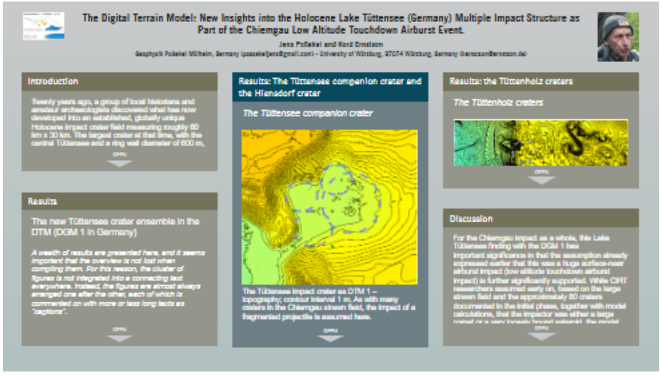
The Digital Terrain Model: New Insights into the Holocene Lake Tüttensee (Germany) Multiple Impact Structure as Part of the Chiemgau Low Altitude Touchdown Airburst Event.



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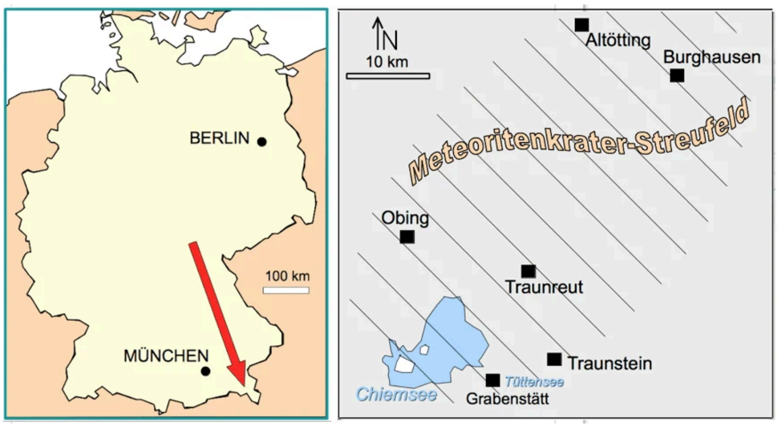
INTRODUCTION

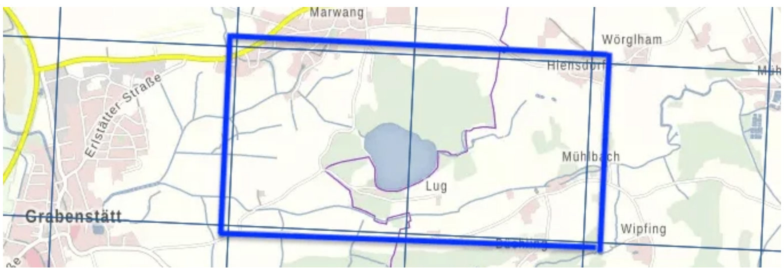
Twenty years ago, a group of local historians and amateur archaeologists discovered what has now developed into an established, globally unique Holocene impact crater field measuring roughly 60 km x 30 km. The largest crater at that time, with the central Tüttensee and a ring wall diameter of 600 m, was established in the early days of research. The crater developed into a key point of impact research [1- 3, and a host of references therein] with very extensive geological work in the order of 100 excavations, geophysical measurements of gravimetry, seismics on the lake, geomagnetics, geoelectrics and ground- penetrating radar. Mineralogical-petrographic investigations of rocks from the excavations and from the surface of the ring wall revealed conclusive evidence in the form of impact melt rocks, shatter cones and shock metamorphic effects, on which the extensive publications provide exhaustive information. From the outset, the spectacular results, with the additional evidence of a new class of meteorites in the form of iron silicides that practically do not occur on Earth [4], were met with incredible rejection of the impact in favor of pure ice age explanations and human activity (which will be discussed in other places (e.g. [5]). To this day, a few hard-core opponents continue to ignore the impact evidence in favor of predominantly abstruse and absurd explanations [6 - 8].



