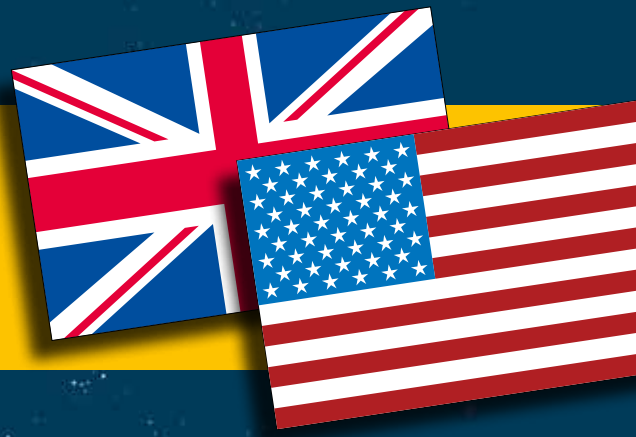
GEOPARK RIES

Europe's Giant Meteorite Crater

Information booklet English



View from Geotope Kalvarienberg, Huisheim - Gosheim

Adventure Geotopes

The Geopark Ries has several Adventure Geotopes with nature trails that you can visit and enjoy. Geotopes (also called geosites) are geological landmarks – they make formation history visible and understandable. Info panels provide information about the particular location, including geology, archeology, cultural history, landscape features and ecology. You can enjoy a visit to the Adventure Geotopes with the guidebook Windows into the Earth, on a guided tour or using the QR code INFO APP for geological information in everyday language:

Info panel, Geotope Kalvarienberg, Huisheim

INFO APP

How it works

1. Please scan the QR code in this brochure or on the GPS sign in one of the 6 Geopark Ries Geotopes.
2. To use offline, download the app.
3. Then start the app. You will get information about the respective Geotope. Choose to read or listen.
4. Geofencing: If the location services of your smartphone are activated, it will notify you when you have reached a landmark in one of the Geotopes.
5. You can find further user instructions under Help in the app.

Scan the QR code or enter **app.geopark-ries.de** into the browser to get to the app homepage and select the Geotope.

Dear Visitors,

Welcome to the Geopark Info-Center!

We are very delighted that you are interested in the Geopark Ries, this unique landscape that was created 14.5 million years ago when a large asteroid crashed into the Earth.

The information displayed here discusses the origin of the Ries landscape as well as characteristic rock formations and the history of settlements in the region. You will also find suggestions on where you can explore special features of the Ries on your own.

For our English-speaking visitors, this brochure provides a good overview of all information presented at the Info-Center.

We hope you enjoy your visit to the Info-Center and the Ries region.

Your Geopark Team

National Geoparks

Preserving our geological heritage

Education for sustainable development

Sustainable research and education

Sites of interest and scenic landscapes to experience, understand and enjoy

National and international geopark movement

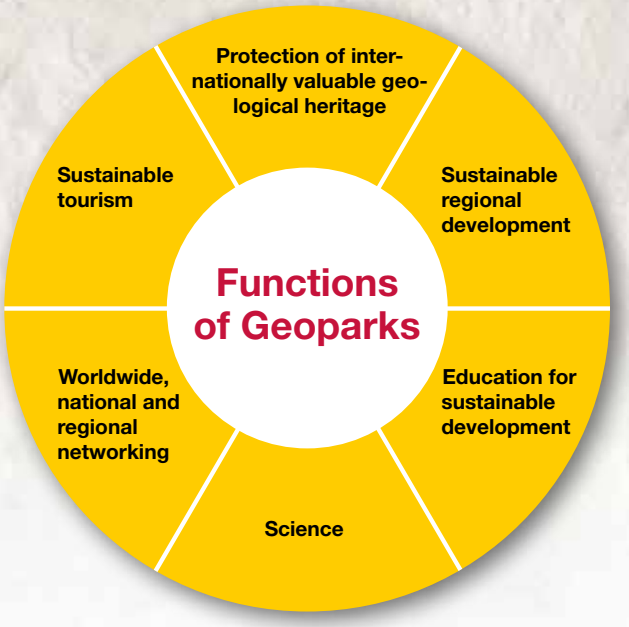
National geoparks are regions with unique geology that also have geological sites of interest (called geosites or geotopes) of special scientific importance, rarity or beauty. In addition, they include archeological, ecological, historical or cultural points of interest.

In Germany there are currently 16 National Geoparks certified by the GeoUnion Alfred-Wegener Foundation (as of 2020).

A main goal of the national and international geoparks is sustainable regional development. Geoparks provide visitors with knowledge of how our Earth was formed, the geological processes that affect it and how geological and geomorphological processes influence habitats. The distribution of natural resources and their effect on land use as well as economic and cultural history are also made tangible in geoparks.

National geoparks raise awareness of the uniqueness of the Earth and thus serve UNESCO's declared goals: preserving natural heritage and promoting sustainability. UNESCO has awarded the designation UNESCO Global Geopark since November 2015.

Focus of geoparks:



The National Geopark Ries as a network

The sustainable approach of the national geoparks requires the coordinated efforts of different disciplines.

The Geopark Ries e.V. fulfills this task with a clearly defined management structure that reflects the diversity of topics and tasks. In addition to full-time management and administration, there are five voluntary Expert Teams.

NATIONAL GEOPARK RIES

Area of the Geopark approx. 1,750 km²

Area of the city of Munich 310 km²

Geopark Ries

Unique feature of the Geopark Ries

The Nördlinger Ries is the best preserved impact crater in Europe. Its remarkable features stand out clearly in the landscape: The flat crater basin is almost 25 km in diameter and mostly without forests; the crater rim rises up to 150 meters high. The Geopark Ries comprises not just the crater with inner ring and outer rim but also the surrounding landscapes in which ejecta masses are preserved even today. Visitors to the Geopark Ries can discover how the impact radically transformed the landscape 14.5 million years ago and still shapes the region today.

The flat Ries Basin, 25 km in diameter is largely unforested; the crater rim, up to 150 meters high, is clearly visible in the landscape.

The Geopark Ries has a surface area of about 1,750 km² and includes 53 communities in 5 different districts. The larger part of the Geopark is located in Bavaria (83%), the small area in Baden-Württemberg (17%).

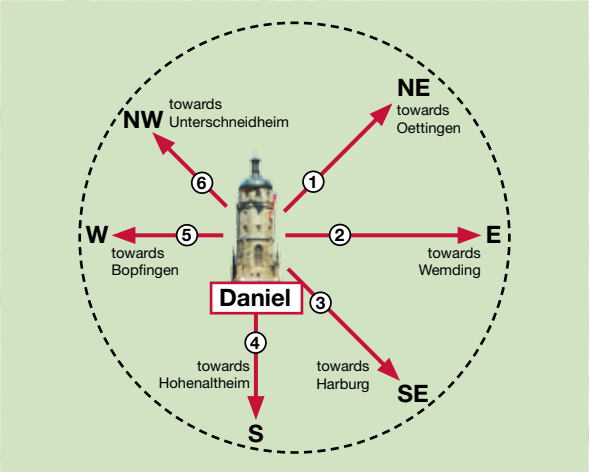
TIPP The Nördlingen Ries Crater Museum is an extraordinary museum with a fascinating theme – the formation of the Nördlingen Ries and other impact craters.

