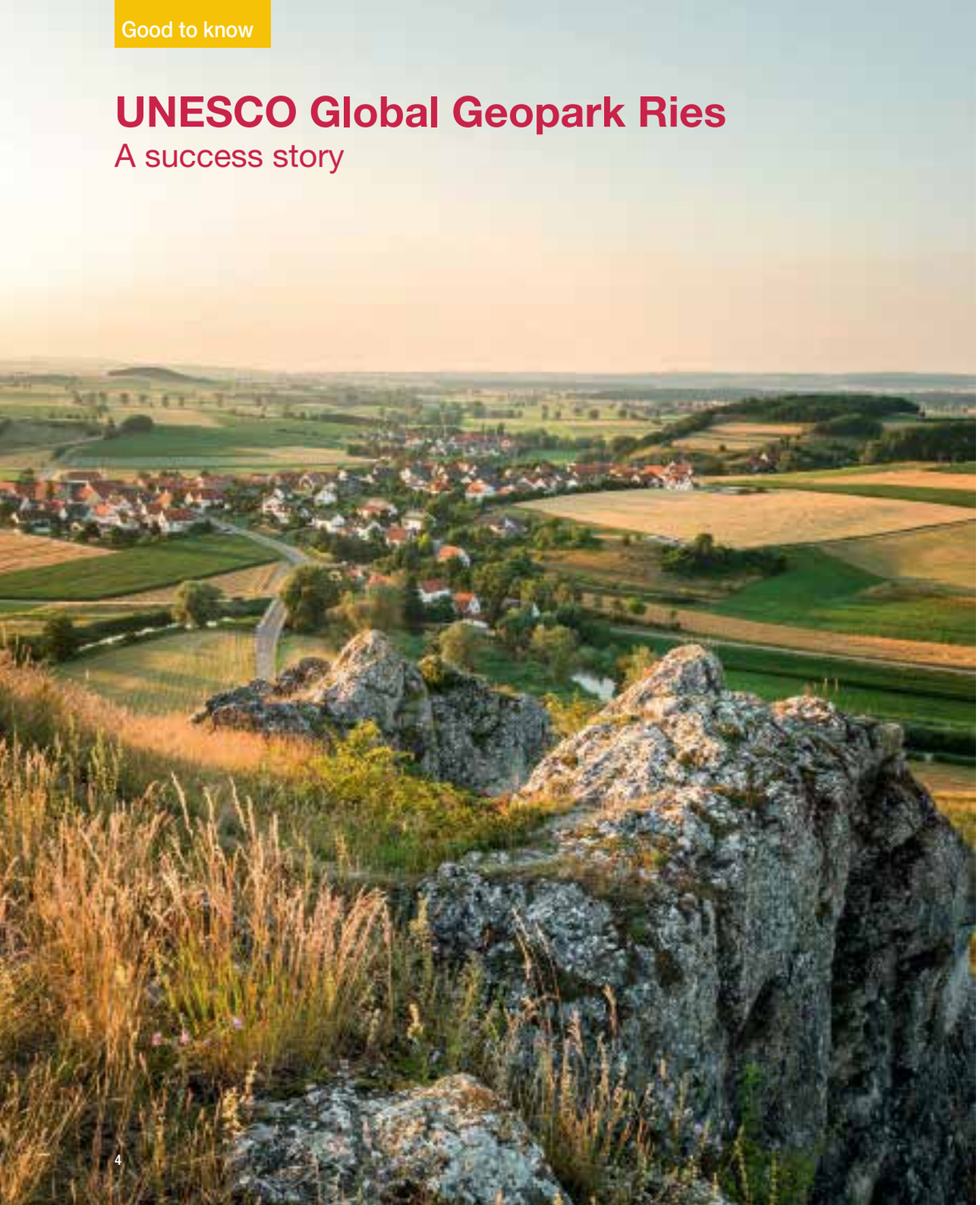
# UNESCO Global Geopark Ries

## A success story



The Ries Crater is one of the best preserved and researched impact craters on Earth – and so a first-class geological feature.
It has a magnetic effect – and not just on geologists. A large and consistently growing number of geo-tourists, school groups, interested excursionists, hikers and bikers from all over the world make their way to the Ries in search of traces of the cosmic catastrophe.

The asteroid impact that occurred approximately 15 million years ago had a fundamental and definitive influence on the landscape and qualities of the geological underground that is still discernible today. Through the UNESCO Global Geopark Ries, these geological and geomorphological processes and their far-reaching consequences become visible and vivid.

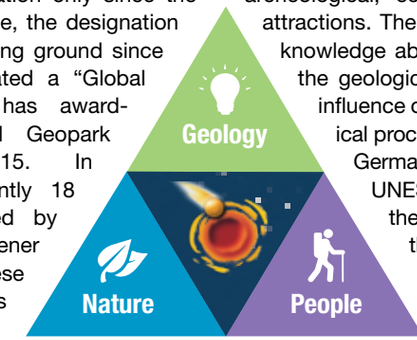
As “Windows into the Earth,” numerous geotopes offer insights in the development of the Ries landscape. At many locations, visitors can trace the influences of the geological formations on the composition of soil and habitats, for example, on the dry grasslands of the crater rim.
Geotopes show: how and why dry grasslands developed at these locations, how this biotope is utilized and maintained by migratory sheep grazing, which factors were advantageous for early settlers who resided in the crater basin as early as the Stone Ages, why even today the Ries Crater is one of the “breadbaskets” of Bavaria.

Beside the geological heritage sites, the Geopark Ries also presents the rich settlement history and cultural qualities of the region. The Geopark focuses the attention of residents and guests on environmental features and natural and cultural treasures and, in this way, encourages respectful interaction with the unique heritage.

The Geopark Ries was designated a UNESCO Global Geopark in 2022. UNESCO Geoparks undergo a renewed quality assessment every four years. The Geopark Ries has carried the quality seal of a German National Geopark since 2006. Among its most important tasks are to make accessible and protect the geological heritage of the region for locals and tourists—and to promote science and scientific cooperation as well as education for sustainable development.

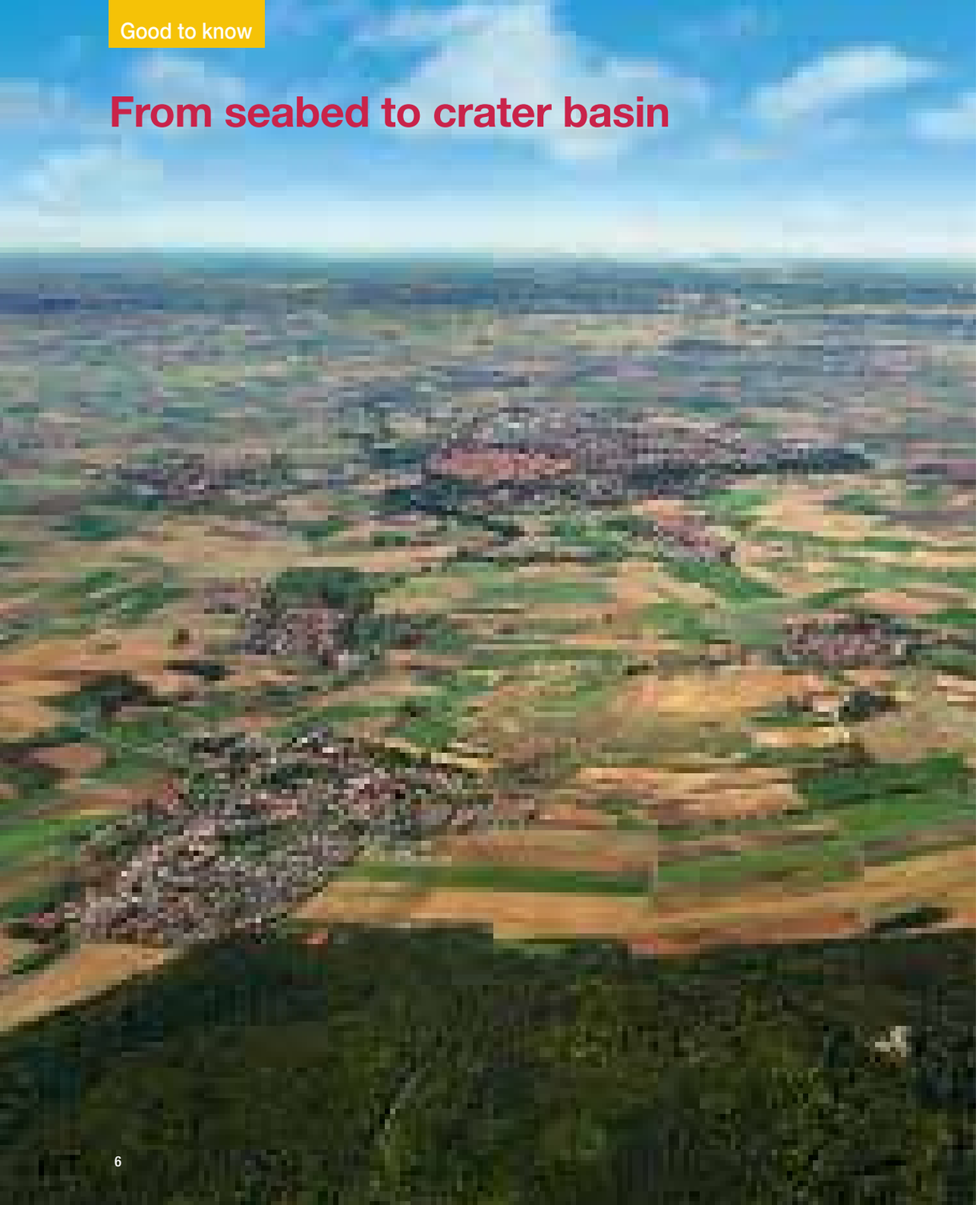
## Geoparks – a worldwide Trend

The protection of unique biotopes has been common in Germany for some time now, and often a geotope is also included. Yet geological features and their protection have increasingly experienced stand-alone appreciation only since the end of the 1990s. Worldwide, the designation of geoparks has been gaining ground since 2001: UNESCO even initiated a “Global Geopark Network” and has awarded the UNESCO Global Geopark designation since 2015. In Germany there are currently 18 National Geoparks certified by the GeoUnion Alfred Wegener Foundation. Eight of these are also distinquished as UNESCO Global Geoparks. Geoparks are regions with unique geology and contain geological sights of interest (geotopes) of special scientific significance, rareness or beauty. Geotopes may also include archeological, ecological, historical or cultural attractions. The goal is to impart to the visitor, knowledge about the formation of the Earth, the geological processes involved and the influence of geological and geomorphological processes on habitats.




German National Geoparks and UNESCO Global Geoparks sensitize the public to the uniqueness of the Earth and serve a declared objective of UNESCO: **the preservation of the creation.**

# From seabed to crater basin





**Tidal flats at the foot of the Alps**

Around 170 million years ago, advancing from the northwest, the Jurassic sea flooded the Vindelician land mass, highlands that existed in today's southern Germany during the Triassic (250-200 million years ago). The coastline ran about where Munich is located today. About 150 million years ago the area around the Geopark was much closer to the equator and thus in the middle of a subtropical landscape of islands, lagoons and a warm, shallow sea.

Later, the continental plate rose, and north of the Alps a seabed with no outlet emerged and increasingly silted up. During the early Cenozoic (66-23 million years ago) and start of the middle Cenozoic (23-5 million years ago), the climate was sufficiently warmer so that palms grew in Central Europe and tree-dwelling primates were widespread in southern Germany. The region of today's Ries experienced a subtropical climate during which it was populated by animals that died out long ago, such as the weaselike **Trochotherium**, primeval horses, various rhinoceros species and crocodiles.

*Trochotherium*

**Starting over – a cosmic bomb destroys life**

In just a few seconds, the impact of the asteroid fundamentally changed the region that became the Ries Crater. Ejected rock debris covered the impact area over a wide radius. Shock waves swept over a broad part of Central Europe and propelled an infernal heat that burned forests as well as remaining vegetation. All life was extinguished within a large radius of the crater. After the crater was formed and the cloud of vaporized and molten rock collapsed, today's Ries was a huge, lifeless debris field.

## Excursion TIP

The Jurassic sea dominated the landscape well before the Ries event and has left behind visible traces. Near Dischingen, about 25 kilometers south of Nördlingen, there are a few partially-rounded blocks of massive limestone that are construed as the remains of a steep coastline. In the Geotope Glaubenberg (page 34) there is a red-colored sandstone block from the Middle Jurassic (Brown Jurassic). The red iron oxide was incorporated in the sandstone by microbes on the former seabed.

