A large crater field recognized in Central Europe

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A Large Crater Field Recognized in Central Europe

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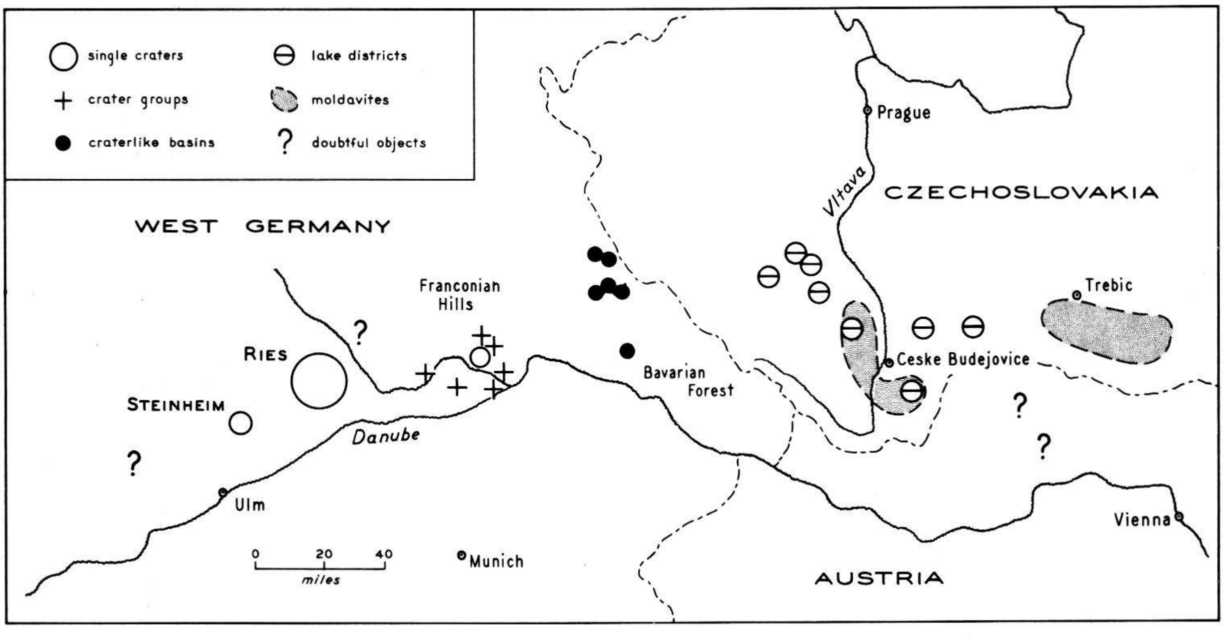
Nachdruck aus der Monatszeitschrift "Sky and Telescope", Vol. 52, Nr. 6, Juni 1975, Cambridge/Mass., mit freundlicher Genehmigung des Verlages.