Location maps of the Chiemgau elliptically shaped impact strewn field witn the Lake Tüttensee impact structures east of Lake Chiemsee near Grabenstätt.

The Digital Terrain Model

The Digtal Terrain Model DGM 1 is a relatively new representation of the topography of the Earth's surface with a dense data network obtained by LASER scanning from an aircraft.



The two tiles covering the Tüttensee crater ensemble (each 1 km x 1 km) of the Bavarian DGM 1 data network [9].

A new situation for impact research on the Chiemgau impact has arisen in recent years because the Digital Terrain Model DGM 1 for the whole of Bavaria and thus for the entire Chiemgau impact field is available online free of charge in the form of tiles with a size of 1 km x 1 km and can be downloaded within a few minutes as ASCII files (x, y, z) ([9], examples [10, 11]). The mesh size of the DGM 1 is 1 m with a vertical resolution of the terrain surface of 0.1 m, which can be interpolated to the decimeter and centimeter range using the SURFER program. With the SURFER data processing, topographic maps with isolines of any density, shaded relief maps and pseudo-3D models of the surface in any view orientation and color scale can be created. In the same extremely high resolution, profiles of any orientation can be extracted from the generated maps, enabling a completely new approach to the analysis of crater morphologies.

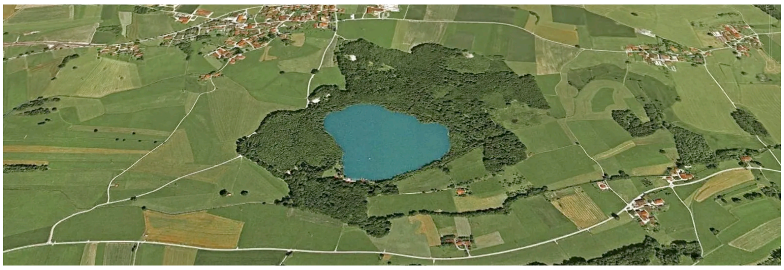
RESULTS

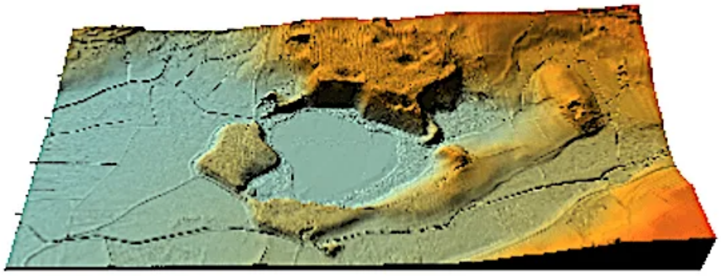
The new Tüttensee crater ensemble in the DTM (DGM 1 in Germany)

A wealth of results are presented here, and it seems important that the overview is not lost when compiling them. For this reason, the cluster of figures is not integrated into a connecting text everywhere. Instead, the figures are almost always arranged one after the other, each of which is commented on with more or less long texts as "captions".