View from the Rollenberg hill (a megablock) into the crater basin.*

** Megablocks are large blocks of rock (tens to hundreds of meters in diameter) moved during impact.*

Panoramic view from the Daniel tower

The Ries landscape can be observed particularly well from a number of viewing points along the crater rim but also from within the crater – especially from the tower called Daniel of St. George's Church in Nördlingen and from the hills of the inner crater ring (e.g., Wennenberg, Wallerstein). The isolated Ipf hill of the Swabian Alb is a good vantage point outside the crater.



Panorama view from the 90-meter-high Daniel in Nördlingen

① View towards the northeast, in the direction of Oettingen

② View towards the east, in the direction of Wemding

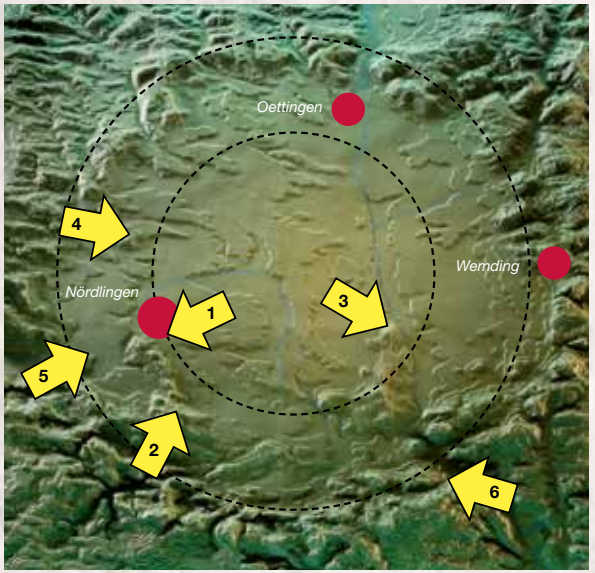
③ View towards the southeast, in the direction of Harburg

④ View towards the south, in the direction of Hohenaltheim

⑤ View towards the west, in the direction of Bopfingen

⑥ View towards the northwest, in the direction of Unterschneidheim

Places of distinction in the Ries



Viewing points are located for the most part on the outer crater rim, the inner crater ring and on individual outcrops in the megablock zone:

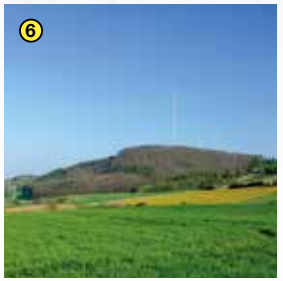
① Marienhöhe, Nördlingen, along the inner crater ring

② The Niederhaus castle ruins lie at the southwest crater rim

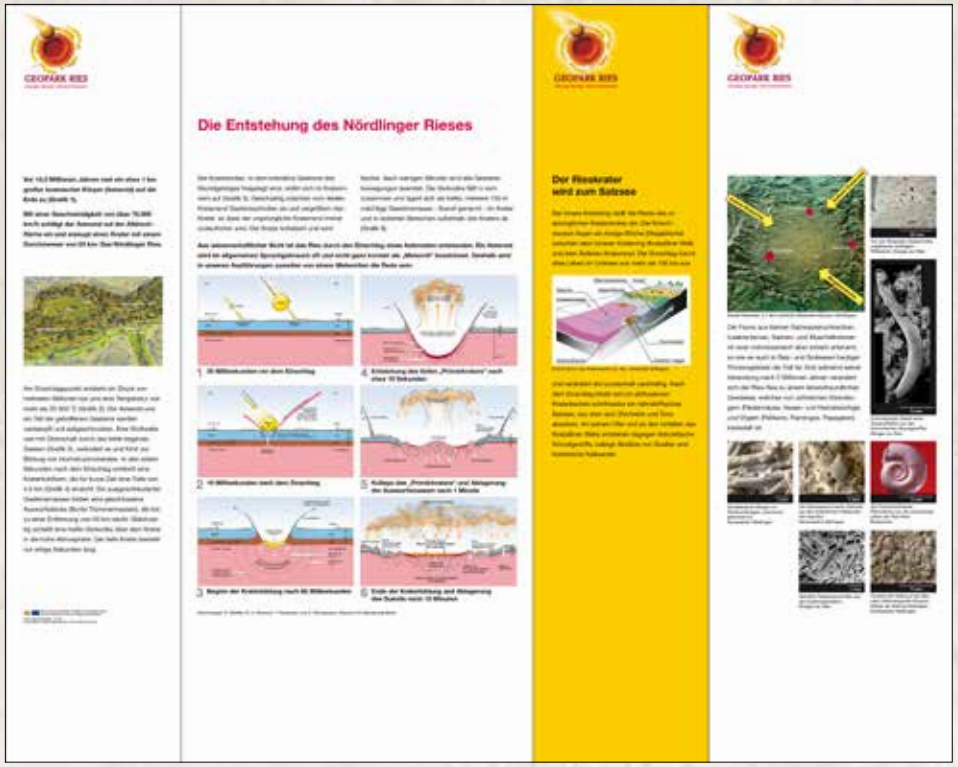
③ The Wennenberg near Alerheim marks the inner crater ring

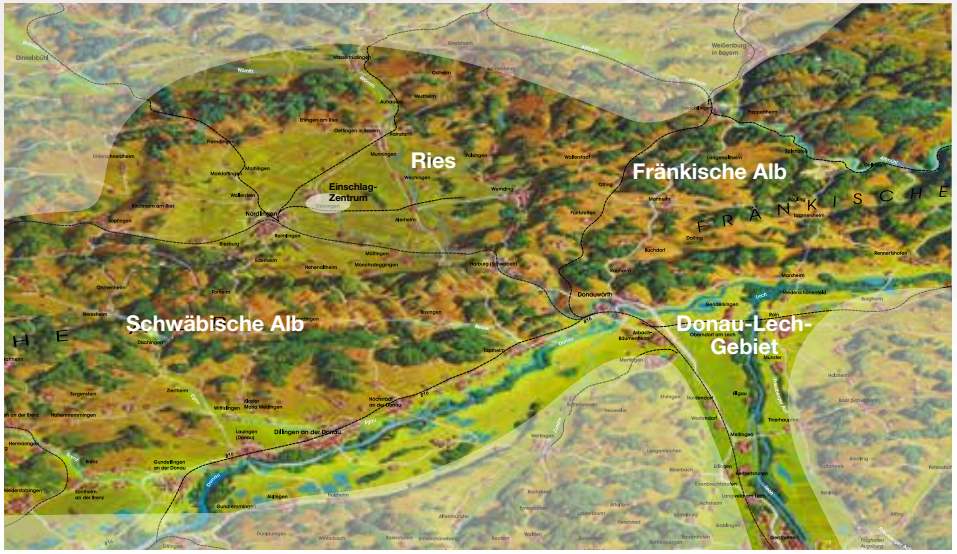
④ Wallerstein Cliff is part of the inner crater ring