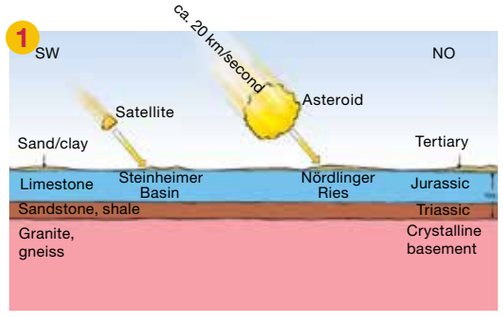
The Jura Museum Eichstätt on the Willibaldsburg ridge over the Altmühl is a natural history museum in one of the prettiest settings in Germany:
**Jura Museum Eichstätt – Time travel into the Jurassic!**

Willibaldsburg, 85072 Eichstätt
www.jura-museum.de

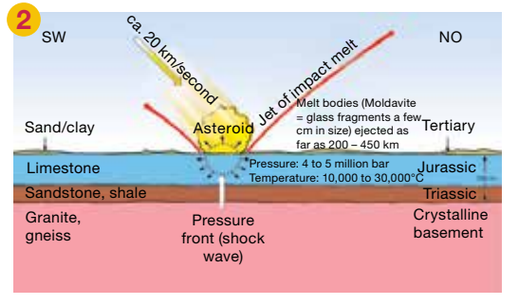
# The Ries event

## A cosmic catastrophe

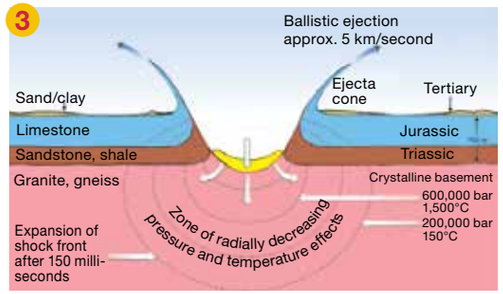
**A celestial body races toward the Earth**
As we know it today, the history of the Ries begins on a day almost 15 million years ago with a cosmic catastrophe. An asteroid with a diameter of about a kilometer is on a collision course with the Earth.



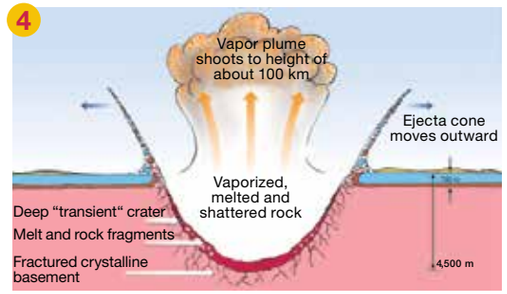

*A few milliseconds before impact*



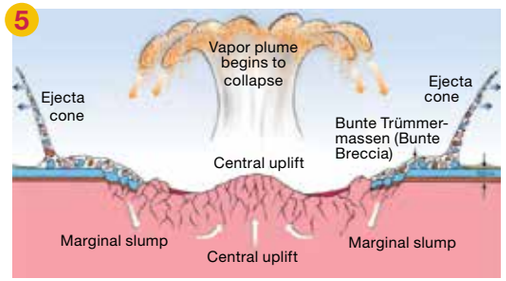

*10 milliseconds after impact*



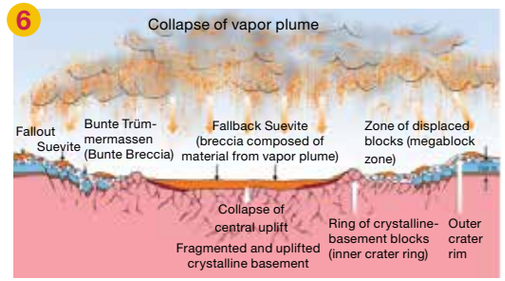

*Start of crater formation after 60 milliseconds*




*Formation of deep "transient" crater after about 10 seconds*




*Collapse of "transient" crater and deposit of ejected rock masses after 1 minute*



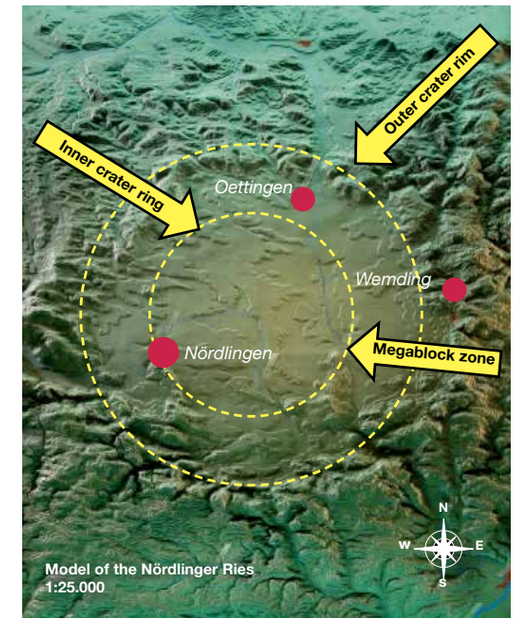

*End of crater formation and deposit of Suevite after 10 minutes*

With a speed of about 20 km/sec (ca. 72,000 km/hr), it races through the Earth's atmosphere in just a few seconds. Even before the impact, the air between the extraterrestrial body and the impact site is so compressed and heated, that material from the Earth's surface and the asteroid melt and are hurled far up into the atmosphere. While still in flight, some molten rock solidifies into glass; these so-called tektites have been found up to 450 kilometers away in Bohemia, Moravia and Lusatia as well as in Silesia (Poland). The tektites created by the Ries impact are called Moldavites.

**Brighter than the sun**
The impact of the asteroid on the Earth releases an unimaginable amount of energy – equivalent to the explosive strength of the simultaneous firing of hundreds of thousands of Hiroshima-size atomic bombs or several gigatons of TNT. The apparent brightness of the explosion on the Earth surpasses by far that of the sun. Even in the first seconds the cosmic bullet penetrates approximately 1,000 meters into the Earth's crust. The entire celestial body vaporizes; the rock in the impact crater melts, vaporizes and rises in a glowing cloud over the crater.

A violent shock wave drives the infernal heat outwards. The shock wave travels at the speed of sound around the entire Earth. Even at a distance of 500 kilometers, it can be clearly felt with a wind speed of Beaufort force six (39-49 km per hour). After 17 seconds the shock wave reaches the opposite side of the Earth at a distance of 20,000 kilometers. Even there, the thunderclap could have been heard at a volume of about 40 decibels (equivalent to rainfall).

***Trümmermassen* and glowing cloud of rock**
The transient crater formed by the impact has a depth of about 4.5 kilometers and a diameter of 12 kilometers. Fragments and large blocks of rock masses from various layers are thrown out of the crater or slide inwards from the crater rim. The surrounding landscape within a radius up to 50 kilometers is covered by a thick layer of *Bunte Trümmermassen* (rock debris) up to 100 meters deep. The crystalline basement rock vaporized by the impact rises in an eruption column up to 100 kilometers into the atmosphere and carries with it pulverized and fractured rock of various stratigraphic layers.



On the steep crater walls, large blocks of rock break off and slide into the center. The diameter quickly expands to approximately 25 kilometers. At the same time, the impact-compressed crystalline basement rebounds to form a central uplift with an inner ring. Combined with the sliding blocks, the crater floor is raised to a depth of around 500 meters.
Just minutes after the impact, the glowing cloud collapses and settles as an ejecta blanket (of debris, molten rock, etc.) over the devastated landscape. The rock that results from it is called Suevite, and it forms a circa 300-meter-thick layer in the crater. The asteroid has completely extinguished all life within approximately 100 kilometers of the impact site. The effects on the water network of the Ries landscape at that time are also significant: The courses of the primordial rivers Main, Altmühl and Wörnitz are dammed; a large lake forms in the northeast of the Ries Crater.

## Crater comparison

Along with the Ries Crater, the Chicxulub crater on the Yucatán Peninsula in Mexico is one of the most famous impact craters on Earth. This impact event is said to have contributed decisively to the extinction of the dinosaurs.

**Germany**
**Ries Crater, Bavarian Swabia**
**Age**
about 15 million years
**Diameter of the impact body**
about 1 kilometer
**Explosive effect**
Several 100 000 Hiroshima-type atomic bombs
**Crater diameter**
about 25 kilometers


**Mexico**
**Chicxulub Crater, Yucatán Peninsula**
**Age**
about 65 million years
**Diameter of the impact body**
about 10 kilometers
**Explosive effect**
100 million Hiroshima-type atomic bombs
**Crater diameter**
about 200 kilometers

**The crater fills up**

A nutrient-rich lake forms in the closed-drainage crater. The warm climate leads to strong evaporation, which increases the salinity. More or less comparable to present-day salt and soda lakes in dry areas, this body of water could not support many forms of life. The variety of living creatures was therefore limited – yet the number of individuals that populated the lake was large. Green algae, cyanobacteria, brackish-water snails and ostracods populated the body of water.

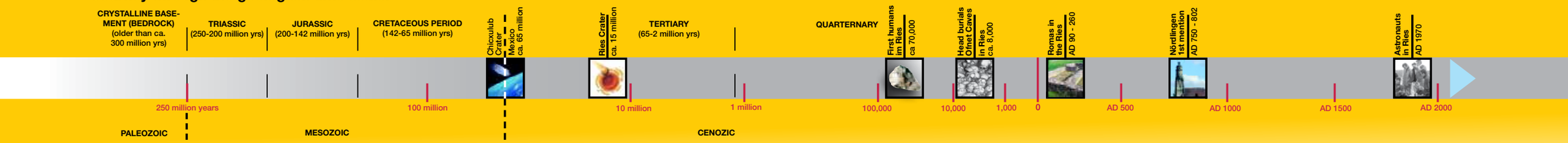
Only after two million years, with increasing sedimentation, did the Ries Lake become life sustaining. It was settled by numerous small mammals (bats, species of hares and hamsters) and birds (pelicans, **flamingos**, parrots).

## Excursion TIPS

One of Bavaria's 100 best geotopes is in **Hainsfarth**, the Büschelberg exposure. Here fossilized small animals like ostracods and the worldwide unique structures of reef-building green algae vouch for the long-ago Ries lake.

Equally impressive is the **Wallerstein Cliff,** where stromatolites (sedimentary rocks of organic origin) were formed by cyanobacteria. The view from the top is phenomenal.

**Journey through the geological time scale:**



# Suevite

## *Schwabenstein*

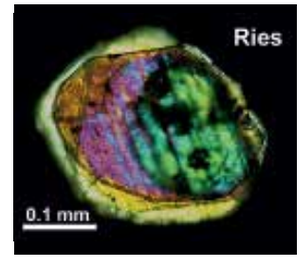
**What is Suevite?**

Suevite, or *Schwabenstein* ("Swabian stone" from the Latin *Suevia* = Swabia) is a typical impact rock. The effects of an asteroid impact go deep underground – resulting in pressures of several million bar and temperatures up to tens of thousands of degrees. The cosmic bomb explodes and completely vaporizes. During these events, huge amounts of rock from the crystalline basement are melted or vaporized and flung into the stratosphere as a glowing, mushroom-shaped cloud. The cloud eventually collapses, and the debris thrown out of the crater is then deposited over the landscape destroyed by the impact. The layer formed by the Ries event is up to 300 meters thick in the crater basin. As the melt cools down, a rock with glass inclusions is formed – **Suevite**.

**A rock writes scientific history**

Even though individual academics brought up the theory of an impact occurrence again and again – until the mid-20th century, the prevailing schools of thought interpreted the Ries Crater as the remains of an extinct volcano. Accordingly, the Suevite in the Ries Crater was considered to be rock of volcanic origin – as shown by the historical designations of *Feuerduftstein* or volcanic tuff. The American scientists Eugene Shoemaker and Edward Chao "set the ball (or stone, in this case) rolling" in the 1960s. They used specialized X-ray techniques to analyze samples of Suevite from the Ries and discovered in them high-pressure modifications of quartz (coesite and stishovite) that could not be formed by the current temperatures and pressures of terrestrial geological processes. This discovery was the decisive impetus for a turnaround to impact theory – in a short time, additional rock analyses and sample borings produced further evidence for the impact occurrence.