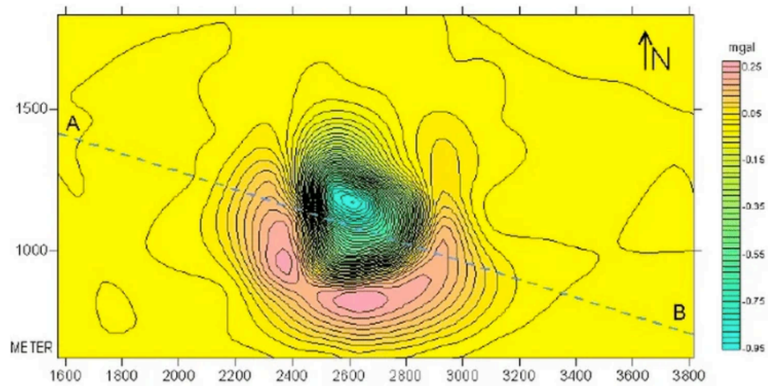
The Tüttensee crater

A short hike through the previous studies





Geophysics



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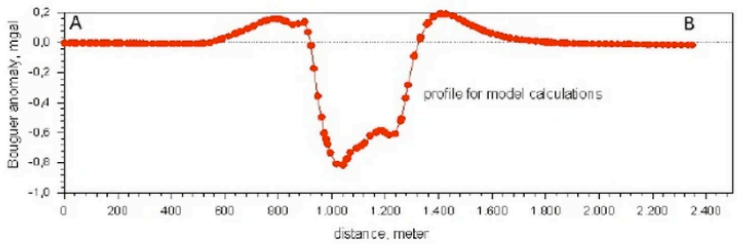