⑤ Riegelberg is a block of Malmian limestone within the megablock zone



⑥ Bockberg is located at the southeastern crater rim





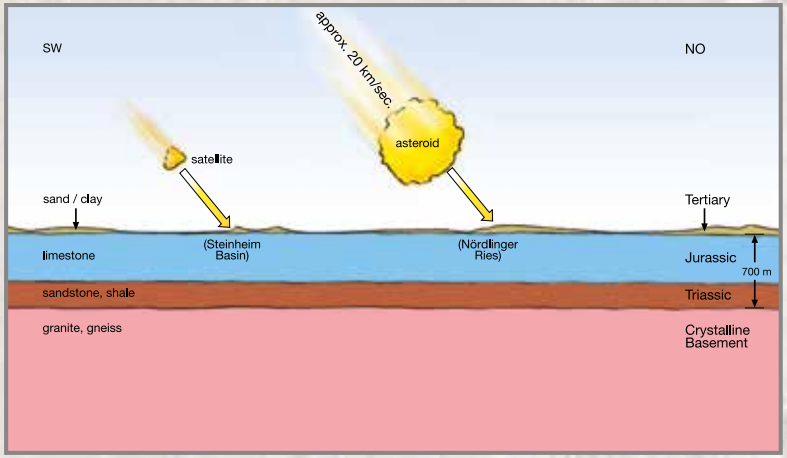
The origin of the Nördlinger Ries

About 14.5 million years ago:
A 1-km-large cosmic body (asteroid) races towards Earth (illustration 1). With a speed of over 70,000 km/hour, it smashes into the Alb plateau and creates a crater with a diameter of 25 km: The Nördlinger Ries.

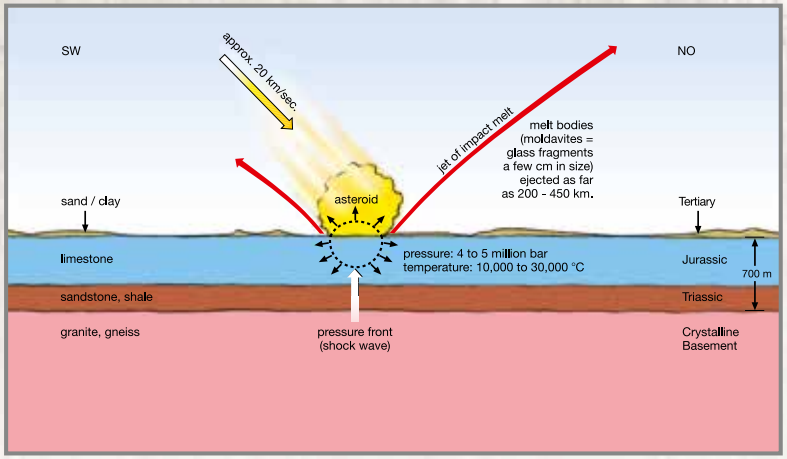
At the point of impact, pressure reaches several million bar and temperature more than 20,000°C **(illustration 2):** The asteroid and part of the target rock vaporize and melt. A shock wave races at supersonic speed through the deeper target rock **(illustration 3)**, changes it and leads to the formation of high-pressure minerals. In the first seconds after impact, a crater cavity is formed that, for just a short time, reaches a depth of 4.5 km **(illustration 4)**. The expelled rock masses form a coherent ejecta blanket (Bunte Trümmermassen = rock debris) extending as far as 50 km from the point of impact. At the same time, a hot, glowing, mushroom-shaped cloud blasts up into the high atmosphere above the crater. The deep crater exists for only a few seconds.

The floor of the crater, where rocks of the crystalline basement are exposed, rises up in the center of the crater **(illustration 5)**. At the same time, large blocks of rock slide down the steep sides of the crater wall, thereby enlarging the crater so that the original crater wall becomes more and more obscured. The central uplift collapses and forms an elevated inner ring inside the enlarged flat crater. The rock movements end after only a few minutes. On the floor of the transient crater a turbulent flow of molten and fractured rocks forms a thick layer of Suevite. Meanwhile the hot vapor cloud collapses depositing another layer of Suevite in the crater on top of the Suevite formed by ground surging. In addition Suevite is deposited on top of the ejecta blanket outside the crater in some isolated areas **(illustration 6)**.

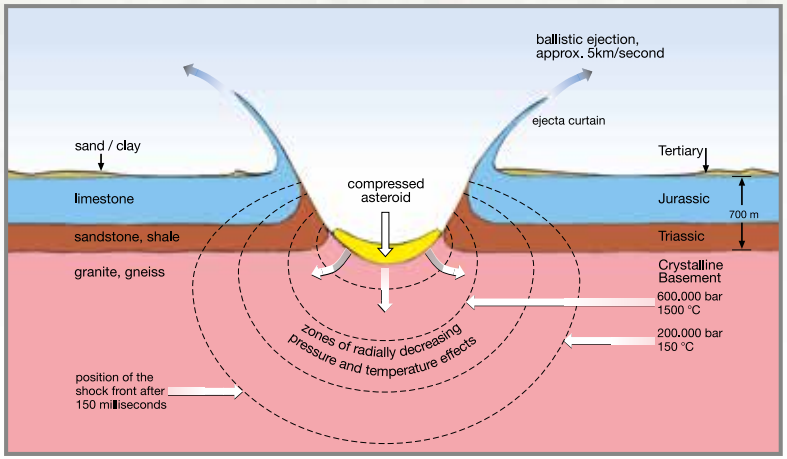
Scientists point out that the Ries was created by the impact of an asteroid. In everyday speech an asteroid is often referred to as a meteorite, although this is not strictly correct. Due to this common usage, however, we will also occasionally refer to a “meteorite” in our descriptions.