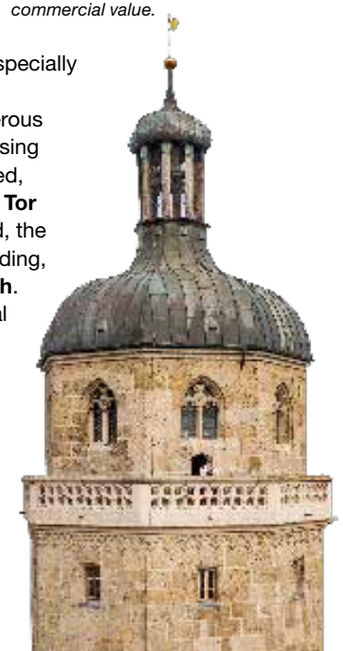
*Suevite on top of Bunte Breccia: Shocked and partly melted plutonic rock covered the ruined landscape in a layer up to 300 meters thick.*




*Suevite contains diamonds, among other high-pressure minerals resulting from the impact, but the diamonds are tiny and of no commercial value.*

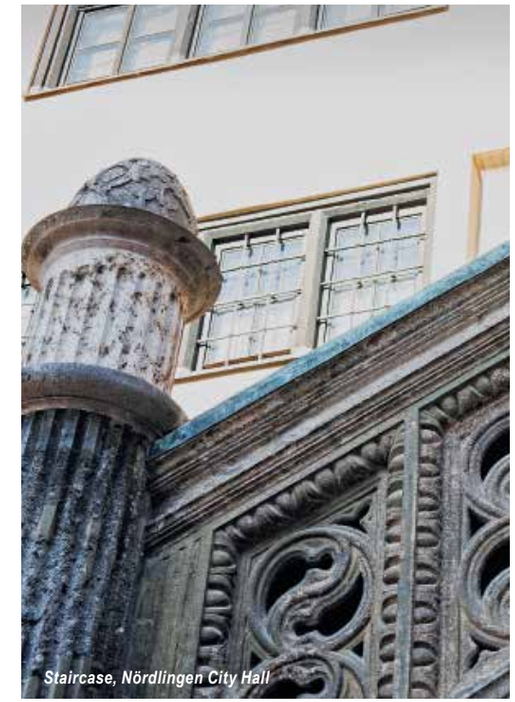
**Stone on stone — Suevite as building material**

Suevite is an easy-to-work, medium-hard stone.
It has been used in architecture in the Ries since Roman times and especially in the Middle Ages.
In Nördlingen, numerous structures erected using Suevite can be visited, including **Baldinger Tor** (Gate), **City Hall** and, the most prominent building, **St. George's Church**.
The building material was extracted from quarries in the surrounding area, some of which were left open, not refilled.



In the quarry Altenbürg, Suevite is found between layers of Upper-Jurassic limestones; in the quarry Aumühle, Suevite can be seen in contact with Bunte Breccia.

In the 18th century, Suevite was discovered to be a suitable binding agent for mortar and cement. The crushed Suevite – also called trass – demonstrates high elasticity, lower susceptibility to cracking and water permeability and high stability against moisture and atmospheric pollutants. Therefore, it is exceptionally well-suited for water-related structures. Today Suevite is found as a building material mainly in restoration mortars in old-building renovations, in the restoration of structures protected as historic monuments and as grout used in tile and natural surfaces.



*Staircase, Nördlingen City Hall*

**Excursion TIP**

**Altenbürg quarry along the Shepherd's Way hiking trail**

The Ries rock Suevite was extracted in the now abandoned Altenbürg quarry, which is located along the Shepherd's Way themed hiking trail. The quarry was probably also the source of the construction material for St. George's Church with the 90-meter high tower "Daniel" in Nördlingen.
The quarry may be visited (the key for the Altenbürg quarry can be borrowed at the guesthouse on the Alte Bürg hill).

# Astronauts in the Ries

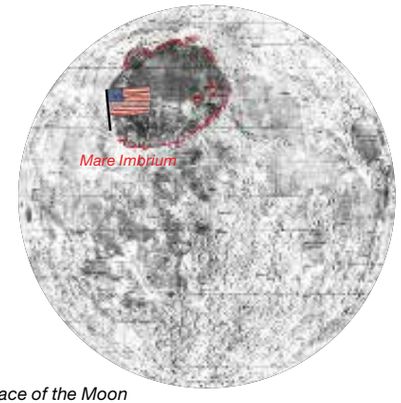
## Science in the Geopark Ries

It is the beginning of August 1970 when the astronauts stand on the floor of the crater basin for the very first time. Although the delightful and densely populated Ries Crater does not really look like a lunar landscape, this is where the space travelers will prepare themselves for the Apollo-14 mission. Field training here will acquaint them with geological aspects of the Moon – the Ries Crater serves as a sort of geological simulator for the impact craters of the Moon.

At first the visit does not resemble work at all, decides the Augsburger Allgemeine newspaper at that time. The crew members sent by NASA look more like "summer tourists from Texas." Commander **Alan B. Shepard** confirms the impression: "I would much prefer to come to Old Germany as a tourist." But the young men face a tough program: In three days they are supposed to visit 13 quarries. "These boys really have to work hard to accomplish their tasks in a few days," says a NASA spokesperson, as reported by the paper.

*Alan B. Shepard and Edgar Mitchell (from left to right in photo)*

**Landing on the edge of the "Sea of Rains"**
The meteorite crater Fra Mauro was the intended landing site for the 1971 Moon mission – Apollo 14 would be the United States' third successful Moon landing. Fra Mauro has a diameter of 80 kilometers and is located on the southern edge of the huge **Mare Imbrium ("Sea of Rains")** basin that was itself formed by the impact of an asteroid. In order to be able to recognize and study typical impact-affected rock and tectonic features on site, the Apollo-14 crew is familiarized with the special features of the comparable Ries geology by geologists from NASA and the University of Tübingen.




*Surface of the Moon*

Stations include the quarry Siegling (see also page 24 "Adventure Geotope Lindle"), where the space travelers study the geologically reversed succession of rock strata (inverse bedding); a Suevite quarry near Otting, where they familiarize themselves with the outward appearances of typical impact rock (see also page 12 "Suevite – *Schwabenstein*"); and the quarry Langenmühle near Maihingen (see also "Geotope Klosterberg" on page 38), where they become acquainted with modifications in the mineralogy of plutonic rock – for example, the formation of high-pressure minerals.

**Science in the Geopark Ries**
Compared to most terrestrial impact craters, the Ries Crater is especially well preserved and considered one of the best studied craters of the Earth. As a consequence, geologists and impact researchers from all over the world come to the Ries to conduct research. The City of Nördlingen operates **ZERIN**, the Center for Ries Crater and Impact Research, located next to the **Ries Crater Museum**. Important geoscientific objects and core samples from the Nördlinger Ries are archived in ZERIN and made available to the research community worldwide for scientific work. Scientific findings from research work in the Nördlingen Ries Crater Museum are comprehensibly prepared and made accessible to the general public.

**The Ries: a planetary learning site**
Research studies of impact events on the Earth and on the Moon are mutually beneficial. During the Late Heavy Bombardment (LHB, or lunar cataclysm) around 4 billion years ago, both the Earth and the Moon were frequently hit by meteorites, asteroids and other remnants of planet formation. In contrast to on Earth, where smaller cosmic projectiles burn up in the atmosphere and the effects of impacts are worn away by erosion or covered by sediment, the Moon has no atmosphere as a protective shield, so erosion is practically nonexistent.

The Moon is therefore a sort of geological time capsule; its surface is dotted with well-preserved impact craters of every size. The Apollo-14 mission confirmed that the geological structures of the debris fields in the Fra Mauro crater, to a large extent, are consistent with those of the Ries Crater. In addition, the terrestrial impact rock Suevite exhibits strong similarity to the impact rock in the Moon craters. NASA continued its research in the Ries; layers of rock were further analyzed in exploratory drillings. And Mars researchers have recently become intensely interested in the Ries. The Ries is and remains a planetary learning site.

### Excursion TIP

**Ries Crater Museum**
In recognition of the importance of the Ries Crater in preparation for the Moon mission, NASA presented to the City of Nördlingen a piece of a Moon rock, which is exhibited and can be viewed in the Ries Crater Museum.

www.rieskratermuseum.de
www.freunde-des-rieskratermuseums.de

# Hand axes and nests of skulls

## Why man settled the Ries

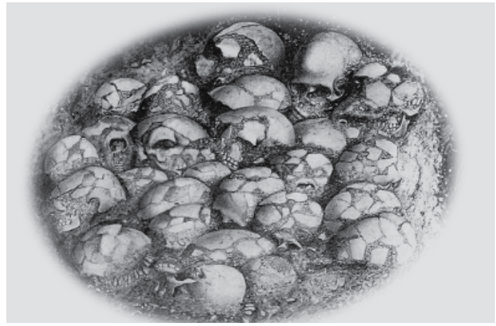
*The Ries is considered a treasure trove ot pre- and early history.*

As long ago as the Stone Ages, early settlers found especially favorable conditions in the Ries. Above all, the dynamic topography of the landscape and its consequences for the soil, microclimate and vegetation appear to be important factors in the decision to settle on the hills in the crater and on the heights.

**Workshops and hunting stations**

Apparently, the southeast region of the crater was especially attractive; the majority of Stone-Age finds come from the area around Harburg and the southern Ries. In fact, the oldest artifact was found near Harburg: **a hand axe** about 130,000 years old – the oldest artifact in Swabia to date. Intensive site visits have also yielded evidence of the presence of Paleolithic humans near Holzkirchen, Wechingen and Schwörsheim. They constructed open-air camps in which to rest while hunting for large animals. Remains from a mammoth were found in the sand dunes near Gosheim.

Thousands of artifacts from the Middle Paleolithic have been found at about 50 sites in the Ries and its immediate vicinity. In addition to lithic flakes and hand axes, excavations revealed the remnants of a complete Stone-Age workshop including toothed devices, points and scrapers. Robert Rudolf Schmidt, an archeologist from Tübingen, made an exceptional find while working at the Ofnet Caves south of Nördlingen. At his direction, a collapsed rock wall was removed. When he examined the layer underneath, he discovered a spectacular find from the Middle Paleolithic: **33 human skulls**.



1 *The skulls were found carefully arranged in the head burial in the Ofnet Caves. Due to its resemblance to a clutch of eggs, it is also called a nest of skulls..*

**Elaborate head burial**

The skulls were found arranged in two small groups, the faces turned toward the west. Evidently the people of the Middle-Paleolithic period attached great importance to the ritual of head burial: the carefully arranged heads were colored with ochre and embellished with over 200 pierced deer grandel (canine teeth) and more than 4,000 pierced snail shells. The first farming settlers from the New Stone Age (Neolithic) also found good conditions here. The Ries had one of the most important concentrations of small-scale settlements of early farmers in the German region. The locations of archeological finds indicate that Neolithic settlers also preferred the southern Ries basin. That was probably due to soil conditions there: Wind from the southwest had blown loess that then accumulated on the leeward side of the crater rim. Almost all Neolithic finds are located in close proximity to the fertile loess soil. The few loess areas in the northern Ries were settled about four centuries later – presumably in the context of a growing demand for space. Around the end of the New Stone Age, early farmers also settled the sandy areas of the eastern Ries.

Grain has been cultivated in the Ries since the 6th century B.C.; root crops and forage plants came later. Still today, the fertile soil of the crater basin and the favorable climate – both indirect results of the impact event – provide good returns. Consequently, the region has been known up to current times as one of "**breadbaskets**" of Bavaria.

## Excursion TIPS

**Celtic hilltop fort on the Ipf**

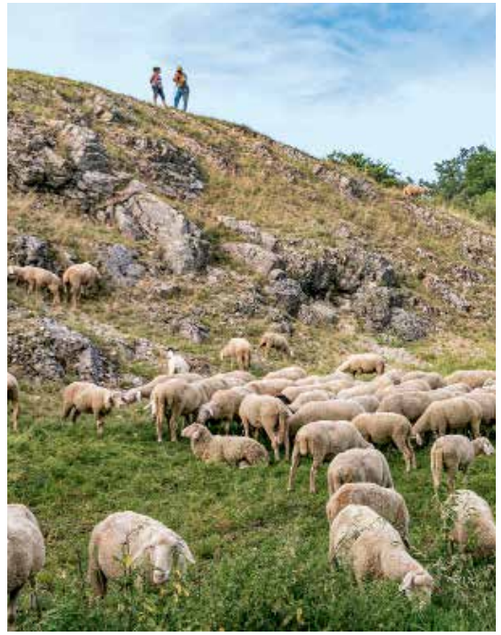
The settlement of a Celtic noble of wide-ranging importance was on the Ipf north of Bopfingen. At the foot of the Ipf is a Celtic open-air museum, which can be visited free of charge. The isolated hill was formed by erosion—its geological origins are not due to the Ries event.


**2 *Villa rustica*, Holheim by Nördlingen**

During the *Limes Germanicus* period, the Romans established agricultural estates on the fertile crater basin to provide supplies for legions at the border. The name "Ries" comes from the Latin name "Raetia."

# Threatened habitats

## Dry-grasslands biotopes



Dry grasslands and heath landscapes are a refuge for many species. The Ries has space for these rare biotopes, but their preservation is not always easy.

**A habitat made by human hands**

Dry (or calcareous) grasslands are found in areas that were originally forested but used by the local population as pasture; they are referred to as herding forests. By nibbling on young trees and shrubs, pasture animals, especially sheep and goats, push the forest back. Clearings and semi-open areas appear until eventually dry grasslands remain.

Dry-grassland biotopes are always on nutrient-poor soil; they provide habitat for a multitude of plants and animal species that thrive in a specialized nutrient-poor and mostly dry location. In spite of the sometimes barren-looking landscape, dry grasslands are among the most species-rich biotopes in Central Europe. They are refuges for numerous endangered species, including many on the Red List of Threatened Species.