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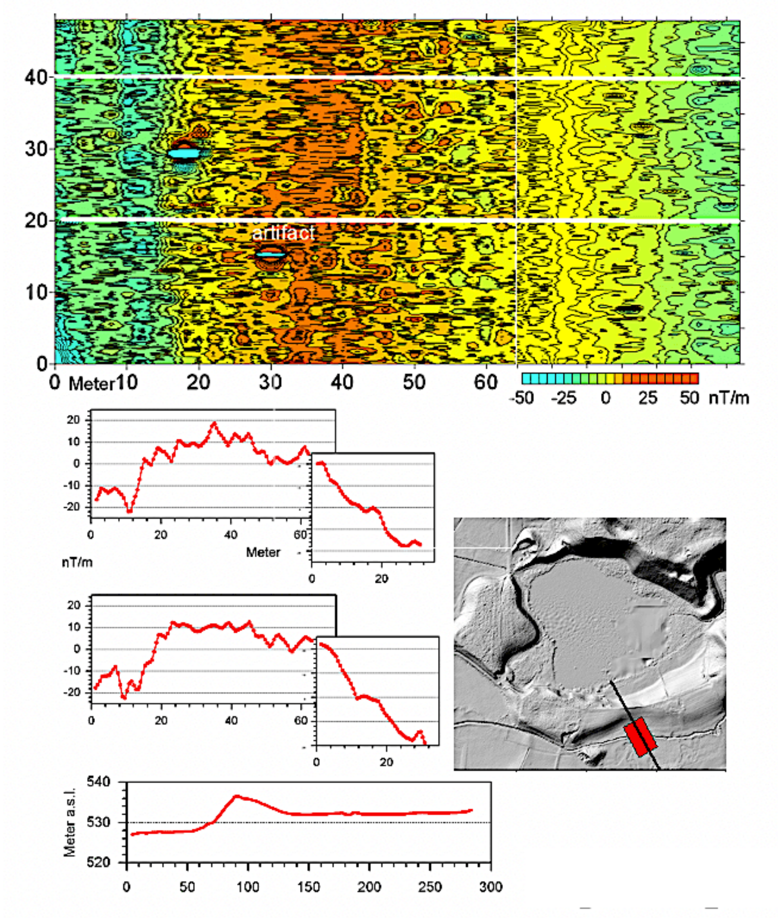
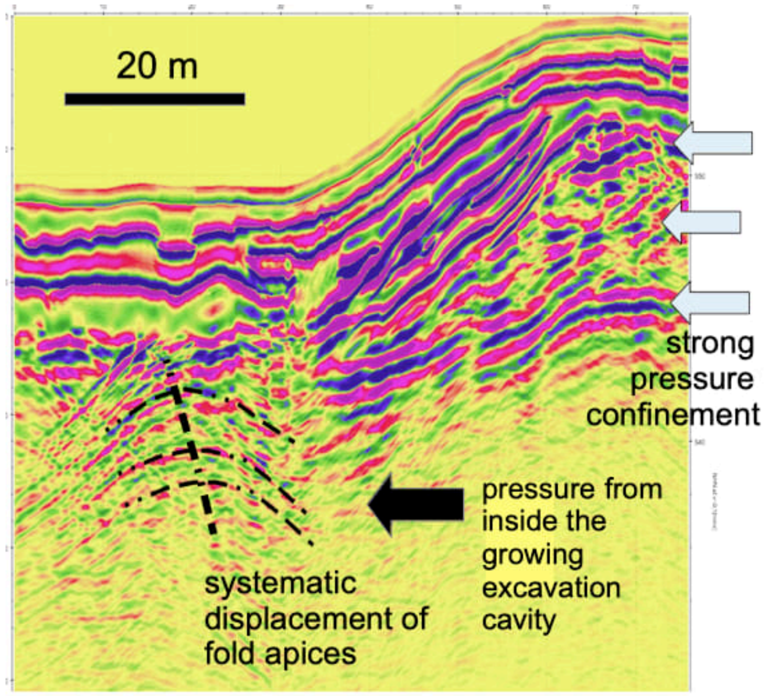
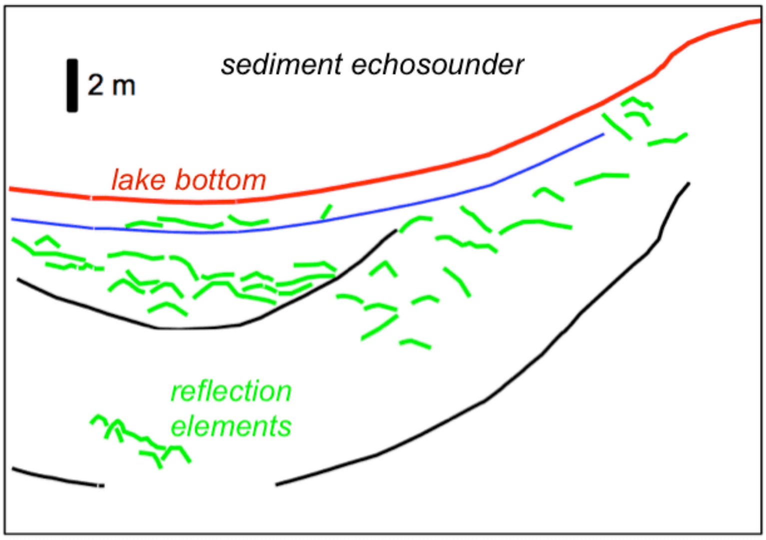