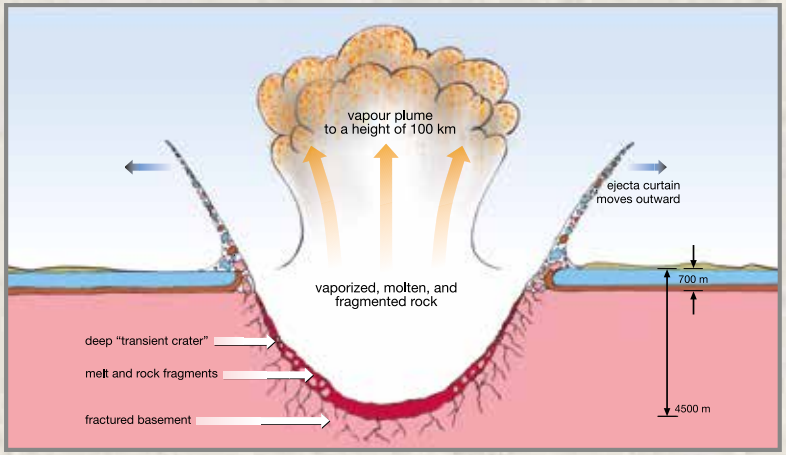
1 35 milliseconds before impact



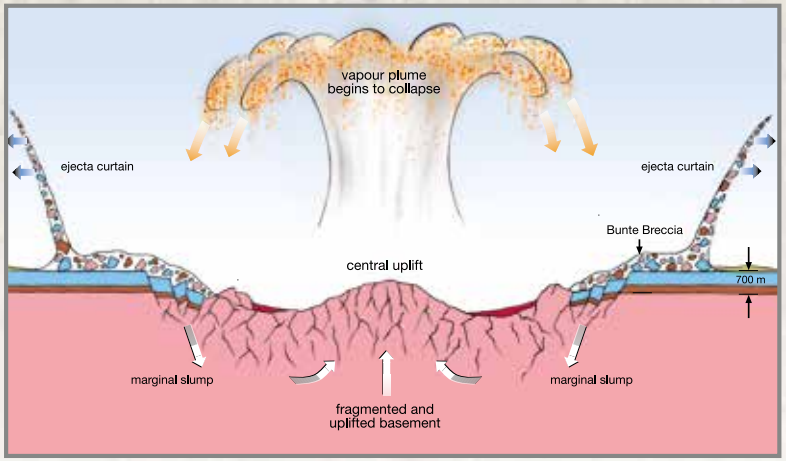
2 10 milliseconds after impact



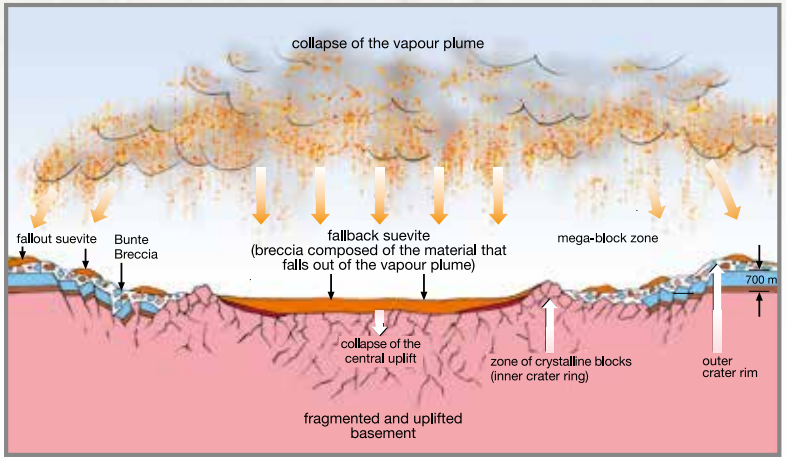
3 Beginning of crater formation after 60 milliseconds



4 Formation of the deep "transient crater" after about 10 seconds



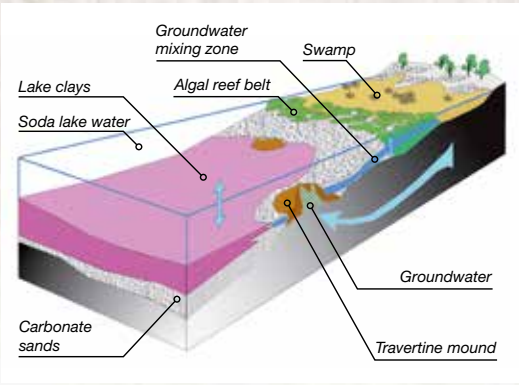
5 Collapse of the "transient crater" and deposition of ejected rock masses after 1 minute



6 End of crater formation and deposition of Suevite after 10 minutes

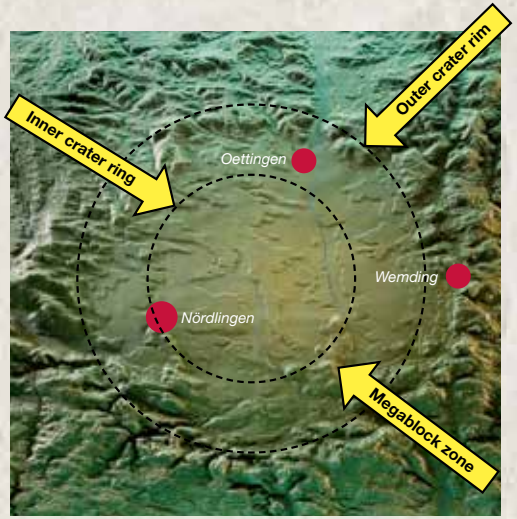
The Ries Crater becomes a salt lake

After the impact, a 300- to 400-meter-deep basin remains inside the inner crater ring. The basin is surrounded by the megablock zone, located between the inner ring and the outer crater rim. The impact had destroyed all life within a radius of more than 100 km, but then a nutrient-rich salt lake gradually begins to form in the inner crater basin and eventually extends out to the crater rim.



Cross section through the crater lake margin (G. Arp, University of Göttingen)

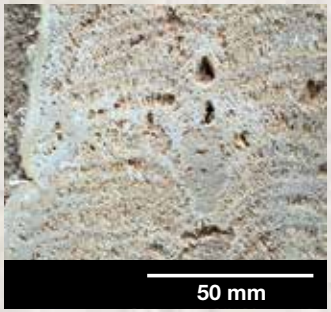
Within this lake, bituminous shales and clays are deposited. At the same time, dolomitic reefs (travertine) formed by green algae, calcareous spring deposits and fossiliferous calcareous sands are formed at the lake shore and in the shallow water covering the hills of the inner crater ring.



Model of the Ries Crater, vertical scale x 3.7 (Ries Crater Museum Nördlingen)

Consisting of small saltwater snails, insect larvae, brine shrimps and ostracods, the fauna is rich in individuals but poor in species, similar to modern salt and soda lakes in drylands. Only 2 million years later, just prior to its final silting-up, the Ries Lake turned into a habitable freshwater environment attracting numerous small mammals (bats, hares and hamsters) and birds (pelicans, flamingos, parrots).