**Dry grassland on the crater rim – a typical Ries landscape**

While the deep, nutrient-rich soil in the crater basin has often been chemically altered by fertilization and agriculture, the geology of the soil on the heights of the crater rim has not changed. The special characteristics of the soil-forming bedrock – including blocks of basement and various sedimentary layers – considerably affect the vegetation. The heavily fragmented rock of the megablock zone is very often permeable to water; dry locations form on warm, sun-exposed slopes.

With about 620 hectares of dry grassland, the District of Donau-Ries is one of the most important “dry-grassland districts” in Bavaria.

Located at the intersection of the Franconian and Swabian Alb, today’s heath landscapes serve a bridging function – a sort of corridor between biotopes. In addition, in this region, it is possible to find western-Mediterranean as well as eastern-continental and Alpine species side by side. The area is therefore considered a “hotspot” of biological diversity.

*Carthusian pink* (Dianthus carthusianorum)

**What is blooming there...?**

Many wild herbs and medicinal plants thrive in dry grasslands. The flora of the alkaline soil of calcareous grasslands is especially rich in flowering plants; in contrast, sandy dry grasslands are acidic and the vegetation often distinctly resembles heath. Typical representatives of dry-grassland flora are, for example, pasque flower (*Pulsatilla vulgaris*), broad-leaved thyme (*Thymus pulegioides*), common rock-rose (*Helianthemum nummularium*), **Carthusian pink** (*Dianthus carthusianorum*) and **stemless carline thistle** (*Carlina acaulis*).

Calcareous grasslands’ warm meadows and abundant flowers are suitable habitats for numerous butterflies and grasshoppers, including rare species such as the hermit (a butterfly still existing only on the Ostalb), Chapman’s blue butterfly, lesser mottled grasshopper and grey bush cricket. The sand lizard (*Lacerta agilis*) uses sun-exposed slopes to warm up and to hunt. The semi-open landscape and transitional areas between dry grasslands and other biotopes are also ideal for many species of birds. For example, the red-backed shrike hunts on the borders between grazing areas and hedgerow country.

*Stemless carline thistle* (Carlina acaulis)

**Sheep: four-legged landscape conservationists**

The heath landscape of the Ries is grazed by eleven large flocks of sheep. Migratory sheep-herding is a form of extensive pasture farming that has been practiced here for centuries. Regular grazing is the only way to avoid the dry-grassland areas becoming overgrown and reverting back to forests.

Nevertheless, socio-economic conditions are not favorable for this economic system – many of the traditional sheep farms have difficulty continuing their operations. At the same time, their use of the land is in competition with intensifying cultivation. Fertilization, reforestation, insufficient interconnections and lack of maintenance threaten this unique habitat.

**The Heide Allianz – united for biodiversity**

It is of utmost importance that the grazing animals are not penned up on the dry grasslands overnight. Excessive fertilization can have a long-lasting and adverse effect on the composition of the plant community.

The Heide Allianz was established to preserve the valuable biotopes in the District of Donau-Ries, and it is a joint effort of nature protection associations and the District with its seat in Donauwörth. Its function is to secure areas for pens as well as for livestock trails, to maintain heath areas and to improve the marketing of shepherds’ products such as wool and lamb.

*Ries-Panorama*

## The Aftermath

### How the landscape of today's Geopark was formed

At the end of the last Ice Age, tundra devoid of forest had developed in the Ries. The steppe-like landscape slowly evolved into a low birch forest. Additional thousands of years elapsed before a forest of oak and hornbeams developed that would represent the foundation for the forest now typical in the region. The area's deciduous forests are especially diverse and species-rich. Warmth and light have the greatest effect on the flora of the beech forest in the spring due to the lack of foliage.

Over the course of millions of years, the appearance of the Ries basin today developed from sedimentation in the Ries lake, subsequent erosion of soil and rock by wind and water as well as deposits of loess and sand during the last Ice Age. The crater basin turned into an almost unwooded landscape, in which rivers and streams and their accompanying wetlands alternate with agricultural fields.

In many places on the edge of the basin and on the crater rim, this landscape turns into dry grasslands. Widespread floodplains and wetlands provide the nutritional basis for the northern lapwing, Eurasian curlew, common snipe and white stork.

*White stork family on church roof in Rudelstetten*

## Adventure Geotopes

### Windows into the Earth

Geological processes have shaped the Earth throughout its 4.5-billion-year existence and constantly transform it further. The surface of our Earth and its forms and outcrops are a mirror into these processes. At some places on the Earth's surface, geological features emerge that eloquently relate the history of the Earth, reveal rare geological phenomena or simply are of particular beauty.

Sites like these – whether they are man-made exposures like quarries or natural landscape features like caves, rock faces or steep cliffs – are called geotopes (Greek: *gé* = Earth, *topos* = place). Geotopes are geological landmarks, represent a landscape and make the formation history visible. That is why they are called "Windows into the Earth."

Nature trails have been laid out around some of these "Windows into the Earth"—also called Adventure Geotopes—to give visitors as comprehensive a picture as possible of the impact event and its consequences. This also enables a deeper experience of nature and ecological interrelationships. Seating areas at "special" places invite visitors to linger. At vantage points, panorama panels explain the view of the crater landscape.

# Geopark Info App

## Progressive Web App


**Our recommendation: To use it offline, download the app before your visit to the Geotope.**

### How it works:

1. Scan the QR code from a Geotope info panel or a Geotope page in this booklet.
2. For easy-to-understand information about the location: Open the link. Choose to read or listen.
3. When the location service is activated, a notification is sent when the next info panel is reached.
4. Further information is available under “Help” in the app.

To get to the app start page as well as the Geotope selection, scan the QR code or open the app: **app.geopark-ries.de**

### Excursion TIP

**Guided tours in the UNESCO Global Geopark Ries:**

Experience the Geopark Ries close up with expert, certified **Geopark Ries tour guides!** Our guided tours offer the unique opportunity to closely explore the **relationship between geology, nature and settlement history.** You can participate in public guided tours, or you can book an individual guided tour for yourself and your group.

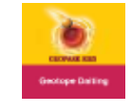
For additional information, visit our website at **www.geopark-ries.de**

# Signs

## along the nature trails

Our themed hiking trails inform hikers about geology, landscape, nature and settlement history.

**Trail signs**
Geopark nature trails are signposted end-to-end.



**Info signs**
In addition, there are often signs pointing out side trips or highlighting vantage points.


**Ground markings**
Markings on forest paths, streets and trees supplement the trail signs.

**Street signs**
point the way to Geotopes


**Panorama panels**
Along the way, panorama panels explain the respective view.

**Info panels**
Informative as well as scientifically oriented panels provide interesting facts along the trails. The color code on the **panel heading shows the topics presented.** You can see a brief summary of the panel contents on the next pages.

**Color codes of our info panels:**

- Geological feature
- Landscape feature
- Settlement history, archeological and cultural history site, ground monument
- Museum
- Church/monastery
- Vantage point


**Safety instructions**
explain the correct behavior to assure your and nature’s well-being.

# Adventure Geotope Lindle

## Searching for traces in the rock debris

### Fact Sheet

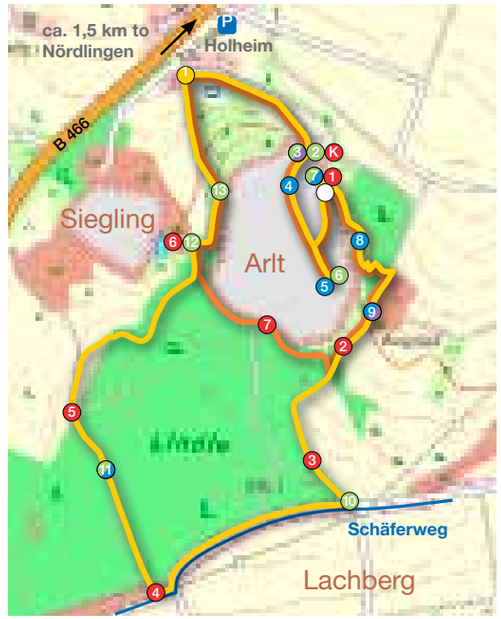
A series of geological features are impressively apparent on the large, exposed rock wall of the former Arlt quarry, now the Adventure Geotope Lindle. Here it can be seen how different types of rock, due to their qualities, were shattered by the shock wave and with what violence the shock wave traveled through the rock.
Along the trail, 13 info panels explain the features of the Geotope and biotope. Seven vantage points look out into the Ries, over Nördlingen and to the crater rim. A seating area invites lingering and picnicking at an outstanding view over Nördlingen and a large part of the crater. The Geopark mascots “Suevie” and “Riesie” guide young visitors on a specially developed Kids’ Trail along the short loop. Leading past two platforms (6/ 7), the path is partly on gravel, but mostly natural and inclined. The trail is not suitable for strollers or wheelchairs.

**Starting Point:**
86720 Nördlingen, village of Holheim,
Am Lindle 1, Geotope parking
Coordinates: 48.820887, 10.461634

**Walking time:**
1 – 2 hours

**Geopark Nature Trail**
Long loop path: ca. 3.3 km
Short loop path: ca. 1.8 km

Scan the QR code
for easy-to-understand
information to read
or hear.




The area just inside the outer crater rim has an abundance of these displaced blocks and is therefore called the megablock zone (see graphic page 9). Located within the megablock zone, Geotope Lindle allows a glimpse into the structure of such a megablock.
The impact of the asteroid first formed a primary crater about 4.5-kilometers deep with a diameter of about 12 kilometers (graphics, page 8). In the seconds immediately following impact, huge blocks slid down the steep sides of the crater rim into the crater below. ▶

1 - 13 = Location of info panels
= Color legend of info panels, see page 23
K = Memory game and site for hammering rocks
6 = Tower
7 = Platform with panorama photo
= Geopark Nature Trail, large loop
= Geopark Nature Trail, short loop – Kids’ Trail
= Seating
= Quarry
P = Geotope parking


The crater thus spread further outwards until it reached a diameter of about 25 kilometers.

The blocks that slid into the crater but not far from their original position are called parautochthonous blocks. The rock of the former Arlt quarry primarily consists of Upper-Jurassic limestone (White Jurassic) – and includes thickly stratified limestone blocks of individual slabs built up into layers, interlocked with massive, homogenously-formed limestone.

*Landscape maintenance: By grazing, Valais Blackneck goats control vegetation in the quarry and on rock walls.*

The juxtaposition of these two types of limestone is especially observable on the exposure wall (info panels 6 / 7 ). It is apparent that in most places the massive limestone was completely smashed into grit by the shock wave of the Ries event, while the thickly bedded limestone blocks were clearly less shattered. There is a simple explanation for this: In the bedded (that is, layered) rock, some of the energy of the shock wave was discharged along the joints between the individual layers. The rock layers did not remain completely intact, however, but were shattered into angular, small-size chunks (brecciation).

The inverse stratification typical for the Ries can also be observed in the Adventure Geotope Lindle: At the very top of the break-off edge of the exposure, the remains of the geologically older *Bunte Trümmermassen* (rock debris) are deposited in pockets, where it has endured more than 14 million years of erosion (more about typical Ries tectonics in “Geotope Kalvarienberg” page 30).



## *FEUERSTEIN* – IRON OF THE STONE AGE 3

Over 125 million years ago, siliceous (glass) sponges lived on the floor of the Jurassic sea here (see Geotope Kühstein). During the sedimentation process, they were trapped in limestone. These sponges contained silicic acid that was displaced in limestone through lime solution and collected by the inclusions. When rock was formed so were these nodules of flint – also known as *Feuerstein* (firestone). Due to its sharp cutting edge, this stone was used as raw material for hand axes and other Stone-Age tools. Visitors may try it themselves: Tapping is allowed only on the boulders placed for that purpose and under supervision – it is very likely *Feuerstein* will be found.

## Apollo Astronauts 13

Beside the former Arlt quarry, on terrain adjacent to the Adventure Geotope Lindle, is the Siegling quarry. This was a site of astronaut training in 1970, in which American NASA astronauts were prepared in the Ries Crater for the Apollo-14 and -17 Moon missions (also see page 16 “Moon landing in the Ries”). The Siegling quarry is not accessible to the public, but there is a good view of it from the observation tower 6.

*American astronauts in the Ries Crater*

*Siegling quarry*

## Excursion TIP

**Kids’ Trail Lindle**

The two Geopark mascots “Suevie” and “Riesie” guide young visitors around the former quarry with exciting information, easy-to-understand explanations, stories and quiz questions. At the start of the path, the two “guardians of the rocks” greet visitors with a play-and-experience station and outdoor Memory game.