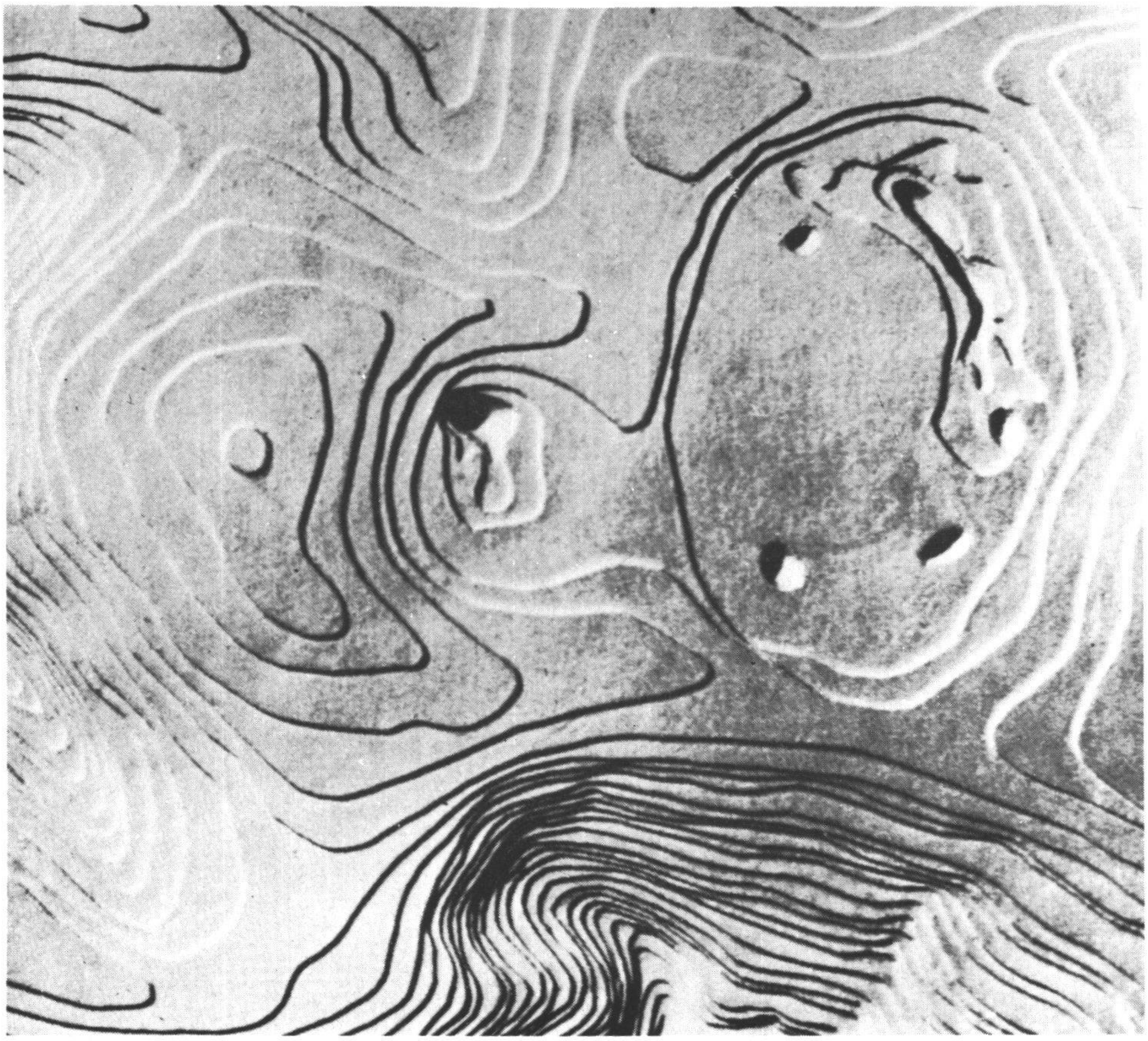
For a century, geologists have been increasingly interested in the Nördlinger Ries, a flat-bottomed nearly circular basin 20 to 24 kilometers (12½ to 15 miles) in diameter, near the south German town of Nördlingen. In 1904 it was suggested that the Ries might be a huge fossil meteorite crater, and since 1965 such an origin has been generally accepted.

The Ries is not an isolated structure. Some 42 km. (26 miles) southwest of its center is the Steinheim Basin, about 100 meters (330 feet) deep and 3.5 km (2.2 miles) across. It was first identified in 1933 as an impact crater. In 1955, small secondary basins in the Nördlinger Ries were discovered by seismic prospecting methods. Then, in 1969 H. Illies described three adjoining circular structures – Pfahldorf, Sornhüll, and Mandelgrund, with diameters of 2.5, 1.5, and 1 km., respectively. These easily recognizable landscape features lie east of the Ries, in the southern Franconian Hills.

An intensified search for other impact craters in this area soon led to the discovery of dozens of circular formations one to three km. in diameter. Often these occurred in swarms, the so-called Hemauer Pulk, for example, consisting of at least 14 individual craters.



Stretching about 250 miles across Central Europe, the chain of features appears to have originated in a single catastrophic event nearly 15 million years ago, when fragments of a gigantic meteorite descended slantwise through the atmosphere from east to west, dropping on Czechoslovakia and southern Germany. The illustrations with this article, except for the last two, were furnished by the author.



This relief model of the Sausthal crater in the Franconian Hills (Frankenalb) is to a scale of 1:30,000. From E. Rutte, in the journal *Oberrheinische-geologische Abhandlungen, 23,* 101, Karlsruhe, 1974.

