Learn more about spall plates and distal impact ejecta!

On clicking on the file name "impact experiment" you may have now downloaded the video file to be played back, e.g., on a VLC Media player. This enables you to run the video at strongly reduced velocity (down to x 0.03 of the normal velocity) and with markedly temporal resolution in order to study the hypervelocity impact in very detail.

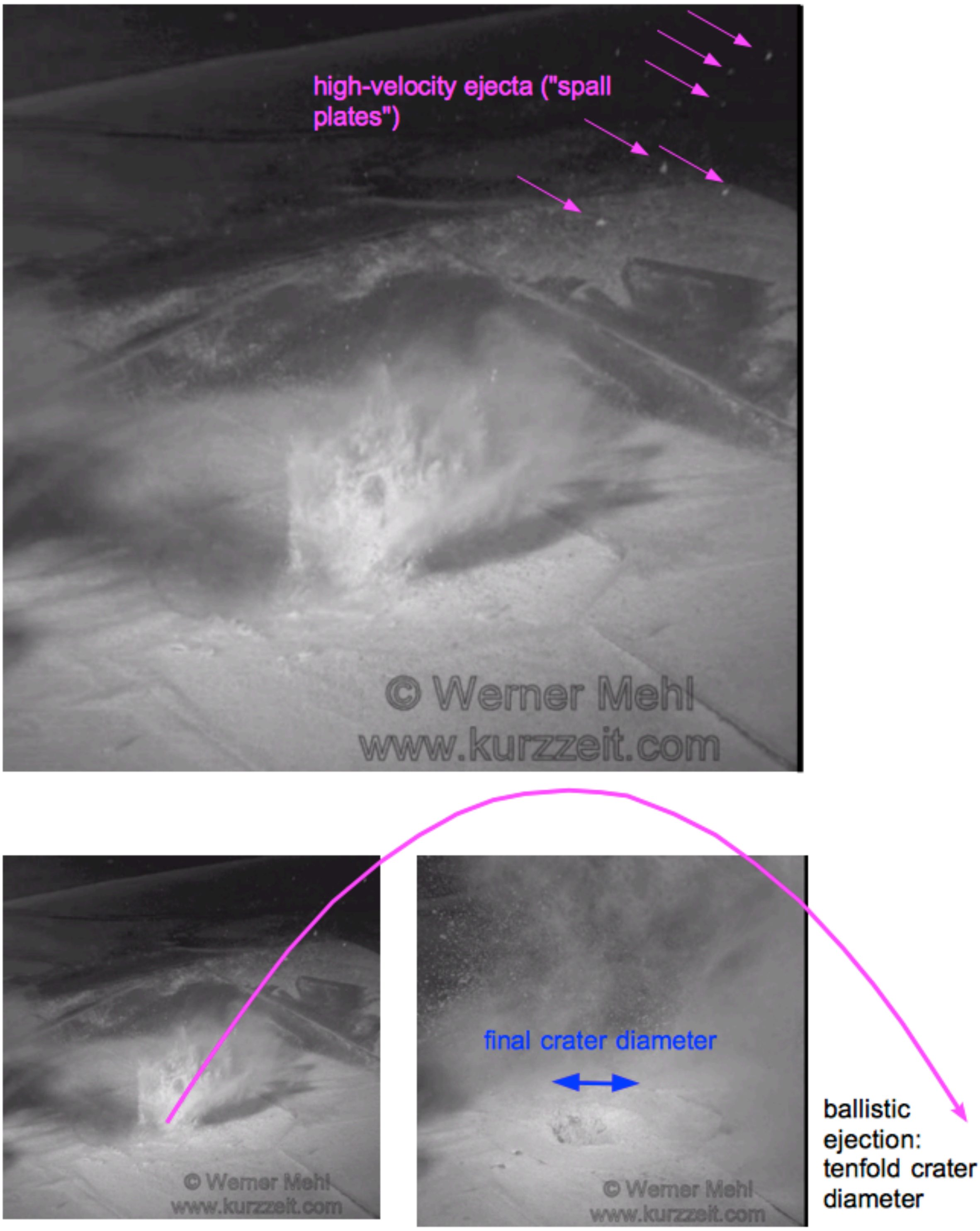

Fig. 1. Distal ejecta (spall plates) in experimental hypervelocity impact cratering.