*Yellow-bellied toads (*Bombina variegata*) find an ideal environment in the ponds and are adapted to the extreme conditions (alternating from moist to dry).*

## Biotope

Typical for the megablock zone of the Ries Crater, soil properties change frequently and abruptly in Geotope Lindle. This is due to the diverse blocks and rock debris that were whirled together during the Ries event and came to rest on the surface in a chaotic dispersion.
Mainly dry biotopes form over limestone because of its high water permeability. But where Bunte Breccia containing clays occurs, the ground is impermeable. Shallow bodies of water arise, fed only by rain, that can again completely dry out. These ponds are spawning waters and habitat for numerous animal species including toads, lizards, various insects and water snails.

## Excursion TIP


**Nördlingen**
The picturesque, well-preserved Old Town is full of lovingly renovated, splendid houses from the Middle Ages and Renaissance. Especially impressive: the completely preserved **city wall from 1327** with five gates, 16 towers and one bastion. The parapet is also preserved, so it is possible to walk on the wall entirely around the Old Town.
The symbol of Nördlingen is called Daniel, the 90-meter-high bell tower of **St. George's Church**. Climbing the steps to the top of Daniel is rewarded with a breathtaking view over the town and the Ries.

## Excursion TIPS

**Shepherd's Way**
The Shepherd's Way offers a longer hike near the Adventure Geotope Lindle and follows a traditional trail for migratory shepherds (length of trail: ca. 19 km; walking time: 5.5-6 hours). The trail begins and ends at the parking area of the Marienhöhe swimming pool in Nördlingen. The trail leads past geological and archeological sites that are explained in six informative panels.

In close proximity to Adventure Geotope Lindle, the **Riegelberg** hill is composed of limestone. Over millions of years, carbon dioxide in water permeating rock can partially dissolve limestone and lead to the formation of caves (karstification). The Ofnet Caves bear witness to this even today.

Archeological excavations in the caves have revealed numerous Stone-Age finds. Above all, the **Ofnet Caves** owe their prominence to Robert Rudolf Schmidt's 1907 discovery: The researcher from Tübingen uncovered two nests of skulls (see also page 16 "Hand axes and nests of skulls").


# Geotope Kalvarienberg Huisheim-Gosheim

## A cosmic bomb moves mountains

### Fact Sheet

In the Geotope Kalvarienberg, the exposures of Gosheim's non-operating limestone quarry demonstrate the force and energy of the shock wave released by the Ries event.
The nature trail leads over gravel and meadow paths through the publicly accessible quarry and then over the Kalvarienberg (Calvary Hill), along a 19th-century Stations of the Cross and past a chapel before returning to the starting point.

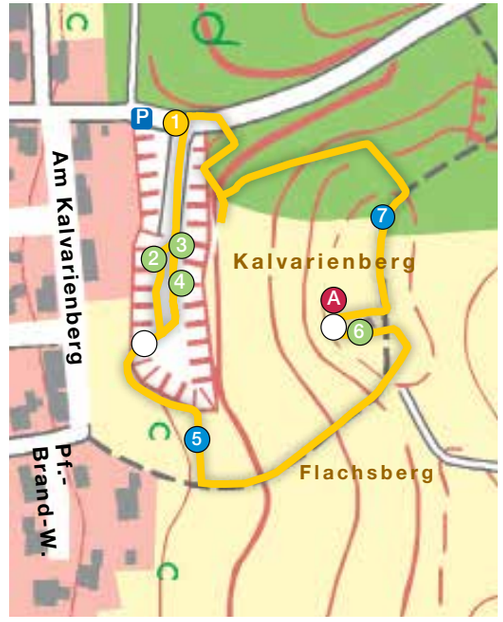
Seven info panels along the way explain the Geotope's special features. A panorama panel describes the views on the western crater rim. Seating areas are inviting spots to linger over a picnic.
The path climbs some stairs and is not suitable for strollers or wheelchairs.

**Starting Point:**
86685 Huisheim-Gosheim,
Grüner Weg 16, Geotope parking
Coordinates: 48.833552, 10.724486

**Walking time:**
ca. 30 min

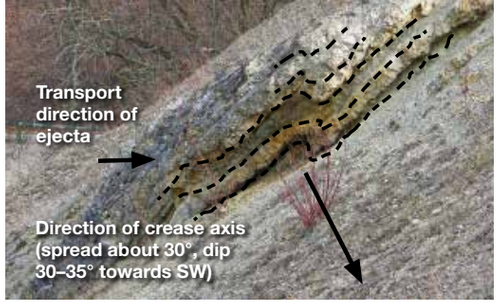
**Geopark Nature Trail:**
ca. 1.0 km

Scan the QR code for easy-to-understand information to read or hear.




Geotope Kalvarienberg is situated directly on the eastern crater rim in the megablock zone (graphic page 9). Here, despite their mass, huge blocks were moved over a wide stretch toward the east by the force of the shock wave produced by the Ries event – today their corresponding bedrock lies several kilometers west of the Geotope. Due to the braking effect of the accelerated blocks, the layers were partially buckled and pleated – wrinkles or creases like these are visible in several places in the quarry. ▶

1 - 13 = Location of info panels
A = Outlook with panorama photo
= Geological feature
= Landscape feature
= Geopark Nature Trail
= Seating
= Quarry
P = Geotope parking




*Creases in Upper-Jurassic limestone, a result of the braking effect of the block; the creases spread toward the southwest.*

Such processes are only conceivable bearing in mind the energy that was released by the impact of the asteroid: Conservatively estimated, the explosion can be compared to hundreds of thousands Hiroshima-type atomic bombs.

New experiments and calculations of the mechanics of the impact event have shown, even a megablock the size of the Kalvarienberg can be hurled through the air on a flat trajectory (ballistic transport) by pressures of nearly 10 gigapascals (about 100,000 atm) – surrounded by a thick cloud of debris.

Other megablocks were pushed over the ground in rolling-sliding movements – comparable to the processes by which glaciers move, just at higher speed. That left traces: The surfaces of some rock blocks display powerfully abraded areas on several sides, brightly polished or surrounded by contrasting mixed clays from various rock layers, whose streaky structure suggest a rolling motion. The clays could have played a lubricating role in rotational movement.

The Gosheim block is fairly rich in fossils; occasionally the fossils are even well preserved despite the shock wave. Fortunately the fossils include small ammonites, important as index fossils to determine the relative geological age. An analysis of these index fossils has verified that, in the exposed block in the quarry, older rock layers are situated on top of younger ones – in geology it is called an inverted deposit or inverse stratigraphy.

This sequence of rock layers, in opposition to the geological age, occurred when the uppermost rock layer sunk into the developing crater while, at the same time, being covered with Bunte Breccia that was ejected from deeper layers by the force of the impact. The deepest and oldest layer, the crystalline basement, rose as a glowing mushroom-shaped cloud over the crater that then dropped a layer of Suevite on top of everything else (see also page 12 “Suevite – *Schwabenstein*”).

Inverse stratigraphy is otherwise found only in fold mountains. In the megablock zone around the Ries Crater, though, it is pervasive – therefore Ries researchers designate this geological feature also as “Ries tectonic.”

## Kalvarienberg

Kalvarienberg (Calvary Hill) is also a destination for Stations of the Cross that start in Gosheim and lead to the summit. There, between rockfaces and dry grasslands, stand a cross and a chapel. Every year on Good Friday, a procession of the faithful makes its way to the cross.

*Chapel of the Sacret Heart*





## Ries Belemnites 4

“Ries belemnites” are a special feature of the limestone at the crater edge. These are fossilized skeletal remains of a small relative of the squid family. The shock wave of the Ries event fragmented the fossils into small slices that were subsequently re-attached to each other by the lime solution circulating in the rock. The resulting fossils – re-assembled offset slices – are typical for the Ries – and remarkable. With luck, a visitor to Geotope Kalvarienberg can see such a fossil.

*Various “Ries belemnites“* (Hibolithes sp.), *a unique preserved shape*

## Dry Grasslands 5

*Red-backed shrike* (Lanius collurio)

Surrounding Geotope Kalvarienberg are stretches of the sunny grazing land, interfused with hedges, so typical for the Ries landscape on the edges of the Crater. Such semi-open dry-grassland biotopes offer ideal conditions for the red-backed shrike (*Lanius collurio*). Birds of the shrike family build their nests in thorny hedgerows and sit on the edges of open areas to hunt large insects such as dragonflies and beetles and even small mammals like mice.

Above all, the red-backed shrike is well-known for his remarkable behavior of skewering his prey on thorns – a method of food storage. His German name, *Neuntöter* (nine-killer), derives from an erroneous folk belief that he will spear nine prey animals before he eats. The migratory bird overwinters in southern Africa.

## Excursion TIP

**Geopark Info-Point Wemding**

In the Info-Point Wemding of the UNESCO Global Geopark Ries, numerous display panels introduce visitors to the topics of the Geopark.

In addition, the Info-Point Wemding explains a variety of “local ” themes: The spectrum ranges from scientific analysis of Suevite from the Otting quarry, to the life and works of botanist Leonhart Fuchs, up to interesting information about the second largest Marian pilgrimage site in Bavaria, Maria Brünnlein.

# Geotope Glaubenberg

## A geological puzzle

### Fact Sheet

The nature trail through Geotope Glaubenberg follows gravel and meadow paths as well as a short street segment to a quarry south of the Harburg community of Großsorheim. The rock layers of the exposed face show chaotic stratification – here the natural order was completely confused in the course of the Ries event.

Four info panels clarify the geology and natural history of the Geotope, and a panorama photo explains the magnificent view over the gently rolling countryside.

**Starting point:**
86655 Harburg, Village of Großsorheim,
Am Rufenberg, Parking at sports area
Coordinates: 48.787908, 10.633233

**Walking time:**
ca. 1 – 1.5 h

**Geopark Nature Trail:**
ca. 2.7 km

Scan the QR code
for easy-to-understand
information to read
or hear.

Geotope Glaubenberg is located on a section of hilly landscape, about four kilometers wide, southeast of the outer crater rim in the so-called megablock zone (see graphic page 9).

The elevations are composed largely of displaced blocks—massive rock debris that came to rest here after being hurled through the air or pushed across the surface by the shock wave of the asteroid impact. ▶


1 - 4 = Location of info panels
3 = with sediment-transfer preparation
A = Outlook with panorama photo
= Geological feature
= Landscape feature
= Geopark Nature Trail
= Quarry
P = Geotope parking


*Deformed Upper-Jurassic block (front left) (2). The stratified Upper-Jurassic block Glaubenberg, a complicated block mosaic. In background, right-hand side, Ice-Age river bed. (3) Profile detail of Glaubenberg's Pleistocene (Ice-Age) fluvial deposits with interpretations of each dominant flow dynamic on the basis of the rubble and, respectively, gravelly sand portions; inclined layers due to more recent slides. (STP) Sampling point of sediment-transfer preparation.*

The geological detail map (info panel (2)) reveals the chaos caused here by the impact. In the area surrounding Geotope Glaubenberg, blocks of crystalline basement rock that are over 250 million years old are situated beside geologically younger Triassic and Jurassic blocks in a chaotic mosaic on the surface – an impressive witness to the way deeper and more shallow lying rock layers were churned pell-mell during the impact event.

The Geotope Glaubenberg nature trail leads to an inoperative quarry in which the town of Harburg had formerly excavated roadway material. The outcrop is composed of limestone from the Upper Jurassic (White Jurassic); fossil finds (ammonites, belemnites and sea urchins) verify an age of about 150 million years. The rock exposed in the quarry is structured predominantly from overlying, interconnected layers. Geologists call it bedded or stratified block.
Tracking the demarcation lines that distinguish these different rock layers, it is apparent that, within individual parts of blocks, they run in different directions, some only slightly diverging, others almost perpendicular to each other. The chaotic position of the blocks is recognizable in this line structure – the natural order is considerably disrupted. Even geologists can barely reconstruct the original positions and common origins of individual blocks – a geological puzzle still waiting for its solution.

**Former riverbed (3)**
East (to the right) of the main face are layers of rubble, sand and crumbly sandstone. These are the deposits of the course of a river, probably a tributary of the ancient Wörnitz. The sediments also contain limestone from the Ries Lake that formed in the crater after the asteroid impact (see also page 6 "From seabed to crater basin"). The river must have come into existence after the Ries event.

**Sediment-transfer preparation (STP)**
Looking closely at the sediment, it is possible to recognize the sequence of different layers. The basis – that is, the undermost layer – is interspersed with coarse rubble. At first the river must have had a strong current, in order to carry along fragments of this size. In the middle layers, the deposits alternate between coarse- and fine-grained sediment. This is a clear indication of an abrupt change in the speed of the current. A possible explanation is short-term climate fluctuations, as often occurred during the Ice Age. During the brief warm periods, the tundra-like permafrost soil thawed for a few weeks and allowed rivers to swell to torrential flows. In the upper section of the sediment layer, fine-grain sand predominates; therefore the current was for the most part slow, before the river eventually ran dry. The rock sequence is illustrated and explained by the sediment-transfer preparation (STP) produced directly from this Geotope rock wall.