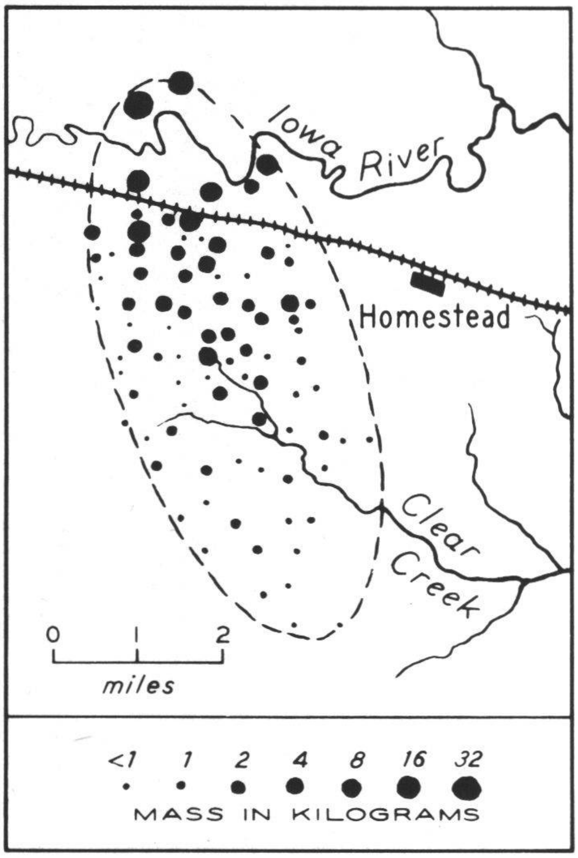
From the beginning, it was suspected that these craters might be related not only to the Ries but also to the neighboring strewnfield of moldavites (glass meteorites or tektites) in Czechoslovakia, which have the same age as the Ries, about 15 million years. As a result, surveys have been pushed farther west with surprising success, notably by E. Rutte and his collaborators at the Würzburg Institute of Geology. Everywhere signs of impact craters were found, some easy to discern as in the case of the Sausthal crater, but others detectable only by thorough geological field work.

By early 1975, the following picture had emerged. Stretching over southern Germany, southwestern Czechoslovakia, and Lower Austria, there is an area at least 400 km. (250 miles) long and 50 to 120 km. (30 to 75 miles) wide where hundreds of impact craters exist. In the western part of this region, these craters are generally two or three km. across, in the east typically one km.

Characteristic of all of these newly discovered impact structures is a kind of rock recognized in 1970 and named alemonite (after the river Alemona). Found throughout this vast area, it occurs especially in the troughs close to craters, as well as between clusters of craters.

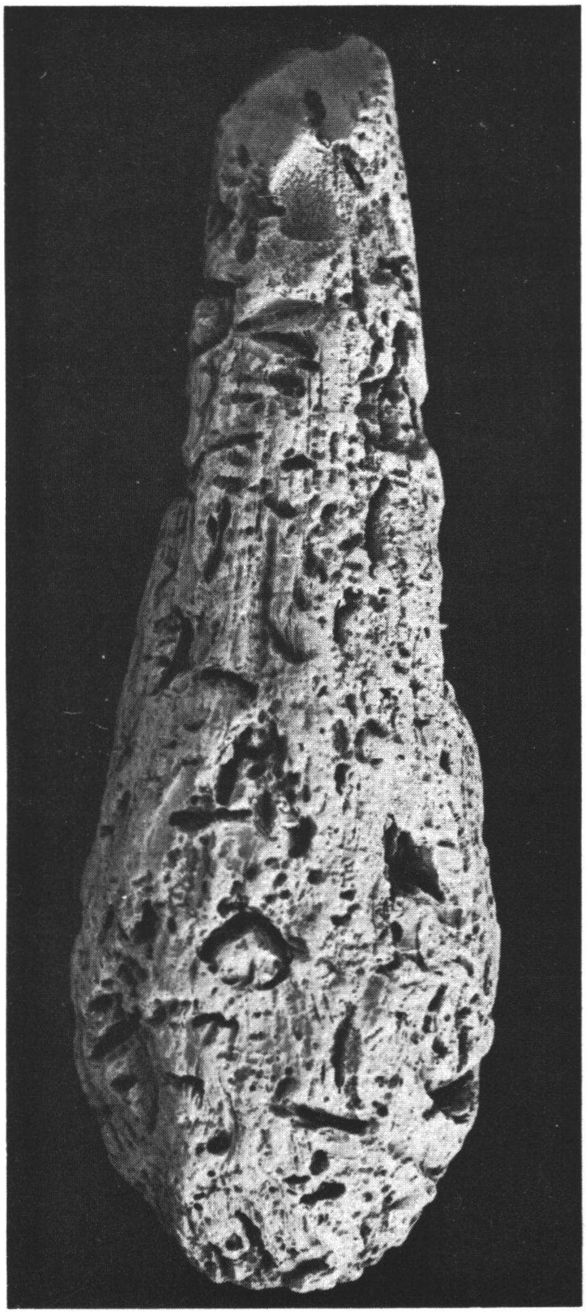
Alemonite resembles suevite, a strongly shocked breccia consisting of crystalline rock and glass fragments embedded in a groundmass. It differs from suevite in the total vitrification of the sediments it contains. The alemonites were formed at the moment of meteorite impact by the violent smashing of surface rock, to a depth of 20 or 30 meters.