Geomagnetics, vertical gradient of the vertical component. Note the magnetic striped pattern parallel and in direct outer connection to the wall as shown in the shadowed relief map of Lake Tüttensee. At the bottom is a DTM profile of the measuring surface. The conspicuous magnetic field pattern is undoubtedly related to the crater formation and is associated with the blanket of ejected material. An impact-induced thermoremnant magnetization of Quaternary pebbles could be the cause of the magnetic anomalies.

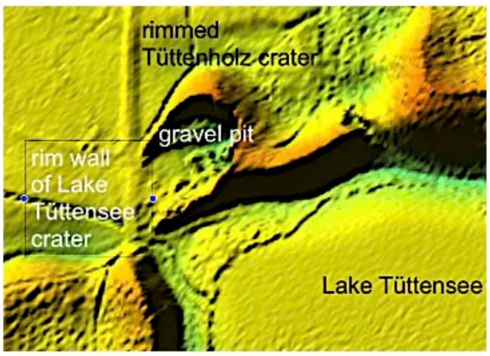


Ground Penetrating Radar GPR across the Tüttensee crater rim wall.

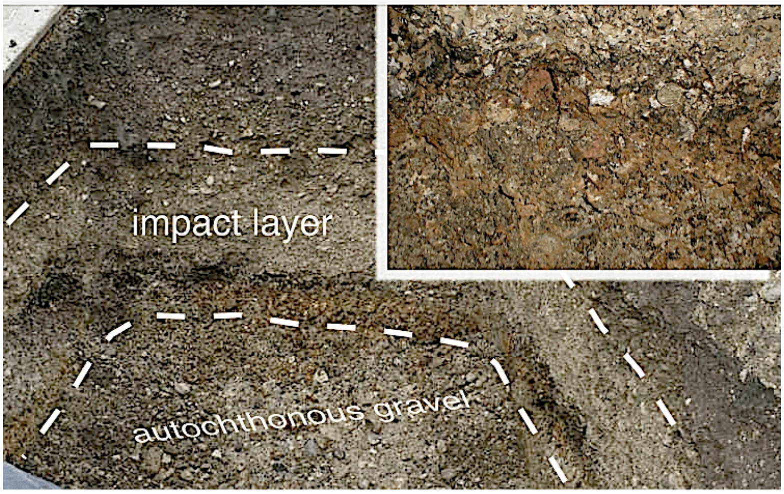


Seismics; sediment echosounder across Lake Tüttensee. The distinct reflection elements basically exclude an undisturbed lake sedimentation and all ice-age fantasies of regional geologists.

Outcrops and excavations

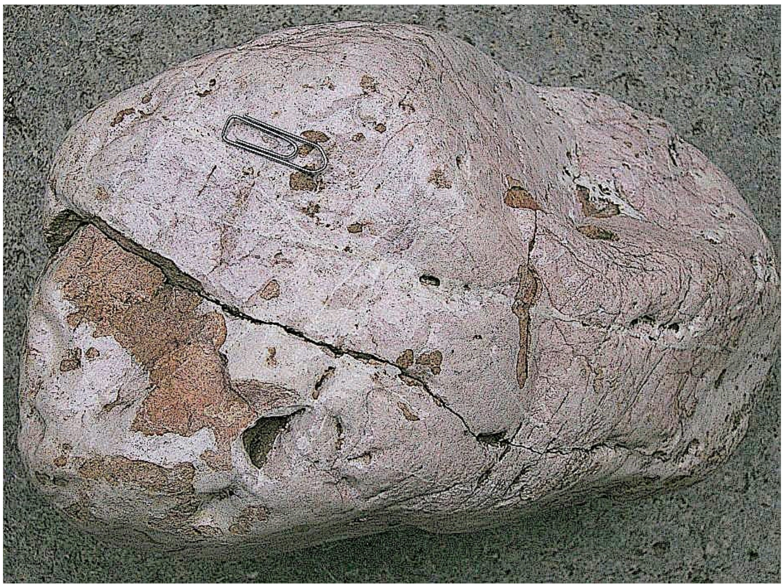


A gravel pit in the Lake Tüttensee crater rim wall exposing the mega-diamictic impact ejecta, which is ignored by Bavarian official geologists who only recently awarded the Lake Tüttensee the status of an important ice age geotope with a dead ice hole.

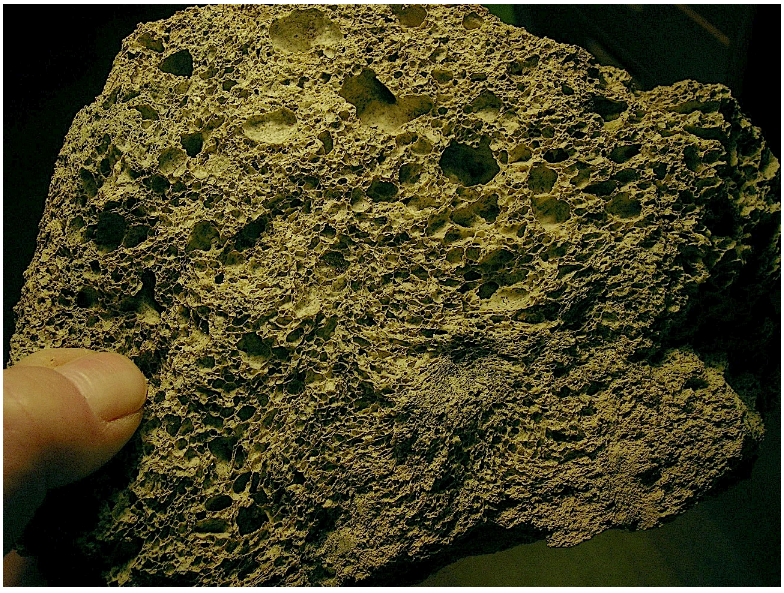


Diamictic impact catastrophy layer, ejecta of the Lake Tüttensee crater.