Here we will focus only on the aspect of the high-speed ejecta to be observed in the very first moment of impact escaping the growing crater much faster than the bulk of ejecta in the ejecta curtain. In Fig. 1 a few of these objects have been marked by arrows. They are "frozen" at a time already a little bit later at a velocity comparable to the projectile velocity (≈ 1200 m/s). However on playing the video several times from the very first you can observe that the objects starting first and foremost are ejected at a much higher speed that we computed from the original picture sequence (with even higher temporal resolution than the video resolution provided here) to attain 3,000 m/s or more.

This unbelievable velocity enables ejecta to be transported over very large distances to establish the existence of so-called distal impact ejecta layers (in contrast to the proximal ejecta, by definition emplaced up to 2.5 crater diameters (e.g., Glass & Simonson 2012).

Below in Fig. 1, we have tried to give a very rough approximation of the distance the high-speed ejecta could have reached in the experiment. We have assumed ballistic ejection along a parabola which we adjusted to the "spall plate" trajectories neglecting air friction. As a result, Fig. 1 shows that a distance of the order of a tenfold crater diameter is a reasonable value that my be even much larger taking into consideration that the very first ejecta started at a much higher velocity.

Considering real meteorite impacts

Ries impact structure

Distal ejecta from the Ries crater have been known since more than 100 years (when the Ries was still considered a big volcanic explosion crater) in the form of the so-called Reuter blocks, meter-sized Malmian limestone blocks found up to a distance of about 90 km from the Ries crater (Fig. 2). The find of a 2 m long shattered Malmian limestone block embedded in a gravel pit near Niedertrennbach some 150 km apart from the Ries crater suggested an origin also from the Ries although an ejection from unknown volcanism at about the same time was also discussed (Herold 1969).

More recently exotic horizons near Lake Constance (Fig. 2) exhibiting shatter cones and stratigraphically being same-aged with the Ries impact event have been attributed also to the Ries impact (Hofmann and Gnos, 2006, Sach, 2014) although an origin from an unknown impact structure buried in the Alpine Molasse sediments has also been considered earlier. (*)

The most remote Ries crater distal ejecta are the well-known tektites (Moldavites). Only recently the hitherto farthermost occurrence has been established in Poland (Fig. 2) (Brachaniec et al., 2014) at a distance of about 500 km from the Ries.

If we list the maximum distances for the Ries distal ejecta we get

90 km (Reuter blocks), 150 km (Niedertrennbach block), 150 - 190 km (Lake Constance exotic layers), 500 km (Moldavites),

and considering the diameter of the Ries crater to be about 25 km, distance-to-diameter ratios between roughly 4 and 20 are given, which match our experimental figures pretty well (see Fig. 1) and illustrate well the theoretical considerations and numerical simulations of Buchner et al. (2007).

