

The Ries meteorite crater – a unique geological feature in southern Germany

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The lecture began by comparing the surface of the moon with that of the earth and pointing out that the reason that the moon is badly crater-marked is because of the number of collisions there have been with meteorites. These are believed to originate from the asteroid belt, a region between Mars and Jupiter, where it seems a planet disintegrated and fragments of it now follow an ellipsoidal orbit around the sun and frequently shower the inner planets with meteorites.

The reason why the earth is not so badly marked is because, even though collisions have been relatively as frequent as on the moon, the earth's crust is dynamic and most craters have been destroyed by tectonic processes or erosion. Well-known examples of craters on earth are apparent near Quebec, the Western Territories of Australia and Arizona and the Ries crater situated in the rectangle between Regensburg, Stuttgart, Nuremberg and Munich in Southern Germany. It was this latter example that the speaker wished to discuss.

The Ries crater is almost perfectly round with a diameter of approximately twenty-four kilometres and is spectacularly different to the surrounding uniform landscape of the Swabian and Franconian Jura Mountains (otherwise known as Alb) in that it is a flat fertile plain. For nearly 200 years German and foreign scientists tried to unravel the mystery of the Ries formation, many theories were formulated, including most popularly that there had been a Ries volcano which had long since disappeared leaving as its only trace its ejecta masses.

Crater rim rocks and the steep sides of Malmian limestone quarries within the crater show signs of some great destruction. Rocks are rarely larger than head-size and the regular, near-horizontal layering that is usually characteristic of Jurassic limestones, has totally disappeared. The

rock itself is so completely fractured it can only be used for rubble for road building. In the region of the rim completely illogical layering of the rocks is found; rocks known to be older than the Malmian limestones are lying on top. A catastrophe of tremendous proportions must have been responsible for the inversion of the rock layers in such a manner and where the older ejecta masses overlie younger rocks the area of contact is striated, polished, scarred, scratched or flawed. These features had been explained, in past centuries, as the result of a Ries glacier.

In 1960, however, Professor Shoemaker, an American who had been working on comparisons between the effects of meteoritic impacts and artificial nuclear explosions, sent samples of Ries rock to his colleague, Dr Chao, in Reston, Virginia. Using X-ray techniques, coesite was found. This is a high pressure modification of quartz needing up to 300 kilobar for formation and is considered to be incontestable evidence of meteoric collision. The speaker showed slides showing the similarities of Ries quartz grains with lunar samples.

Much research has since been carried out on the Ries crater and scientists now conclude that the impact occurred some 14.8 million years ago and that the meteorite had a diameter of between 800 and 1200 m and hit the surface at a speed of approximately 20 to 60 km per second. The energy released is comparable to fifty 100 megaton bombs exploded simultaneously.

With the help of a series of diagrams, the speaker explained one theory of how the meteorite pierced the atmosphere and hit the Tertiary surface of the Alb. Milliseconds before impact the air between the meteorite and the earth was compressed and intensely heated, lateral release of the pressure consequently melted and forcibly expelled a thin layer of the earth's

surface. A fountain of small glass drops was jetted out and evidence of these are found in parts of Czechoslovakia! The meteorite then struck the earth and penetrated approximately 700 to 1000 m into the crystalline basement. The body itself and adjacent rock were immediately compressed into a quarter of their original volume, and within only a few seconds a deep basin-shaped primary crater was formed. Compression waves, many times the speed of sound, were propagated into the surrounding rocks, spherically.

After only two seconds the main ejection phase began. First younger rocks and then older ones were discharged in an inverse sequence to the original layering. A thorough mixing occurred in some regions creating the Bunte Trummermassen which covered the whole of the Ries foreland. Tons of Malmian limestone megablocks flew through the air to distances of up to 60 km away.

Some of the meteorite's kinetic energy was converted to heat, the rocks reaching temperatures of several thousands of degrees. The meteorite and adjacent rock vaporised and an incandescent vapour cloud left the crater. Melted crystalline basement fragments, dust and a small portion of sedimentary rocks mixed and were deposited on top of the Bunte Trummermassen with inclusions of deformed glass bodies. This on cooling created the rock 'fallout': suevite. A similar rock found in the crater basin with fewer glass inclusions is believed to never have been highly ejected and is termed 'fallback' suevite.

The compressed rock of the crystalline basement sprang back causing an upward movement and intense mixing of the crystalline rocks. This resulted in the central part of the primary crater being filled and the rim sank creating an inner ring of elevations.

The ever climbing gas and vapour clouds caused deluge-like rainfalls. Immense mud torrents raged within the crater and the crater was filled with boiling mud. Ejected rock masses had disrupted the drainage systems of the region and soon the crater became filled with water – pouring in as rivers over the rim and seeping in from the groundwater as well as from the torrential rainfall. The Ries lake had formed and is believed to have had no outlets and, due to high evaporation and ground solutions, was very rich in salts and had a high soda content. Very few well adapted water

plants and animals could settle in and around the lake. Almost immediately sedimentation began, firstly of coarse, clastic rocks then with finely layered silts and marls. After two million years or so a change in climate and larger inflowing streams changed the water to predominantly fresh water and finally the lake silted up. Brown coal deposits in eastern Ries are evidence of swamps and their plant remains.

The speaker went on to show slides of fossils to be found in the Ries crater. Green algae, such as *Characeans* and *Cladophorites*, were largely responsible for the construction of bulky calcareous build-ups at the lake edge. The snail, *Hydrobia trochulus* is found in tremendous numbers and is an indication of the high salinity of the Ries lake as are the rock building ostracods, *Amplocypris risgoviensis*. In contrast the presence of the snail, *Planorbarius cornu mantelli* in later times, indicates a more fresh water environment. Numerous fossil finds of bird bones, feathers and eggs document one of the best early Tertiary bird fauna in the world and many mammals have been identified from various outcrops.

The present form of the Ries was reached towards the end of the Tertiary and during the Ice Age was subjected to alternating cold and warmer spells. In the course of the last cold spell the Ries was subject to similar conditions to the modern day Arctic. Summer vegetation consisted of hardy cold-steppe shrubs and herbaceous plants but no trees. One region of the crater is well known for finds of mammoth and wild horse teeth and skeletons of woolly rhinoceros.

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