Lake Tüttensee crater impactites



Glass-coated sandstone boulder from the Lake Tüttensee crater.



So-called swimstone, a shocked, highly porous Tüttensee crater impact melt rock, which in the past was collected by children in large numbers and thrown into the lake in competitive games.

Mühlbach excavations; catastrophe layer, Bunte breccia ejecta.

Impact corrosion by heat and/or nitric acid.

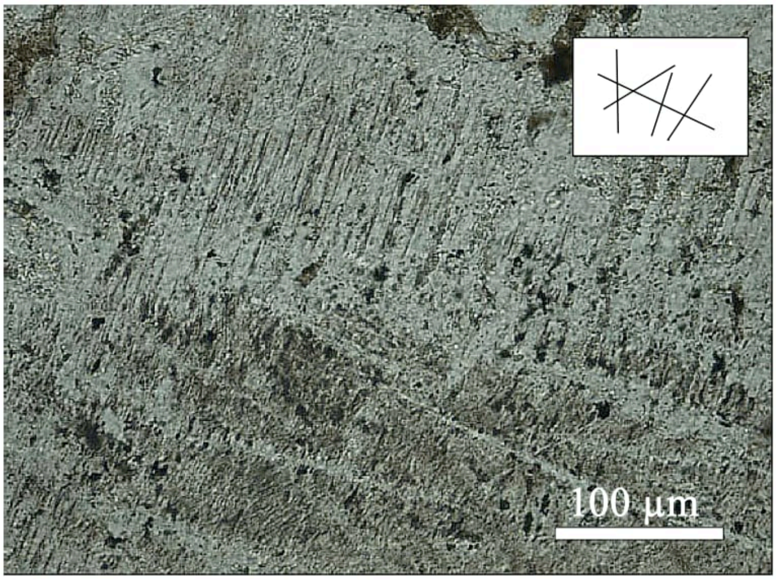
Quartzite block from the Mühlbach impact ejecta excavations, which must have been molded under extreme pressure in contact with other stones.

Bones and teeth and a (human?) tuft of hair from the Mühlbach catastrophy layer excavations.

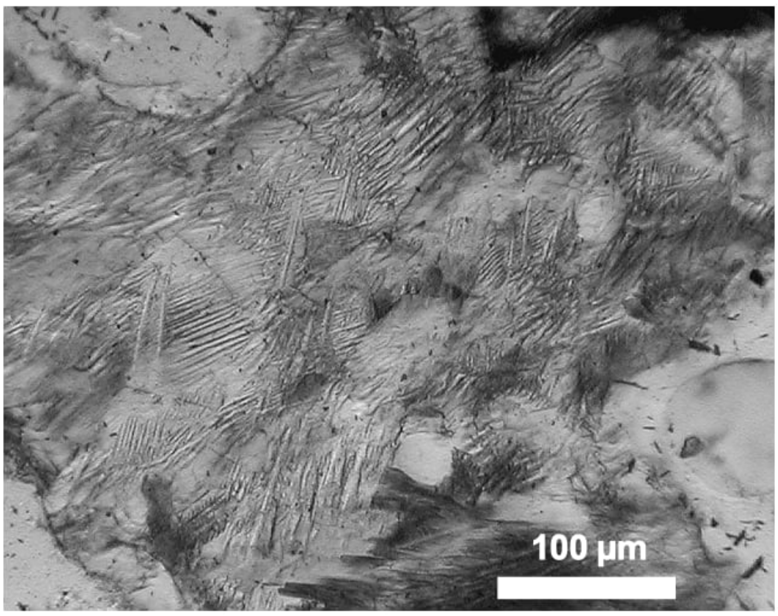
Shatter cones

Shatter cones (counter cones) from the Lake Tüttensee crater rim proves impact shock deformation.

