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From Volcano to Impact Crater: Shifting a Paradigm

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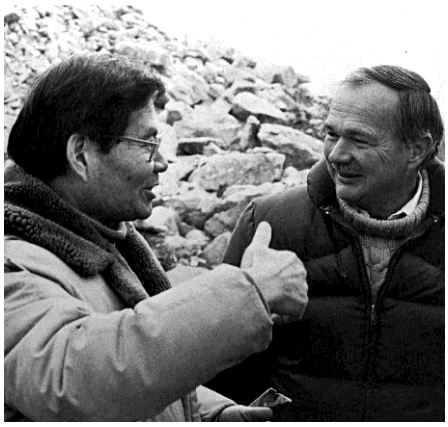
During much of the 20th century, geologists in Germany struggled to understand two conspicuous geological structures in southern Germany: the Steinheim Basin and the much larger Nördlinger Ries (internationally better known as Ries Crater). What at first glance looked like the product of volcanic activity turned out to be confusingly complex and puzzling. Huge amounts of rock rubble, from the finest rock flour to house-sized blocks, covered the landscape, apparently the product of two gigantic explosions. But nowhere else on Earth did volcanism have such an effect and where were the volcanic rocks anyway? There was no lava, but only a small amount of "tephra" around the Nördlinger Ries, which was found locally on the explosion debris and was therefore apparently deposited later, after the actual explosion. The more research was done, the more confusing the "Ries Problem" became.



Edward Ching-Te Chao (left) and Eugene Merle Shoemaker (right) discussing high-pressure metamorphism at Ries Crater in the late 1960s (photo courtesy of Dr Wulf-Dietrich Kavasch).

In 1961 the mystery was finally solved by the discovery of high-pressure minerals by US geoscientists, Eugene Merle Shoemaker (1928–1997) and Edward Ching-Te Chao (1919–2008) and the volcanic explanation was replaced by the interpretation of the two structures as impact craters (Shoemaker & Chao 1961). The community of local German Ries Crater geologists was, however, largely unconvinced. And so, on 17 December 1961, tumultuous scenes occurred at a geological meeting, the traditional Thomas-conference in Tübingen. The local professor of mineralogy, Wolf von Engelhardt (1910–2008), had announced a talk about the impact nature of Ries Crater as deduced from mineralogical evidence. Meanwhile, his geological colleague Georg Wagner (1885–1972), an influential advocate of a vast central volcanic explosion had tried to organize an opposition of Ries Crater experts. This, Wagner endeavoured to achieve with the help of the young chairman of the conference session, Helmut Hölder (1915–2014), who recollected the dramatic event of December 1961 in an interview:

> "Shortly before this meeting, Prof. Georg Wagner […] said to me, Mr Hölder, he said, Mr. von Engelhardt will be speaking about his tiny nickel spherules. After he has finished his talk, you are going to give the first word to—that was an order, because I was the much younger one—then you give the first word to my friend [Richard] Löffler [1886–1967]. […] and he will tell Engelhardt what is necessary, and then you give the word to me. And so it happened. Indeed, Engelhardt gave his talk about nickel spherules in suevite, and then I opened the discussion and said, as I was told, as desired by the old

> Georg Wagner: “Maybe Prof. Löffler has something to say concerning this talk, if you please.” Then Mr. Löffler stood up and said: “Yes, after I have heard this talk, I now think, that we shall need to think again.” And that was a big blow for my Georg Wagner. I still see him before me, as he collapsed horrified. And then, of course, I said, ehm, and now, maybe Prof. Wagner wants to say something. Wagner, in shock, struggled to his feet and said: “I cannot follow here, I don’t believe it. For 50 years, I have walked the Ries with my students and I have never seen a sign of that meteorite.” Then, in the last row of the completely occupied lecture hall [...], Prof. [Heinrich Friedrich] Siedentopf [1906–1963] got up, who was then the astronomer in Tübingen, and said: “Colleague Wagner, from this meteorite you cannot have found anything, because there is a boundary level in the impact energy and if the force of the impact, because of the size of the meteorite, is larger than this boundary level, then it will melt and cannot become fossil.” This was an immensely thrilling discussion then; a dramatic discussion […] it had been one of the most dramatic experiences of my career. I am still happy that I have experienced it so directly, even actively as chairman. It had been the first time in Württemberg that this meteorite was publicly talked about” (Hölder in an interview; see Kölbl-Ebert 2015: 197–8).

One of the greatest factual obstacles for the acceptance of Ries Crater and Steinheim Basin as impact craters was that the intense geological research at these puzzling localities had produced so many details that investigators completely lost the feel for balancing these data in a more general, pan-European or even global setting. They, as a German proverb says, could “no longer see the forest because of all the trees”. Also, mineralogy so far had had no business with the Ries Crater, which was considered to be a “geological” problem, to be tackled by traditional fieldwork with walking boots and hammer, and nobody at the geological institutes had expected any reasonable input from mineralogy. “The paradoxical case arose that a mineral, at first only visible microscopically, should be regarded as sufficient proof for the meteoritic origin of the vast Ries Basin” (Ekkehard Preuss in 1963; see Kölbl-Ebert 2015: 202).

The Ries Crater in southern Germany (image courtesy of Landesmedienzentrum BW: Fotoarchiv Brugger).

Hölder thinking about the philosophical aspects that influenced his colleagues and also himself keenly felt his former world-view shattered by the events:

> “In this situation, the […] meteorite hypothesis must not be dismissed right away. Yes, quite apart from its potential correctness, it is of special interest in the history of science. It is based on the discovery of the mineral coesite, which belongs only to the last decade. It is the problem of research that it has always to expect such unknown things. If it does

> not want to be crippled by this fact, so it must accept error—as well as the tolerance of it. A meteorite impact, which alone according to the present state of knowledge can have formed the mineral coesite as a high-pressure modification of quartz, for geological research is something like a slap in the face: because earth history actually endeavours to demonstrate the geohistorical conditions for the occurrence of a geohistorical event, for the self-appearance of a piece of earth crust. The strike from outside into a geohistorically self-formed space, which the Ries certainly represents in several respects, can be random chance, demonstrating that the Earth is a fundamentally open system facing the cosmos, historically not closed within itself" (Hölder 1962: 16).

This cosmic "slap" was felt even more severely after the "romantic/holistic" ideas of "German Geology", which was developed by national-socialist geologists during the German Nazi-regime 1933 to 1945 (Kölbl-Ebert 2017). Quite apart from its nationalistic/chauvinistic background, "German Geology" had supported the notion of a local, self-sufficient earth history shaping and reshaping a given piece of land; where the sum of historical events determined the fate of this particular space without the influence of more global processes. This idea, of course, was doomed to fail completely in the face of an intrusion by an unconnected outside event.

Solving the "Ries Problem" turned out to be of far-reaching importance for scientific thinking as well as for methodology. While the old guard was still busy with resistance, others began to test the volcanic and the impact theory against new fieldwork, mineralogical and geophysical data. A full research program, including drilling, was established by an interdisciplinary working group. Even NASA took an interest in Ries Crater as part of the Apollo lunar landing program.

In addition to the paradigm shift in the local theory of Ries Crater formation, the years between 1961 and 1975 brought to Germany another change of paramount importance; a change from simple field-geology to a more chemically/physically oriented geoscience, from self-sufficient stratigraphy to a process-oriented view, from local to global and even interplanetary perspectives and, last but not least, from chauvinism to internationality, thus reforming scientific culture for the better: towards interdisciplinary interests and an international orientation.

Further Reading

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