The ram's horn snail Planorbarius from the final freshwater period of the Ries Lake. From Breitenlohe

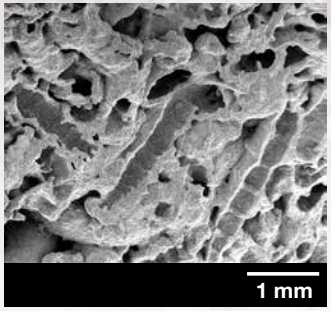


Green-algal reef dolomite formed by the filamentous alga Cladophorites. From Ehingen am Ries

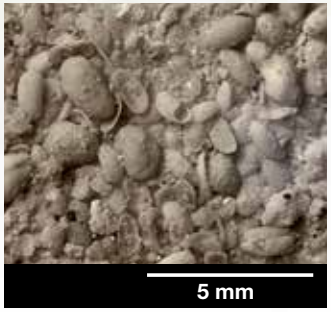
Fossilized skeleton of a millipede from the dolomitic green-algal reefs. From Ehingen am Ries

Accumulation of charophyte stems showing spiral ribbing. From northwest of Maihingen

The saltwater snail Hydrobia from fossiliferous calcareous sands of the lake shore. From northwest of Maihingen



Calcified pupal cases of flies from calcareous spring deposits. From Ehingen am Ries



Fossiliferous calcareous sand of the lake shore composed of millimeter-sized ostracods of the genus Strandesia. From northwest of Maihingen

The rock types of the Ries Crater

Suevite

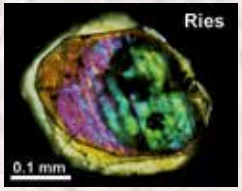
The cosmic catastrophe created a new rock type: Suevite (from the Latin suevia = Swabia). Suevite is a so-called impact breccia, which is composed primarily of fragments of granite and gneiss from the crystalline basement and of lumps of melted crystalline bedrock. Suevite was formed by a turbulent flow inside the transient crater and when the hot debris cloud above the crater collapsed and fell back into the crater and on top of the ejecta blanket.

The rock fragments within Suevite reveal that they were subjected to different degrees of pressure and temperature (impact or shock metamorphism). The special feature of Suevite is the presence of lumps of what had been molten rocks (”glass bombs“ also called Flädle).

Suevite from the Otting quarry

The mystery about the origin of the Ries crater was solved in 1960 and 1962 through the analysis of the Suevite that led to the discovery of the high-pressure forms of quartz, the minerals coesite and stishovite. Later, diamond was also found. These minerals, which are typical for impact deformed rocks, can be regarded as “fingerprints” of the cosmic bodies impacting the Earth. The term Suevite is used today for corresponding rocks occurring in all impact craters both on Earth, on the Moon and on other planets.

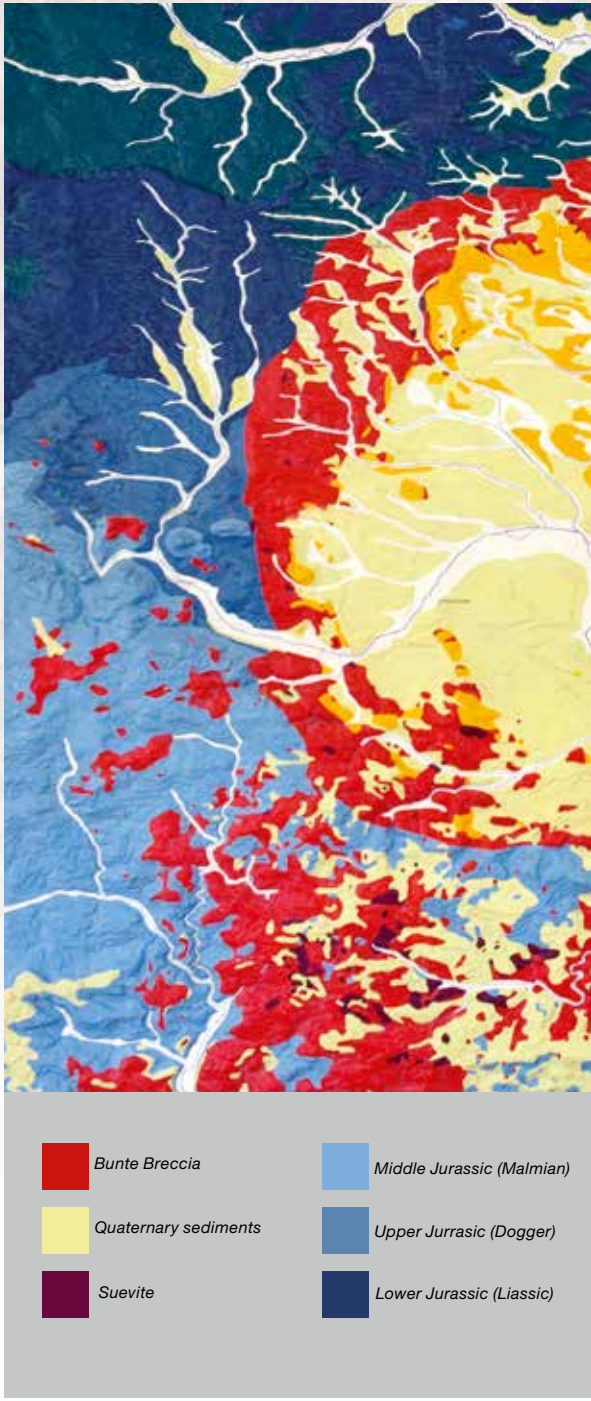
Edward Chao (left) and Eugene Shoemaker (right), who identified the Ries as an impact crater

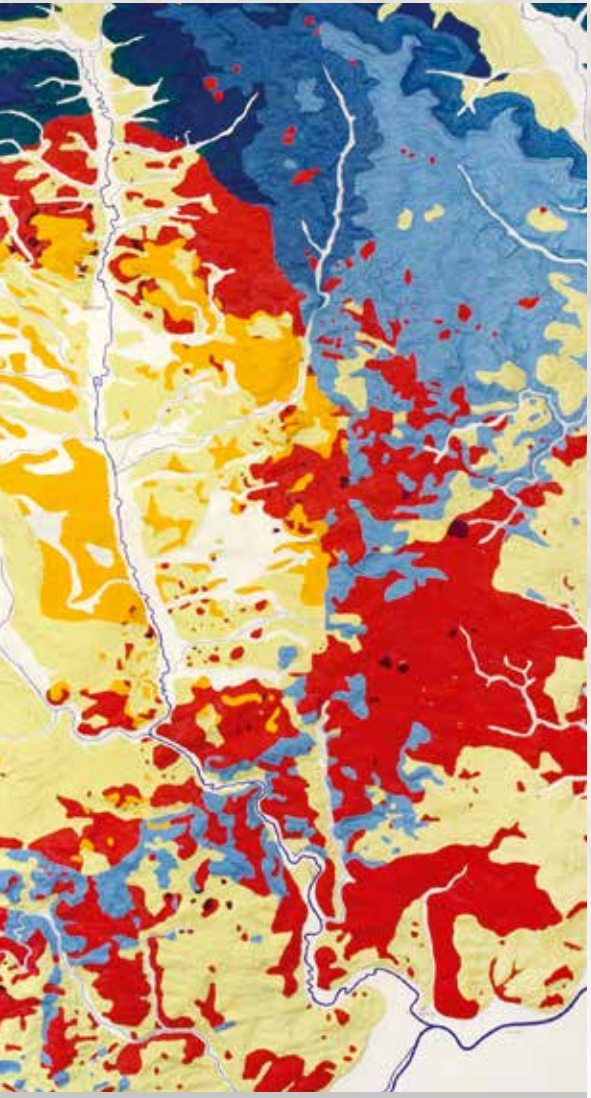


Impact diamond from the Ries crater

Bunte Breccia (a mixed breccia composed of rock fragments of different colors)

When the crater was formed, the various target rocks were shattered (fragmented), ejected, turbulently mixed and deposited outside the crater as a continuous blanket.