Chemical analysis of an alemonite from the Kehlheim area gave these percentages, expressed as oxides: SiO_2, 98; Al_2O_3, 0.4; Fe_2O_3, 0.2; TiO_2, 0.2; oxides of alkali metals, 0.3. The very high proportion of silica cannot have been derived from the impacted sandstones of that region, and therefore a cosmic origin for some of it must be considered. And, in fact, a characteristic mineral of the Kehlheim area is tektite glass, like the roundish pea-sized moldavites found in Czechoslovakia. Unlike the widely distributed alemonites, the moldavites are concentrated two sites, near Česke Budejovice and Trebič (see map on page 25), where they occur in great numbers.



▲
Each dot marks where a stony meteorite fell during the Homestead, Iowa, shower of February 12, 1875. Coming from the southeast, the heavier stones flew farther, forming the pattern sketched here by O. C. Farrington.

A $2\frac{1}{3}$-times enlargement of a moldavite from Netoliz in southern Bohemia shows its broken and pitted surfaces. Tektites are glassy, with lower refractive indexes than manmade glasses. Photograph from the Smithsonian Institution, Washington. ▶



The impact localities we have mentioned form an elliptical strewnfield, reaching from the Steinheim Basin in the west fully 468 kilometers to the most easterly site of moldavites in Czechoslovakia. In the middle of this chain lies the Nördlinger Ries, which must have played a decisive part in the origin of this large region of craters.

We can reconstruct the scenario as follows. The Ries catastrophe of 14.8 million years ago was obviously caused by a giant meteoritic body, which as it approached the earth broke up into a swarm of fragments. The breakup could have been caused either by passage through the earth's Roche limit, or by atmospheric resistance acting on a structurally weak configuration.

Ordinary meteorites often show just such fragmentation, landing as a shower of stones or iron meteorites in a elliptical strewnfield. The more nearly horizontal the descent, the more elongated is the scatter ellipse. Moreover, the largest fragments fly farthest, while the smallest reach the ground first. In this way, it is easy to deduce the direction of flight.

The meteorite swarm causing the Ries catastrophe came from the east. The main mass, perhaps a kilometer in diameter and weighing 2 x 10^9 tons, together with a second large part, flew farthest west to form the Nördlinger Ries and Steinheim Basin. The medium-sized fragments descended, assorted in size, across the Franconian Hills, the Bavarian Forest, and western Czechoslovakia, producing meteorite craters that were progressively smaller from west to east. The smallest fragments, subject most of all to atmospheric drag, were the moldavites that went down far to the east in central Czechoslovakia.