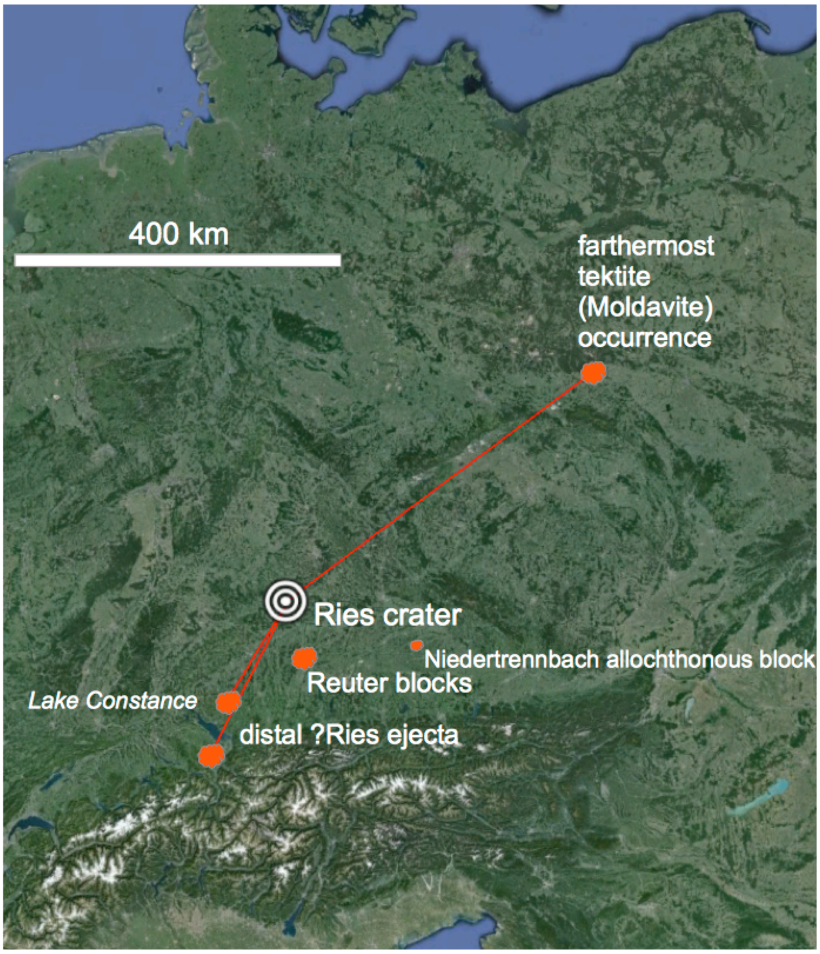

Fig. 2. Distal ejecta from the Ries impact structure.

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(*) The find of nicely developed shatter cones in Malmian limestone in the exotic layers near Lake Constance and their attribution as distal ejecta to the Ries impact crater (Hofmann & Gnos, 2006; Sach, 2014) raises some questions. The same holds true also for the identification of shock-produced planar deformation features (PDFs) in quartz grains from the exotic horizons (Alwmark et al. 2012). We remind of the interference zone (Melosh 1989) of impact cratering from where ejecta start with highest velocity but show lowest shock metamorphism. We also remind of the Ries Bunte breccia sedimentary ejecta without significant shock effects including the complete absence of shatter cones despite nicely suitable rocks. Since according to current knowledge shatter cone development and PDF formation require shock pressures of at least roughly 2 GPa and 10 GPa, resp., the origin of the exotic layers as distal ejecta from the Ries crater creates some doubt, and the idea of a more adjacent impact site so far unidentified and buried in the Alpine Molasse basin should still be considered.

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The Chiemgau impact

The uncovering of big "erratic" blocks as individuals, without any accompanying other stones, embedded in a pure loamy underground has for a long time rather puzzled the locals in the region of the Chiemgau impact event near the Lake Chiemsee and the Lake

Tüttensee meteorite crater. From the find situations a glacial transport as moraine material appeared absolutely impossible, even for geologic laypersons. But what or who had dumped the blocks in the ground, which frequently were angularly shaped and showed intense fracturing (Fig. 3). The answer to the problem was given when the Lake Tüttensee had been established as a meteorite crater belonging to the large Chiemgau impact strewn field, and in particular when we had performed our hypervelocity impact experiments demonstrating that distal ejecta transport over distances of tenfold crater diameter is easily achieved. In the case of the Geiselprechting location where the megablock is exposed by the farmer who had excavated the "monster", the distance is less than only three times the crater diameter, and an origin from Lake Tüttensee as high-velocity spall plate seems most reasonable.