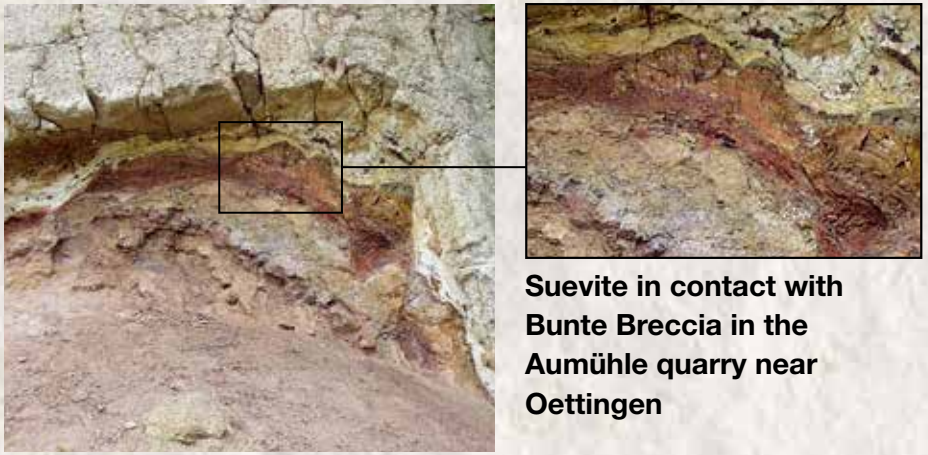


Keuper (Upper Triassic)

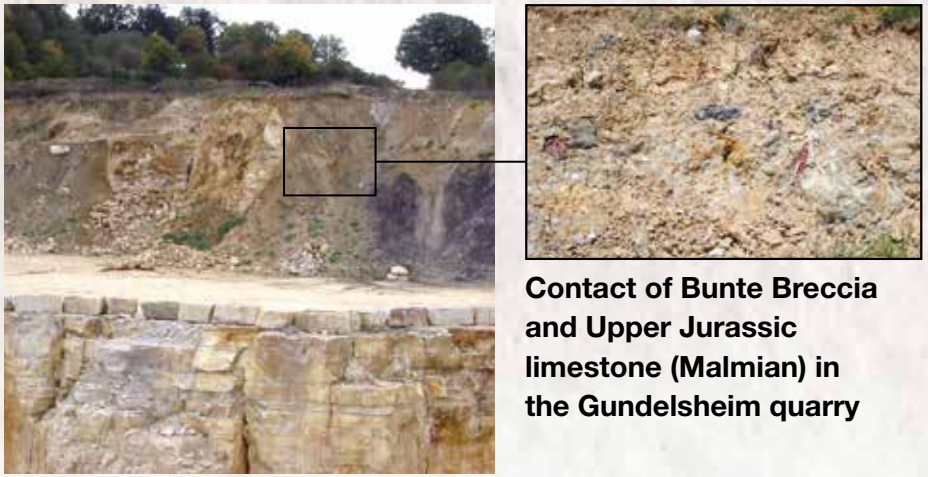
Ries lake sediments (Tertiary)

It consists of chaotically mixed rock fragments which originate from different bedrock formations. As these display different colors, the chaotic (polymict) breccia appears multi-colored. This led to the name “Bunte (multi-colored) Breccia.”

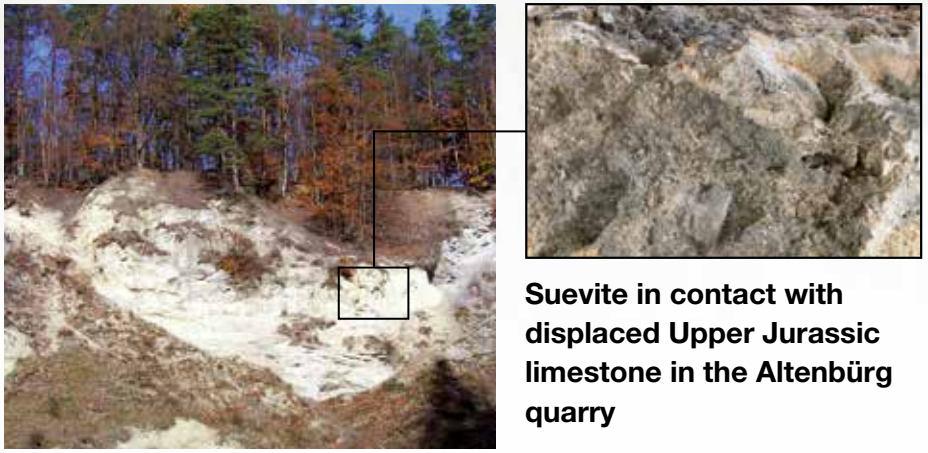
The proportions of the various rock components in the Bunte Breccia, which originate from different levels of the target rock section, vary considerably from place to place, and also in their size, ranging from fine dust to kilometer-sized blocks. Rocks from the lowest target levels (granite, gneiss, amphibolite) are white, grey, dark green, and reddish. Rock pieces from the upper Triassic have light-grey, green, and reddish colors. Together with various rocks of the Jurassic period (yellow to light-grey limestones, dark-grey clays, beige to red sandstones) and light-colored sands from the early Tertiary time, they provide an interesting interplay of colors.
All rocks of the Bunte Breccia were subjected to lower pressures and temperatures than the components in the Suevite, which formed a “hot” layer deposited on top of the “cold” Bunte Breccia.



Suevite in contact with Bunte Breccia in the Aumühle quarry near Oettingen



Contact of Bunte Breccia and Upper Jurassic limestone (Malmian) in the Gundelsheim quarry



Suevite in contact with displaced Upper Jurassic limestone in the Altenbürg quarry

Development of the Ries landscape

Chalk beech forest in the Jura

Beechwood forests on the high plains of the Jurassic

At the end of the last Ice Age the Ries was covered by tundra without forests. Then slowly a low birch forest developed, and over the millennia oak and hornbeam forests followed. That is how the present-day Jurassic forest originated. These deciduous forests have a rather wide variety of trees. Warmth and light, particularly in spring because of the lack of foliage, influence the flora of the beechwood forest.

Various stages of development, including the Ries impact, followed by sedimentation in the lake, erosion, and the blowing in of loess and sand, represent the basis for the development of the present-day landscape in the Ries region.

Pasque flowers on meager dry grasslands along the rim of the Ries Crater

Eurasian curlew in the Ries wetland area

In the Ries Basin, which is almost entirely devoid of forest, rivers and streams alternate with wetlands, extended fertile areas used for agriculture and lean grass areas along the western, southern and eastern crater rim. The vegetation reflects the properties of the local soils.

Traditional sheep farming in heath areas with a view across the Ries

Dry grassland and wetlands

Ries – a landscape full of variety

The dry grassland and juniper heathland traditionally provide pasture for migratory sheep farming. Numerous species of animals and plants otherwise threatened with extinction have found their home here. Extensive meadows and wetlands provide the necessary nutrition for the lapwing, the curlew, snipe and white stork.