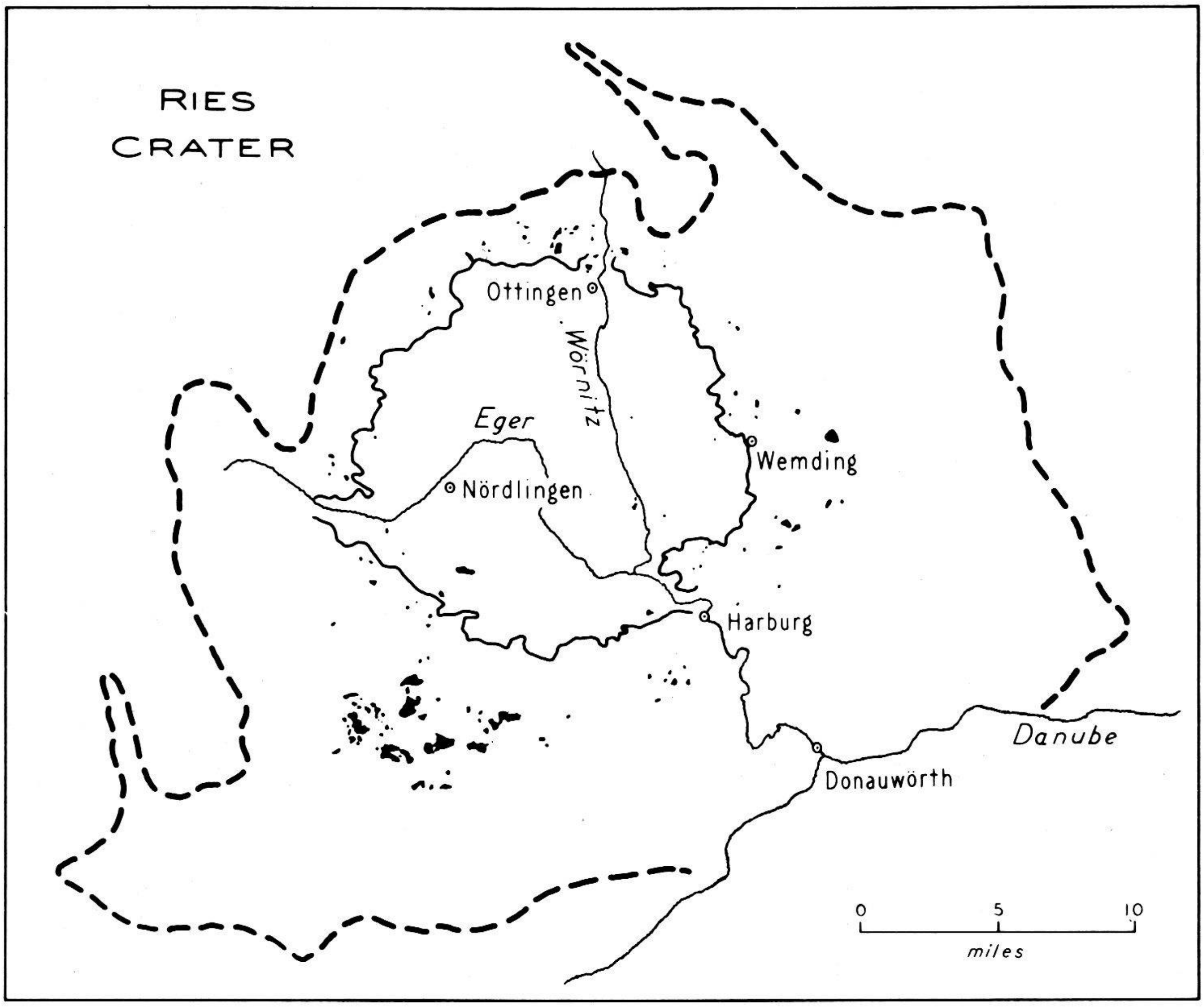
It must be admitted that certain individual craters in southern Germany are asymmetrical, leading some authors to conclude that the meteorite swarm came from the north-northwest. However, these localities are all on the northern side of the Danube River Valley, where the terrain slopes downward to the south. Hence the asymmetry of these craters is probably due to meteorites landing on an inclined surface, rather than to the direction of motion.

The origin of the moldavites has been controversial but can be explained if we assume that the huge meteoroid causing the Ries catastrophe consisted of tektite glass, which normally is very rich in silica. When this meteoroid formed in space, rapid cooling of its outer layers produced an onion-skin pattern of cracks. Later, as the meteoroid began to fragment, these outer layers peeled off and descended slowly through the earth's atmosphere as small objects, while the main mass continued on its trajectory. Such a model seems required to account for the large extent of the Czechoslovakian moldavite strewnfields, as well as for the properties of other tektite fields found in Africa, North America, Indochina, and Australia.

According to this model, the small moldavites are the only material preserved unchanged from the giant glass meteoroid, whereas the larger fragments on striking the earth exploded and produced impact craters. In this way, a small fraction of their substance mixed with terrestrial surface rocks. As we have suggested, this may have been the origin of alemonite and suevite with their high silica content.

The study of meteorite craters is fairly new, attention having been directed to Barringer Crater in Arizona at the beginning of this century. At first, only single craters were discussed. The discovery of the Henbury craters in 1930 offered the first example of a crater group. By 1955 about 75 craters in 50 localities were known, whereas today the corresponding numbers are about 1,000 and 216.

That is, emphasis has now shifted from single craters to crater clusters. This change is not solely due to the discoveries in Central Europe, since new groupings have been found in many parts of the world. For example, the crater landscape of Quillagua in Chile consists of at least four clusters containing a total of about 100 individual craters. It can hardly be doubted that crater clusters are the rule and isolated craters the exceptions.



The thin inner line is the Ries crater rim; the thick outer line is the limit of breccia. Suevite patches are black in W. von Engelhardt's map.

Clearly, impact structures are more common on earth than most astronomers believed a few years ago. During its early history, our planet was probably covered by craters much as the moon, Mercury, Venus, Mars, and the Martian satellites are today. Most of the terrestrial craters have been destroyed by erosion, and the surviving examples often can be established only by modern methods of investigation. As these techniques improve, and especially as understanding grows of the geological and mineralogical effects of impact, there should be a spectacular increase in the number of known meteorite craters.