## Special geological and landscape features (4)

An additional exposure in the easternmost point of the nature trail offers a glimpse into the period before the Ries event. About 170 million years ago, today's Ries was flooded by a sea advancing into the region from the northwest. The coastline of this sea had already reached the vicinity of today's Munich. The Middle-Jurassic, reddish, sandstone blocks were formerly part of the bed of a sea strip that – similar to the Wadden Sea – was strongly affected by tides.
The rivers that flowed into the sea here brought with them a large amount of ferrous rubble. The shallow sea bed was extensively inhabited by microbes (biofilms), including specialized bacteria that through their metabolic activity turned iron into iron (III) hydroxide (the mineral goethite) and thus enriched the seabed where eventually rock layers formed out of the sediment.
*Doggererze* (a type of iron ore; Dogger is an earlier name for Middle Jurassic) demonstrates an iron content of up to 40%. Since the start of the 16th century and into the period of the Second World War, *Doggererze* was mined in the Ries and distant surroundings to the Swabian and Franconian Alb as well as in Lothringen for iron production.
In Geotope Glaubenberg, alkaline soil over limestone alternates with acidic soil over Middle-Jurassic sandstone – as a result, an abrupt change in vegetation at the edges of different blocks is often noticeable. Typical representatives that grow on the acidic ground of

*The displaced sandstone blocks were moved a long distance during the impact event. In spite of the strong shock wave, the sandstone surprisingly retained its original layers. The shock wave, however, loosened the formerly firm sandstone to predominantly fine-grained sand.*

sandstone blocks are the colonial bent, thyme-leafed sandwort, field wormwood, red bartsia, carline thistle and greater musk-mallow.
On the walls of the sandstone blocks, the sandy soil provides ideal living conditions for other inhabitants: Mining bees (genus *Andrena*) and solitary-living bees of the genus *Anthophora* dig their nests in the soil here. The burrows for living and breeding can reach up to 65-cm deep in the loose, sandy subsoil.

## Excursion TIP

*Harburg Castle is the largest and best-preserved medieval fortress in the Geopark Ries.*

The Ries is a land of fortresses and castles. Especially well preserved and certainly worthwhile to visit, **Harburg Castle** sits enthroned above the town of the same name. The extensive medieval complex – with archways and other structures of Suevite – was first mentioned in a document in the year 1150.
A walk along the battlements is like immersion in the Middle Ages – peeking out through embrasures, passing jail cells, gates and towers. Tours are regularly scheduled.

# Geotopes Klosterberg

## Geological dispatches from the depths



### Fact Sheet

The exposures in Klosterberg permit a glimpse into the deep geological underground of the region. Here, on the northwest edge of the primary crater, rocks of the crystalline basement are exposed. The nature trail leads through the lovely landscape of Mauchtal (valley of the millstream Mauch) to two former crystalline quarries, Langenmühle I and II, and further to the Hahnberg quarry where a Ries-lake-period algae reef is exposed.

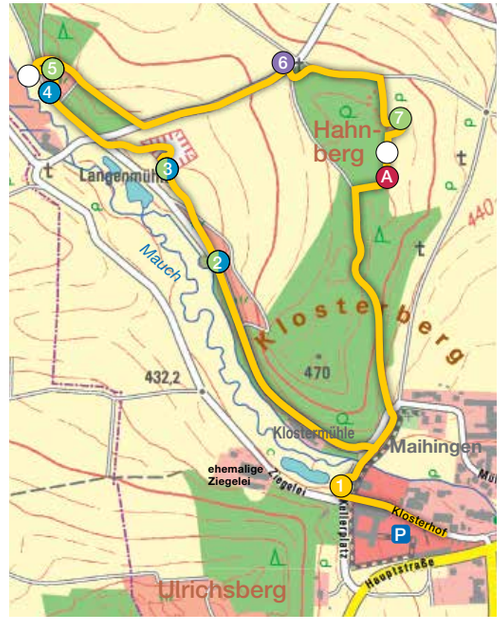
Seven info panels explain the geological, biological and historical features of the Geotopes, and a panorama photo elucidates the view of the crater landscape.
The nature trail around the Geotopes Klosterberg leads to publicly accessible quarries over gravel and meadow paths; therefore, the trail is not suitable for strollers or wheelchairs.

**Starting point:**
86747 Maihingen, Klosterhof 8,
Parking at Museum KulturLand Ries
Coordinates: 48.928996, 10.491040

**Walking time:**
ca. 2 h

**Geopark Nature Trail:**
ca. 2.6 km

Scan the QR code for easy-to-understand information to read or hear.




In the Paleozoic – over 300 million years ago – the continental plates of the two largest land masses at the time, Laurasia (or Euramerica, northern) and Gondwana (southern) collided. This collision caused the so-called Variscan, a mountain-building event. These mountains (of crystalline basement) appear today in Central Europe, for example, in numerous low-mountain ranges including the Vosges, Black Forest, Harz and also Ore Mountains. In many places – as around the Ries – the crystalline basement was subsequently covered by layers of sediment and rested hundreds of meters below the surface. ▶

1 - 7 = Location of info panels
A = Outlook with panorama photo
= Color legend of info panels, see page 23
= Geopark Nature Trail
= Seating
= Quarry
P = Museum KulturLand Ries = Geotope parking

However, in the Geotopes Klosterberg – on the edge of the primary crater – the crystalline basement appears on the surface. Why? During impact, the Ries asteroid penetrated the sedimentary layers and first created a 4.5-km-deep crater that reached the crystalline basement (pages 8/9). The vaporization and ejection of rock led to a release of pressure – and the compressed basement of the basin floor rebounded.

Subsurface material was pushed upwards hundreds of meters, sometimes at an angle, and so arrived on the surface. This phenomenon, unique for the region, can be explored in the former crystalline quarries, Langenmühle I and II, of the Geotopes Klosterberg.

Among the plutonic rock to be found in the Ries are granite and gneiss. Granite is igneous rock formed by the crystallization of melt. Gneiss is designated a metamorphic rock, formed under high pressures and temperatures during mountain building. For geologists, the blocks transported to the surface during the Ries event are very interesting dispatches from underground; they deliver clues, as to which rock exists at which depth, and allow comparison to the near-surface exposures of the places where the Variscan highlands appear. The Geotopes outside Maihingen also are of interest to space exploration. This is where the Apollo-14 and -17 astronauts who prepared for their missions in the Ries studied the mineralogical changes to crystalline basement caused by the Ries event (see also page 14 “Moon landing in the Ries”).

## Excursion TIP

*A special attraction of the monastery church is the historic Baroque organ, constructed 1734-37, with its preserved original meantone temperament .*

**Convent in Maihingen & Museum KulturLand Ries**

Combine a walk on the Geopark nature trail with a visit to the convent in Maihingen. Construction of the convent began in 1437.
Originally built of tuff and brick, the complex was significantly enlarged by the Brigittine order of Augustinian nuns. Besides the convent church Maria Immaculata (cornerstone ceremony 1712), the former mill, brew house and farm buildings exist today. Housed in the former convent’s commercial buildings, the Museum KulturLandRies impressively documents rural life in Ries.



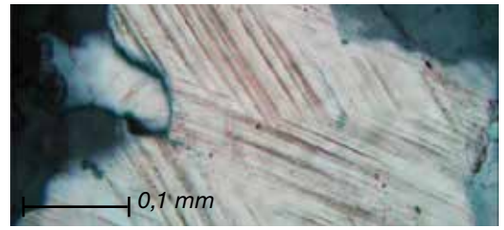
## High-pressure minerals: evidence 5, hunt for ore 1

**Rock-solid evidence**

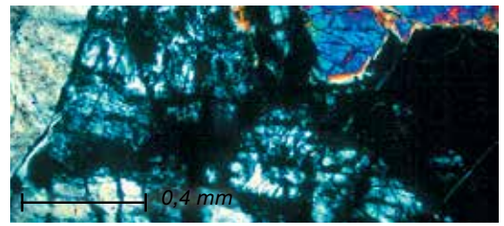
Ever since American underground nuclear-weapon experiments in Nevada in the 1950s, it is known that sudden pressure load affects minerals. On the basis of these findings, the renowned impact researcher Eugene Shoemaker examined thin sections of crystalline rocks from the Ries for corresponding deformation structures and the accompanying new mineral formations.

He found, among others, the high-pressure minerals coesite and stishovite, melted glass and so-called diaplectic glasses of quartz and feldspars as well as characteristic lamellae and fractures in the thin sections – all properties of rock that clearly point to an asteroid impact. In this way Shoemaker could definitively prove in 1960 that the Ries was an impact crater. The interpretation of the Ries as a crater of volcanic origins was shelved.

Thin-section microscopy/electron microscopy of relevant minerals affected by a shock wave




*Quartz with planar elements (shocked)*




*Plagioclase, planar deformation features (shocked, Moon)*

**Mining for biodiversity**

Crystalline rock, like that in the Geotopes near Maihingen, frequently also contains metallic ores such as gold and silver. Early on, that aroused interest in the Ries. In the 1670s, Prince of Oettingen-Wallerstein had exploratory shafts dug; quarries and exposed slopes were eagerly prospected. But according to historical sources, the activities ended in 1684 after even diviners were unsuccessful. As known today, the special features of Ries geology are due to greatly brecciated rock masses – in which no continuous, commercially-workable veins of ore are to be found. Dreams of gold and silver were dashed.

*Various types of bats hibernate in rock cellars.*

The tunnels created during the search for ore later served the convent and breweries in Maihingen and Marktoffingen as storage for beer and foodstuff. Today the tunnels and shafts provide suitable winter quarters for numerous species of bats. For example, documented here are the greater mouse-eared bat and the brown long-eared bat. In summer the Mauchtal, with its mosaic of diverse and near-natural habitats, provides a superbly suitable hunting ground for the bats. In this way, the exploratory tunnels make an important contribution to species conservation today.

# Geotopes Kühstein

## Reefs in the Ries

### Fact Sheet

The Geotopes Kühstein are located directly on the edge of the village of Mönchsdeggingen. Here, on the southern rim of the crater, two quarries offer a look into the geological past of the region: a 160-million-year-old belt of reefs and the remains of a delta of the Ries lake. The nature trail lies in the so-called megablock zone of the southern Ries Crater rim.

On the 2.7-kilometer-long trail, eight info panels explain the phenomena of the Geotopes and the biological as well as historical significance. The top of the Buchberg hill provides a spectacular view of the Ries, its inner ring and outer rim. The village association, Dorfverein Mönchsdeggingen e.V., has provided a panorama panel explaining the view.

**Starting point:**
86751 Mönchsdeggingen,
Almarinstraße
Coordinates: 48.772322, 10.574693

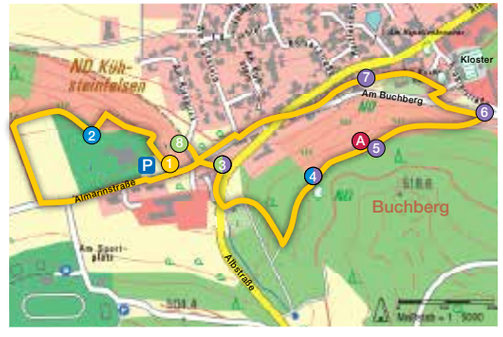
**Walking time:**
ca. 1 – 1.5 h

**Geopark Nature Trail:**
ca. 2.7 km

Scan the QR code for easy-to-understand information to read or hear.

The Upper Jurassic (White Jurassic), about 160 million years ago, was the great age of reefs. Worldwide, an enormous variety of reef-building organisms abounded – not just corals, algae and microbes, but also calcareous and siliceous (glass) sponges. In deeper water regions siliceous sponges created some large hilly structures (so-called mounds). The outcrop on the Kühstein cliff 8 opens a window into this geological period: Here relicts of a former sponge-reef appear.

When the White-Jurassic block exposed on the Kühstein hill—and its neighboring block—slid into the crater during crater formation, the blocks were in part greatly mechanically stressed. Nonetheless, the upper sections of the exposures are especially well preserved . ▶




1 - 8 = Location of info panels
A = Outlook with panorama photo
= Color legend of info panels, see page 23
= Geopark Nature Trail
= Seating
= Quarry
P = Geotope parking

The section of the reef visible on the Kühstein cliff belongs to the so-called Ries-Wiesent reef-tract that traversed the region of the Franconian Alb in the Jurassic sea. It was part of a gigantic, interconnected belt of sponge reefs that stretched over 7,000 kilometers from the Caucasus across today's Romania, Poland, Germany, France, Spain and Portugal to Newfoundland and even Oklahoma – an impressive witness to the importance of sponge organisms to reef building at that time.

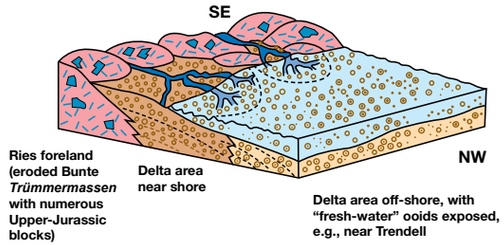
Never again in the Earth's history have siliceous sponges attained this significance. For a long time, researchers questioned whether still-living sponge reefs existed. Only in 1987 did they discover, in 200-meter-deep water off the western Canadian coast, a similar hill-shaped reef formed by sponges – a real surprise.