Meandering river Wörnitz between Fürfäll- and Ziegelmühle

Dry-grassland flora with rock outcrops

Family of white storks on the church roof in Rudelstetten

Archeology and history of settlement

View across the Ries from approx 3,000 m altitude

The rather flat interior plain of the fertile Ries Basin and the favorable location at the intersection of different cultural spheres were excellent conditions for early settlement since the Middle Paleolithic Age and for the development of a self-contained cultural area.

The Ries is regarded as a treasure trove of pre- and early history and provides evidence for an impressively continuous settlement: from the Paleolithic Age through the Roman and Alemannic eras, through the Middle Ages, and into early modern times. The nobility, monasteries, and churches all created a cultural variety with many different elements. The names of towns and villages ending with “-ingen” and “-heim” bear testimony to the Alemannic and Franconian settlement history of the Ries. The history of settlement of the Ostalb District, which extends into the Ries, is closely associated with the history of the Nördlinger Ries.

This 9-cm-long hand axe from the foot of the Rollenberg hill near Großsorheim is regarded as one of the oldest artifacts of the Ries area.

Entrance to the Great Ofnet Cave (depth approx 17 m)

Early Celtic chief’s residence on the Ipf

Reconstruction of skulls from the Ofnet Cave in the City Museum in Nördlingen

Roman flautist from Holheim

Excavation of the remains of the Celtic settlement on the Ipf

Villa rustica (Roman farmhouse) near Holheim, 2nd/3rd century AD

In the Celtic Hallstatt period an important chief’s residence was developed on the Ipf, a butte belonging to the Swabian Alb. This residence represents a center of the whole cultural province, with its influence certainly extending right into the Ries plain. The Ipf mountain is one of an exclusive set of about 20 important former Celtic residences in Central Europe.

It is truly justified to call the Ries and the surrounding countryside the land of castles: Still preserved fortresses, castles and castle ruins bear witness to the enormous wealth of the former lordships, as rarely found elsewhere.
Especially noteworthy are the Harburg ①, one of the largest, oldest and best preserved castles in southern Germany, Baldern Castle ②, the ruins of Niederhaus Castle ③, and also the Residence at Oettingen ⑤ with its precious stucco work and famous banqueting hall. Among the most important heritage sites are the former Benedictine monasteries of Auhausen and Mönchsdeggingen ⑥, the Cistercian convents Kirchheim ⑧ and Kloster-zimmern, the Carthusian monastery at Christgarten ⑨ and the city monasteries of Nördlingen, Donauwörth ⑦ and Wemding ④, together with numerous churches in the villages and towns, most of which feature valuable decoration.

Harburg Castle, one of the largest castles in Southern Germany

Baldern Castle

Niederhaus castle ruins

Maria Brünnlein, Wemding

Residence castle Oettingen

Church in the monastery, Mönchsdeggingen

Heilig-Kreuz Monastery, Donauwörth

The convent of Kirchheim

Carthusian Monastery, Christgarten

The former Free Imperial City of Nördlingen. It is possible to walk the whole way around the Old City on the intact city wall.

Market Square, Bopfingen at the Ipf

Market Square, Wemding

Cities and towns were of special significance for the development of the cultural environment:
Former Free Imperial Cities include Nördlingen ⑩, Bopfingen ⑪, and Donauwörth (until 1608).
Oettingen is a former noble residence town, and Wemding ⑫ has belonged to Bavaria since 1467.
The castle and town of Harburg fell to Oettiingen in the mid-13th century and was a place of noble residence from 1493 to 1549.

St. George's Church with the Daniel tower in Nördlingen

Geology and architecture

The Suevite quarry of Altenbürg

Suevite, which was created by the Ries impact event, has been used as building stone in the Ries and the surrounding areas since Roman times. Especially in the Middle Ages it became the building material for numerous buildings in Nördlingen and its surroundings. St.George's Church ①, for example, with its tower called Daniel, is built almost entirely of Suevite. It is not known exactly whether the building material came from just one quarry, the quarry of Altenbürg.

Baldinger Tor (Gate), Nördlingen

Deutsches Museum (German Museum), Munich

The use of Suevite

Suevite has not only been used for the construction of churches, but also for other buildings of non-religious character in the region around the Ries and beyond. In Nördlingen parts of the City Hall, the Baldingen Gate ② and other gates of the city wall, as well as parts of the city fortifications (e.g. the Berger wall), have been built with this material. In the area around Nördlingen, Suevite was used at Harburg and for a number of village churches. In Munich Suevite building stones can be admired at the German Museum ③ and the former Royal

Bavarian Traffic Ministry. Even Berlin hosts several Suevite buildings.

Outdoor staircase of the Nördlingen City Hall

Of special importance is the use of Suevite for decorative purposes. Examples include parts of the outside staircase of the Nördlingen City Hall ④ (built in 1618 by Master Builder Wolfgang Walberger in the late Gothic and Renaissance styles),

City Museum in Nördlingen – pillars of Suevite

Portal of Suevite

part-relief works (Schneidt'sches Haus), numerous archways on buildings such as the Sparkasse, Schneidt'sches Haus and Museum "augenblick". Many of these arches, however, have presumably been painted over (e.g. Reihl´sches Haus, Alte Schranne).There are advantages but also problems in using Suevite in construction, because of its special composition. The stone is actually a sedimentary rock formed as a poorly consolidated material which solidified through time (diagenesis). Its stability has been described by Weinig (1987): "The porous, coarsely fragmenting rock with irregular cracks and altered zones is only moderately stable and has therefore a variable and limited durability." On the other hand, this material is easily shaped by hand tools.

Suevite is susceptible to weathering: Oriel of the Nördlingen Town Hall

The main problem is its susceptibility to weathering. Weathering damage can occur in one part while adjacent parts remain more stable. Therefore the mechanical strength and the presence of unstable minerals in the groundmass of Suevite are of special concern. The latter react very sensitively to changes in environmental conditions and can therefore easily weather out. This results in the deterioration of the Suevite building stone.

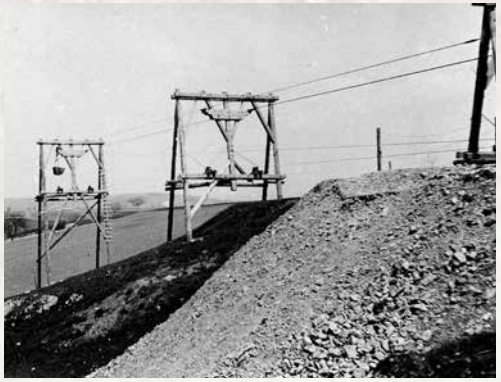
The economic wealth of the Ries

Suevite

Although Suevite has been used as a unique building material and as raw material for stone masons and artists, its main use is now in the cement and mortar industry as a value-adding component for special cement products. These are used for the restoration of old buildings and for natural stone floors.