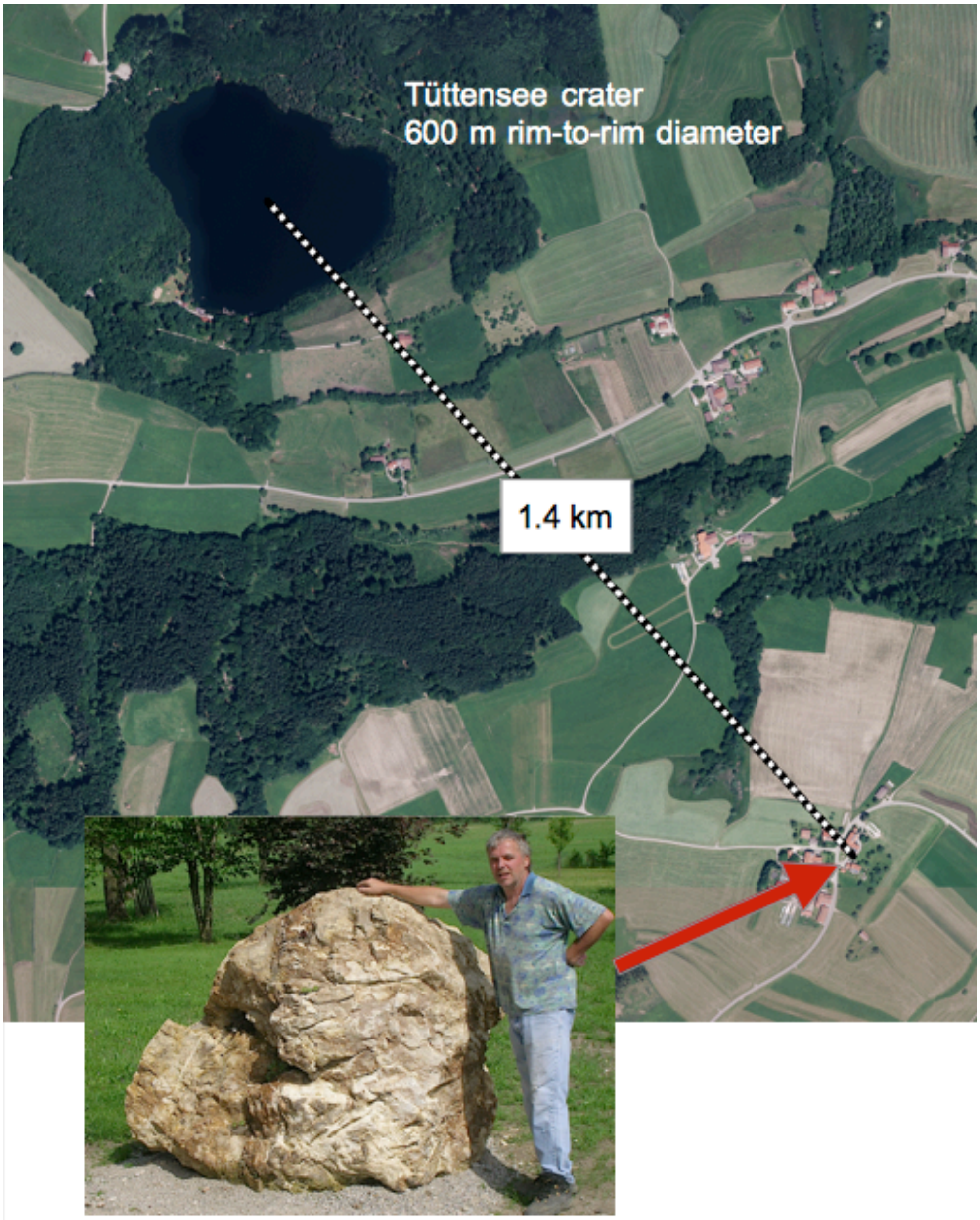

Fig. 3. One of the big "erratic" blocks suggested to have been excavated and ejected as high-velocity spall plates in the Chiemgau impact event.

Literature

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