The Mönchsdeggingen quarry offers another geological highlight near the former community sheep farm 3. Close observation of the rock layers reveals how coarser and finer rubble alternates. Also called clastic rock, these fragments – according to layer – exhibit completely different forms and degrees of rounding. Coarse and fine rubble is partially separated into layers, but there are also banks with fully mixed components.

This outcrop exposes sediment of a former river delta. Here a tributary emptied into the former Ries lake. The sequence of layers in the rock profile illustrates the climatic circumstances around the time of the Ries event, which was characterized by increasing seasonal precipitation. The inflow amounts and water levels of the Ries lake were evidently subject to strong fluctuations at times. The deposits and degree of cementation in the sediments changed with the strength of the current – which explains the sequence of the various layers. The profile of the river delta also reveals something about climate fluctuations on a small scale; the alternating rock sequences can thus be interpreted as an indirect climate archive .


*Presumed expanse of the over 7,00-km-long Upper-Jurassic siliceous-songe reef belt*


*Small hill-shaped reefs (mounds) of living siliceous sponges, ca. 200-meters deep, off Canada's western coast.*




*Block-diagram reconstruction: presumed situation on shoreline of Ries Lake during period of the filling of the river delta at Mönchsdeggingen from the southeast (SE) to the northwest (NW). Possible shore vegetation not included.*

## Biology on Kühstein 2

Among the rare animal species on the Kühstein hill is the smooth snake (*Coronella austriaca*) that is dependent on sunlit woods and dry grassland. Smooth snakes love dryness and warmth, so sun-exposed dry grasslands provide a biotope well-suited for them.
Smooth snakes often remain motionless and trust their camouflage. The snakes strangle larger prey by tightly coiling their bodies around their victims.

Although the smooth snake is strictly protected, again and again it is mistaken for the common European adder (also strictly protected) and killed as an allegedly dangerous poisonous snake. They are also threatened by the progressive destruction of their habitat.

In addition to protected biotopes themselves, the prominent Kühstein cliffs are rimmed by species-rich dry grasslands with individual juniper trees and hedgerows. Biotope mapping has recorded 130 plant species in the area around Kühstein. Above all, the cliffs exhibit valuable rock-face vegetation, including basil thyme (*Acinos arvensis*) and the fern called wall-rue (*Asplenium ruta-muraria*). The most well-known representative of rock-face vegetation is the white stonecrop *(Sedum album).*

*Although often mistaken for the common European adder, the smooth snake is not poisonous and is completely harmless to people.*

*The white stonecrop is a succulent plant with fleshy, water-storing leaves that has adapted to a hot, dry climate.*

7 *The "court linden" (or "court lime tree") in Mönchsdeggingen is estimated to be over 1,000 years old. During the Middle Ages, the village court or council would be held publicly under the tree. Moreover, the linden in Mönchsdeggingen was probably used as a "dance linden" with a podium for musicians and dancers.*

## Art in the Woods 4

*"Säulengang" by Elke Stadlmayr. The "Kunstwald" project concerns transience and itself undergoes natural changes through the years.*

# Geotope Kalvarienberg Donauwörth - Wörnitzstein

## In the midst of debris – the southern Ries foreland

### Fact Sheet

A 1.7-kilometer-long nature trail leads through the Geotope Kalvarienberg in Wörnitzstein. The Geotope lies in the middle of a geological debris field – rock blocks flung by the asteroid impact landed here as *Bunte Trümmermassen*.
In addition to illustrating how these ejected materials affected the transformation of the landscape, the four info panels describe settlement and natural history features. The nature trail leads to the publicly accessible quarry over gravel and meadow paths and, therefore, is not suitable for wheelchairs or strollers.

**Starting point:**
86609 Donauwörth - Wörnitzstein,
Abt-Cölestin-Straße
Coordinates: 48.731171, 10.725210

**Walking time:**
ca. 1 h

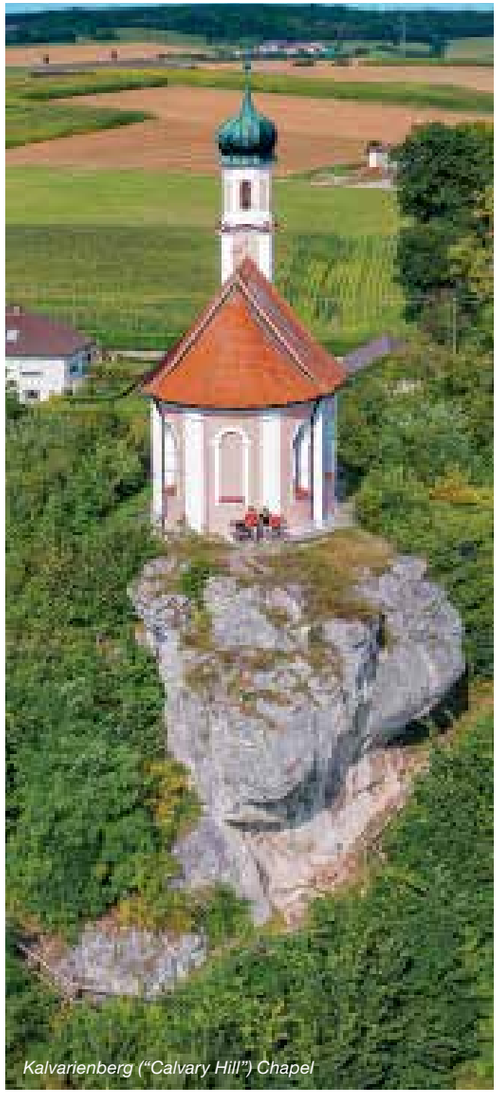
**Geopark Nature Trail:**
ca. 1.7 km

Scan the QR code for easy-to-understand information to read or hear.


The impact of the Ries asteroid devastated an area of hundreds of kilometers surrounding the crater. The Jura plateau was fractured into myriad fragments. Blocks of all sizes – including *Schollen* hundreds of meters in diameter – flew, rolled or slid in all directions from the crater. Masses of sediment – among them Jurassic and Triassic Keuper – were shattered into the tiniest particles. Mixed together, the smashed sediment and the hard block fragments became *Bunte Trümmermassen* (literally, colorful detritus), tiny remnants of which have been detected up to almost 200 km from the crater.

1 - 4 = Location of info panels
= Color legend of info panels, see page 23
= Geopark Nature Trail
= Quarry
P = Geotope parking

In the midst of this debris lies Geotope Kalvarienberg in Wörnitzstein. Here, a good 20 kilometers from the crater center, are blocks of considerable size. Further crater-outwards the size of the blocks decreases. After the Ries event, the *Trümmermassen* were affected by erosion and weathering – but to varying extents, depending on the hardness and composition of the debris. Strikingly etched, two displaced blocks protrude out of the landscape to this day: the Sendenberg and the Kalvarienberg. The hills of weathering-resistant detritus characterize the typical landscape in the Ries foreland.



*Kalvarienberg ("Calvary Hill") Chapel*

Especially prominent, the Kalvarienberg rises from the landscape. Enthroned on the summit is the Kalvarienberg Chapel, erected in 1750 under Abbot Cölestin zu Kaisheim. The cliff of massive (White-Jurassic) limestone came to rest eight kilometers away from the crater rim after the impact. Despite being profoundly shattered by the shock wave, it offered a good building site – meanwhile most fissures have mended. From the top, there is a great view of the Ries foreland and the Wörnitz valley.

The displaced limestone block now called Sendenberg (2) also stands out strikingly over the landscape. The exposure shows bedded and massive rock sections, with respectively different degrees of disruption, that are interwoven together. In addition, the bedded portions are tilted relatively steeply, an indication of the turbulently acting forces during transport. The megablock must surely have been repeatedly rotated and also fragmented. For a long time, material for road construction was extracted from the block because of the extensive mechanical shattering.

The debris that landed in the Ries foreland also had a large effect on the course of the bodies of water at that time. Rivers were dammed and rerouted; due to the flows of the primordial Main and Altmühl, a large body of water (Rezat-Altmühl Lake) formed to the north of the crater; it can be geologically traced today.



## The Wörnitz valley (3)

With respect to nature protection, the Wörnitz valley is one of the most valuable in Bavaria, providing habitat for numerous species immediately threatened with extinction. One of the most prominent species is the white stork, who uses waterfront fields as feeding areas. Horsts are located in nearby Donauwörth and Harburg. The fields between Wörnitzstein and Ebermergen boast a diverse mosaic of wetland meadows, shrub swamps, large-sedge reeds and reed beds rich in sedges and rushes.

The water of the Wörnitz is somewhat burdened with an increased input of nutrients, but it is nonetheless the only body of water in Bavarian Swabia to have a so-called bream region – the species-richest fish region of a river of this lower reach. The main fish species is the common bream (Abramis brama), but there are also white bream, common roach, wet catfish and the predatory fish zander, northern pike and perch. The presence of mussel species (thick-shelled river, painter's and swan) is indicative of especially good water quality.

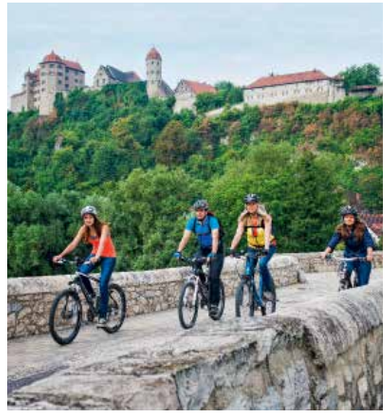
**Warinza – a river despite debris**

The Wörnitz is a river with a long history. Even before the Ries event, the primordial Wörnitz ran close to its current course. Drilling and geophysical deep soundings have been able to demonstrate that it flowed through an 80-meter-deep, fjord-like, carved river valley with steep sides and eventually into the molasse basin to the south. This early Wörnitz valley was blocked by the debris ejected during the Ries event.

*Wörnitz with millstream: Typical for the use of water power is splitting off into a millstream (waterway on left) and lower course. Water level is regulated by a low-head dam (in foreground).*

Following the Ries catastrophe, some time passed before the primordial Wörnitz, together with the early Eger, could once again reclaim the original course through today's crater region. In the period after the Ries event, the primordial Wörnitz washed away soft Ries-Lake sediment and contributed to the uncovering of the original crater form. In this way the river participated noticeably in the design of the Ries landscape familiar today.

### Excursion TIP



**For good sports: the Wörnitz bike path**

The Wörnitz bike path follows the course of the Wörnitz from its source until it flows into the Danube, about 132 kilometers long in total. It meanders through wide meadow valleys, then across the Ries Crater, breaks through the crater-rim heights near Harburg and reaches the Danube in Donauwörth.

The bike path is about 100 kilometers long and presents a relatively low elevation profile. Along the route, there are landscapes and attractions to admire – and a regional cuisine to enjoy. Well-known spots like Schillingsfürst, Dinkelsbühl, Wassertrüdingen, Oettingen, Harburg and Donauwörth – to name just a few – invite lingering or an overnight stay.

www.woernitzradweg.de

# Geotopes Daiting

*Bohnerze* (iron ores) and *Plattenkalke* (laminated limestones)

## Fact Sheet

The Geotopes Daiting nature trail brings the history of ore mining to life, with a close connection to the community of Daiting. Cultural history and economic aspects form the thematic focus on the info panels along the four-kilometer-long loop trail. A quiz about plants accompanies hikers along the way and provides entertainment for all ages.

An additional trail version of two kilometers is also designated. Seating provided at the starting point and in the quarry invites visitors to linger and picnic.
For younger visitors, a child-friendly adventure trail with the Geopark mascots “Suevie” and “Riesie” has been developed along the longer loop trail. Here, too, quizzes liven up the circular route.

**Starting Point:**
86653 Daiting,
Sports field Natterholzer Straße
Coordinates: 48.792761, 10.912342

**Walking time:**
1 – 2 h

**Geopark Nature Trail:**
Long loop path: ca. 4 km
Short loop path: ca. 2 km

Scan the QR code for easy-to-understand information to read or hear.


The Daiting nature trail was created as part of a nature conservation project that focuses on optimizing former quarries from a nature protection perspective. The quarries are not only “windows” into the history of the Earth, but they also provide habitat for a large number of specialized animal and plant species. ▶

1 - 13 = Location of info panels
= Color legend of info panels, see page 23
= Geopark Nature Trail, longer loop – Kids‘ Trail
= Geopark Nature Trail, short loop
= Seating
= Quarry
P = Parking at sports field

### *Plattenkalke* (laminated limestones) and crater geology

About 150 million years ago, the area around Daiting lay in the middle of a subtropical landscape of islands, lagoons and a warm, shallow sea. Calcareous organisms (e.g. sponges and algae) created massive limestone reefs. Calcareous sediments were deposited in the shallow lagoons, which solidified into slab limestones.