Baptismal font made of Suevite in the Church of the Trinity at Haunsheim

Transport of Suevite from Bollstadt to the Bayerische Trasswerke AG in Möttingen by means of a narrow track railway, 1919



After 1924 the transport to Möttingen was done by cable rail

Agriculture

The bedrock formations, the resulting soils and the climate have made the Ries the “corn basket” of Bavaria. Cereals have been planted in the Ries since the 6th century BC. Since about 1800 root crops and fodder plants have also been cultivated. (www.museumkulturlandries.de)

Farming in the Ries is focused on maize, sugar beet and potatoes

A cart loaded with goods on the way to the market. Scene from the Museum KulturLand Ries in Maihingen.

Setting up sheaves of grain in the form of “almonds” in the Ries 1935

Aeolian (wind-blown) sand/quartz sand

This high quality sand is found near Laub and Gosheim. It is often used for the construction of sports facilities because of its special physical properties (round, smooth grains) and is also recommended for sports stadiums, golf courses and riding facilities.

Quarrying of quality sands in Laub

Use of Ries sand in a horse-riding facility

Bunte Breccia

This unique formation containing a lot of limestone and clay provides a basis for the brickwork, limestone and cement industry. Already in the 19th century the Bunte Breccia was used and processed by this industry. Today the latest generation of such building materials is produced from Bunte Breccia with the most advanced industrial techniques.

Production plant at the Märker Zement und Kalk GmbH, Harburg

Bricks – natural building material for optimum living standards

Geopark Ries – an important training site for space missions

In August 1970, NASA conducted geological field training in the Ries crater for the astronauts of the Apollo 14 and 17 missions.
The task of the German geoscientists involved in this training was to familiarize the astronauts with the particular rock types of an impact crater. This training course provided an important basis for the later retrieval of rock samples from the Moon. The astronauts trained in the Ries were therefore able to recognize impact rocks at lunar craters and to take samples from specific impact formations.

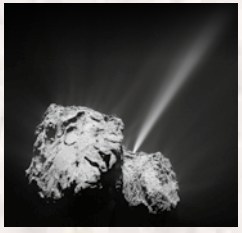
American astronauts carried out field training in the Ries for the Apollo missions

Suevite from the Ries

A sample of Moon rock from the Apollo 16 mission on display in the Ries Crater Museum, Nördlingen

Apollo 14 emblem

Dwarf planet Ceres, orbited by the space probe Dawn from 2015 to 2018



Comet P67/Churyumov-Gerasimenko, studied by the ESA space probe Rosetta

In 2011, the scientific team of the **NASA Dawn mission** visited the Geopark Ries to familiarize themselves with the geological structure of an impact crater.
In 2018, the **OSIRIS scientific camera team of the ESA Rosetta mission** carried out geological field studies in the Geopark Ries so that they could better evaluate the mission's data. Further visits are being planned.
Astronauts of the European Space Agency (ESA) have also carried out several geological field-training sessions (2017/2018) and have scheduled additional training.

Center for Ries Crater and Impact Research Nördlingen (ZERIN)

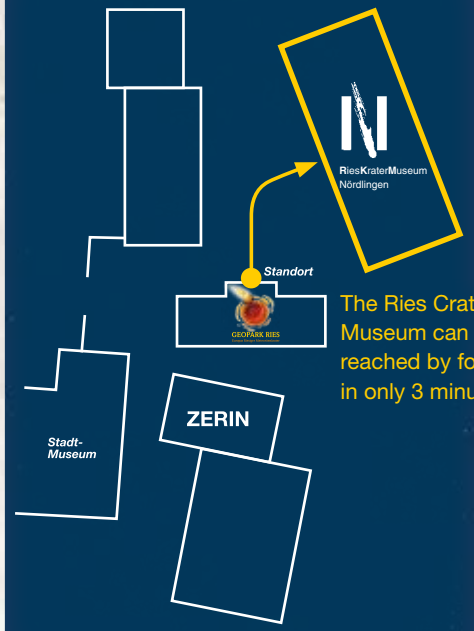
Since 1998 the City of Nördlingen has operated the Center for Ries Crater and Impact Research Nördlingen (ZERIN) not far from the Ries Crater Museum. A research, training and documentation center supporting the Museum's work, ZERIN provides research facilities for visiting scientists, seminar rooms, a technical library and an extensive archive of rock samples from the Ries and other impact craters. Scientists from all over the world utilize ZERIN's facilities, knowledge and resources for their own research. ZERIN offers a scientifically valuable and otherwise rarely available resource – core samples from drill holes in an impact crater to a depth of 1206 meters.

ZERIN, Vordere Gerbergasse 3, Nördlingen

Archive of drill-hole core samples

The Ries Crater Museum in Nördlingen

As the "Museum in the Crater" the Ries Crater Museum provides a fascinating view of the "Ries catastrophe" – explaining its cosmic connections and revealing its consequences that are still visible today. A highlight is an original Moon rock brought back to Earth by Apollo-16 astronauts.



The Ries Crater Museum can be reached by foot in only 3 minutes.

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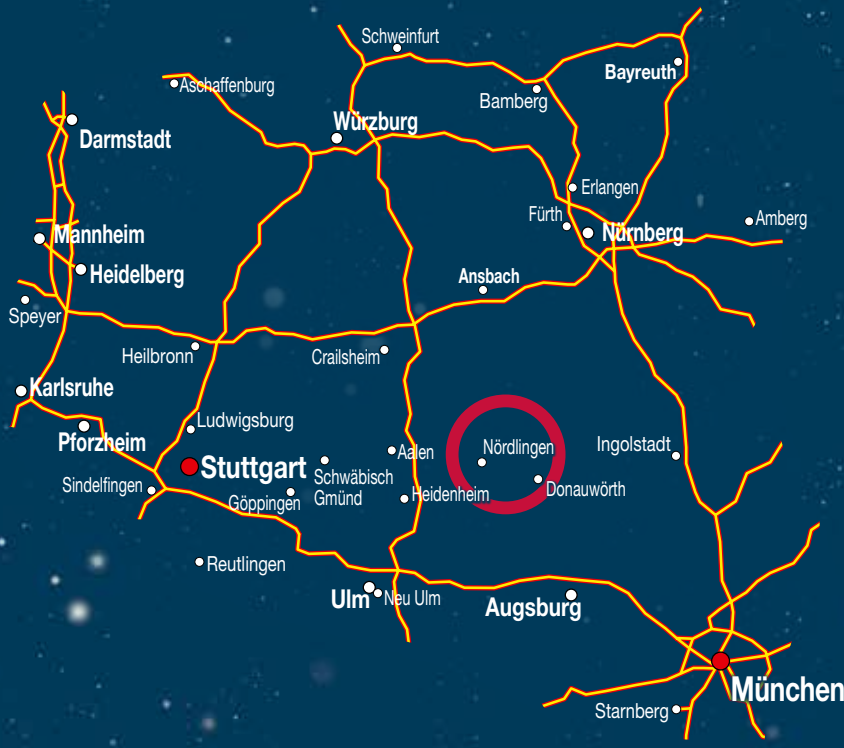
Location in Southern Germany



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