*The laminated limestone quarries near Daiting became famous because of their wealth of fossils.*

About 15 million years ago, an asteroid struck 27 kilometers northwest of today's Daiting Geotopes and drastically changed the geology in the area. The region around present-day Daiting was overlain by turbulently mixed rocks that were ejected from the crater. The thickness of these so-called *Bunte Trümmermassen* (variegated rock-debris masses including Bunte Breccia) averages 30-50 meters.
Bunte Breccia still covers large areas of the southwestern Franconian Alb. It is recognizable by its multicolored ("bunt" in German) composition and by the crushed limestones.

### Iron-ore mining pits

*Bohnerze* are iron-ore nodules named (in German) after their bean-like shape. For thousands of years, they have been picked up and washed out in the extensive karst regions, dug out of deep pits in ore-rich areas, and even extracted from deeper mines built in some places.
*Bohnerze* are in many cases concentric mineral aggregates consisting mainly of brown iron minerals. Humic acids released by decaying plants in turn caused iron to precipitate from calcareous weathering clays and in the fluctuation range of calcareous groundwaters. They accumulated in cavities in karst areas. In the forest between Daiting, Natterholz and Blossenau one encounters funnel-shaped pits, which are partly overgrown. They are the remains of numerous ore mines. In the 19th century, open-pit mining was used here to extract *Bohnerze*, which was washed in the Berger Weiher pond or in the river Ussel. The extracted ore was brought to Obereichstätt by horse-drawn carts and smelted there in the smelting furnace. These ore mines were the starting point for the fossil search in the exposed laminated limestone.

Bohnerze

### Life in the Jurassic sea

Hearing of Solnhofen fossils, one thinks primarily of the finds near Solnhofen and Eichstätt—but the region around Daiting is also an important site. In fact, the first reptile find in the area, a marine crocodile, published in 1817, came from the "*Bohnerz* pit at Meulenhart" near Daiting. In the years that followed, other important fossils were found here, including tuataras, long-tailed dinosaurs and even a bony fish that bears its find-locality in its name: the Daitingichthys. The prehistoric *Archaeopteryx* is one of the most famous fossils in the world. It represents an evolutionary link between dinosaurs and birds. The Daiting *Archaeopteryx* was the eighth of thirteen specimens found in the late 1980s.

*The Daiting* Archaeopteryx *is probably the most famous fossil from this region.*



### Forests through the ages

In the course of post-glacial reforestation, mainly mixed beech-oak forests developed in the area around Daiting. Since the Neolithic Age (3000-1700 BC), human activity has been affecting these forests. The forest was increasingly plundered as a source of raw materials and firewood and also depleted by forest grazing (e.g. pigs) and litter use (i.e. gathering fallen leaves and needles for livestock). The first forestry regulations were created in the Middle Ages, ushering in regulated and sustainable forestry. In Daiting, too, the citizens regulated the use of wood, and since then the forests around the village have been managed responsibly and moderately by the "Daiting Rechtler" (persons authorized by the municipality to work in the municipal forest). The 194-hectare Daiting Rechtler forest is of particular importance for landscape, water and biotope protection.
In order to meet the challenges of climate change, spruce-dominated stands have long been converted into mixed deciduous forests, old species-rich deciduous forests have been preserved and promoted, and valuable deciduous hardwoods have been cultivated. In the Monheim area, the pine is also known as "almond" in the vernacular. The name of the forest area "*Mantelholz*" (meaning almond wood in German) is probably derived from this.

*Structure-rich deciduous forests with old trees are also an optimal habitat for bats.*
*The Carthusian pink is a typical and conspicuous flowering plant of the dry grasslands.*

### Dry grasslands, stone meadows, cliffs

On the nature trail you are traveling in an old grazing landscape. Species-rich calcareous dry grasslands were created through centuries of sheep grazing. At the end of the 20th century, the dry grasslands fell into disuse and the diversity of species dwindled. Today, fortunately, a shepherd is once again tending sheep grazing in the area.
In the former quarries, on cliffs and stone meadows, prevailing conditions (very little ground cover and exposure to heat) are hostile to life, but for some animal species, e.g. snakes and lizards, they are ideal habitats.

**Excursion TIP**

### Kids' Trail

In the Geotopes Daiting, the two Geopark mascots "Suevie" and "Riesie" guide young visitors with exciting information, easy-to-understand explanations, fun stories and quiz questions along the way around the former quarry. A small accompanying brochure for children, with coloring pages and quiz questions, has been prepared for the nature trail.

# Geotope Amerdingen

## Extraction of the valuable “*Schwabenstein*”

### Fact Sheet

The former Suevite quarry in Amerdingen is about one hectare in size and includes large expanses of water. Three themed info panels explain interesting facts about geology, biology and the history of the Geotope.

To protect the animals and plants, parts of the Geotope are not accessible. The Geotope has been designated as a natural monument since 1981. Visitors to the Amerdingen “Geotope of Silence” can consciously perceive and enjoy the sounds and noises of nature. Please respect these protected zones!

**Starting point:**
Kapellenstraße, 86735 Amerdingen
Coordinates:: 48.722989, 10.488164

**Geopark Nature Trail:**
1 km

**Walking time:**
0.5 h

Scan the QR code for easy-to-understand information to read or hear.

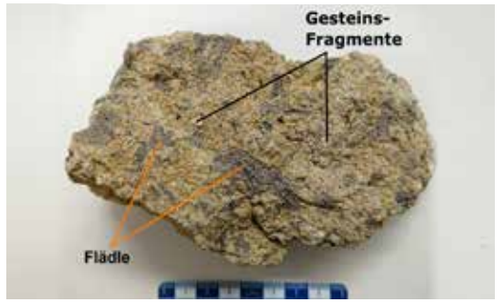


Amerdingen is located about 14 kilometers south of Nördlingen and about five and a half kilometers outside of the southern outer crater rim.
The debris masses ejected during the asteroid impact covered the landscape here too. The lower-lying rock material from the basement—mainly granites, gneisses and amphibolites—shattered and vaporized after the impact and rose in a glowing cloud several thousand meters into the atmosphere. Shortly thereafter the glowing cloud collapsed, and the rock masses covered the area like a “blanket” and cooled. These deposits are in some places up to several tens of meters thick. The rock that was formed during the cooling is called Suevite.

*Due to its picturesque location on the water as well as the open Suevite walls, the Geotope is also an important biotope for native flora and fauna.*

The abandoned former “trass quarry” on the Kapellenstrasse provides a unique window into our Earth’s history. As a geosite in the UNESCO Global Geopark Ries, it is an important treasure. Suevite is susceptible to weathering and can only be studied in man-made exposures and quarries.
Over time, nature reclaims the bare rock faces, first with colonizing plants and animals, and a unique natural monument is created.

**Suevite extraction: use of the building stone**
The first quarries began to operate in the vicinity of Amerdingen even before the 19th century. The heyday of the quarries, however, was between 1905 and 1920, when there were at least four Suevite quarries around Amerdingen alone. Up to 120 workers were employed in these quarries in the Kesseltal (Kessel valley). The quarried material was roughly processed on site and first transported to the worksite in Nördlingen.
After further processing into finely shaped stone, it was transported by rail, for example to Munich (construction of the Ministry of Transport) and Augsburg (to build the postal administration headquarters).
Suevite was popular not only as a building stone but, because of its fire resistance, also for lining furnaces.



*Suevite rock*


*Suevite was used for the construction of the former Bavarian Ministry of Transport building in Munich.*


*The most conspicuous aquatic plant is the yellow-flowering fringed water lily.*

**Life in the quarry**
On the quarry floor, a pond landscape formed in the fluctuation zone of the groundwater above water-confining layers. Except in midsummer, the pools are interconnected to each other by small channels. The area is of great importance as a breeding ground for the common toad, grass frog, tree frog and historically also the yellow-bellied toad.

## Project partner

**Heide-Allianz Donau-Ries**
The Heide-Allianz landscape-conservation association was founded in September 2010. It is a partnership of the District of Donau-Ries, Ries Nature Protection Association, Association for the Protection of the Wemding Marsh and Nature Protection Alliance.
The purpose is to preserve the juniper heathland as a man-made landscape—and the biological diversity—by means of itinerant sheep herding. The implementation of projects in cooperation with towns and municipalities aims to preserve biological diversity and strengthen the biotope network and wildlife corridors. The public is informed in a variety of ways about the significance of dry grasslands for species conservation and the characteristic landscape as well as the importance of grazing by sheep and other pasturing animals.
The Geotopes of Daiting and Amerdingen were developed in the framework of the nature conservation project “**Quarrying sites in the District of Donau-Ries—from wounds in the landscape to nature paradises**” supported by the Bavarian Nature Conservation Fund Foundation. The Heide-Allianz and UNESCO Global Geopark Ries concluded a cooperation agreement for this purpose.

# Glossary
## Scientific terms

**Beaufort**
The Beaufort scale is the most widely used system to express wind speed. Beaufort Force 6 is equivalent to ca. 39-49 km/h.

**Biofilm**
Connected, layered communities of microorganisms that grow on firm ground such as marine sediment.

**Middle Jurassic**
Soil type formed by deposits in the Jurassic Sea; ocher-brown to reddish color and fine-grain structure are characteristic. Formerly equated to Dogger or brown Jurassic.

**Breccia**
(Italian *breccia*: loose gravel), part of *Bunte Trümmermassen*
Originally consolidated clastic rock with angular-cornered fragments; formed in various ways. The term Bunte Breccia refers exclusively to the foreland of the Nördlinger Ries; it describes debris resulting from the impact of the Ries meteorite – more or less loose, local, often very different compositions of *Trümmermassen*, formed by the intense, random mixing due to ballistic ejection and movement of materials, then deposited over the Ries foreland.

**Diaplectic glass**
In contrast to normal glass created by under-cooling a melt, diaplectic glass is formed when the lattice of a crystal is destroyed by extreme force in the form of a shock wave

**Dry grasslands**
Areas of grassland not suitable for agriculture, permeable soil, maintained by grazing; generally nutrient-poor soil, nevertheless distinctive for the great diversity of animal and plant species supported by the habitat.

**Extraterrestrial**
(Latin extra: outer; terra: Earth)
Heavenly bodies outside of the Earth and its atmosphere are designated as extraterrestrial.

**Fluviatile sediment**
(Latin *fluviatile*: of a river)
Reduced rock fragments carried by flowing waters.

**Gneiss**
Rock with parallel texture, formed by geological metamorphic processes that affect large areas, contains more than 20% feldspar.

**Impact**
Designates impact of a cosmic body (for example, meteoroid, asteroid or comet) on the surface of a usually larger body; it forms an impact crater.

**Infernal**
Synonym for horrible, hellisch.

**Silicic nodules**
Originate from former siliceous sponges that built small reef patches on the seabed; also known as flint.

**Loess**
Fine-grained sediment, not layers, contains calcium carbonate, generally yellow-brown color.

**Massive limestone**
Limestone without internal separation seams, "massive" appearance, predominantly the result of reef building by siliceous sponges or corals, often visible as hill-shaped rises in rock masses.

**Megablock (zone)**
Blocks of various compositions, with diameters from tens to hundreds of meters, rarely larger: characteristic for the peripheral areas of meteorite craters (so-called megablock zone), mostly slightly moved (parautochthonous).

**Upper-Jurassic limestone**
Light-colored limestone of the youngest series of the geological system Jurassic, widely distributed in Ries region, original rock unit affected by meteorite; appearing in both manifestations as massive and bedded limestone.

**Parautochthonous**
Blocks pushed or slid minimal distances, retaining a certain connection to original root location (autochthonous). The outer Ries Crater rim is characterized by a megablock zone composed of blocks that slid (see graphic page 13). The Geotope Lindle highlights one of these mega-blocks.

***Schollen* (Blocks)**
Generally larger, more or less isolated blocks of rock, in the Ries area, resulting from the mechanical fragmentation of the surface by the impact of the meteorite.

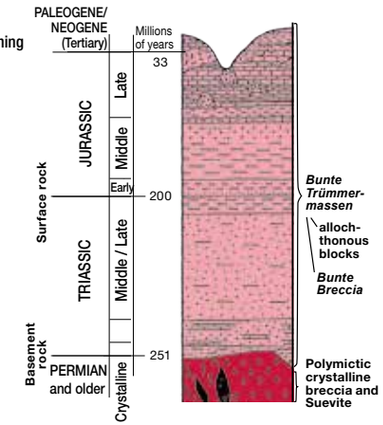
**Stratigraphic**
Pertaining to the age determination of rock layers.

***Trümmermassen***
▷ Breccia

**Tuff**
Volcanic rock



**Impact rock of the Ries**
**Stratigraphy of starting material**




*Pre-impact geology*



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