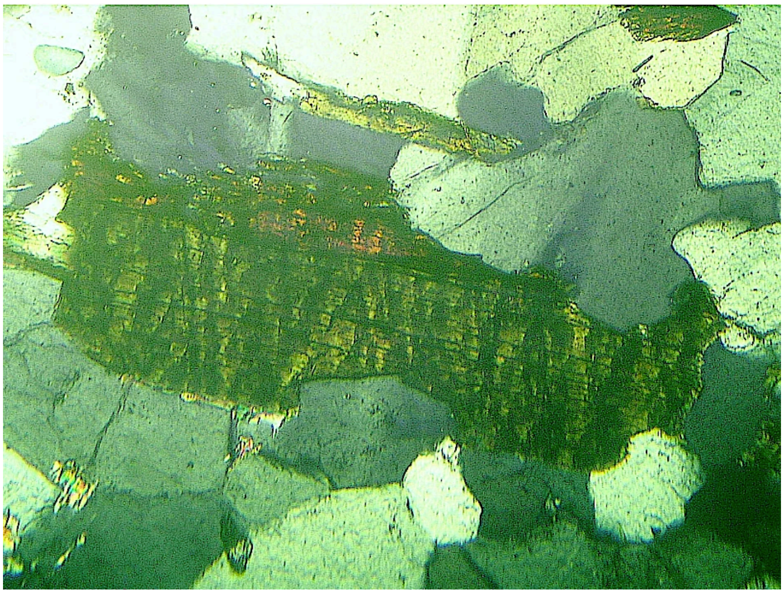
Photomicrographs, shock effects in thin section



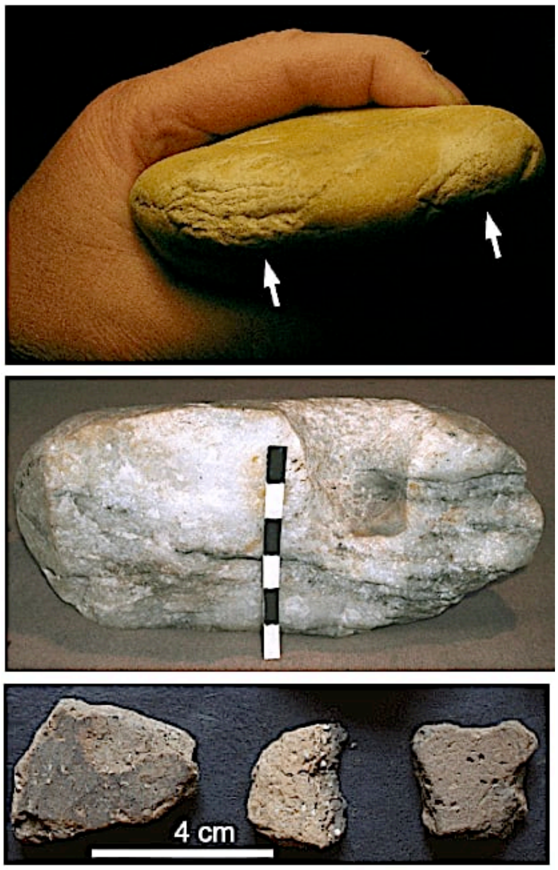
Multiple sets of planar decoration features PDFs in quartz.



Multiple sets of planar decoration features PDFs in feldspar in impact melt rock.



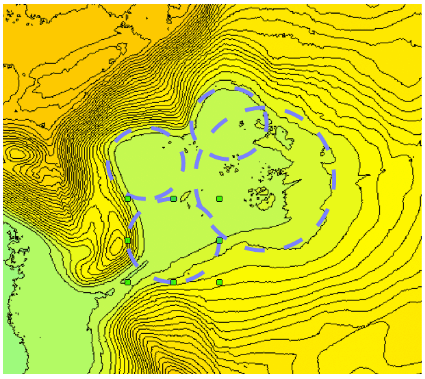
Multiple sets of crossing kink bands in biotite, in this form, a clear shock effect.



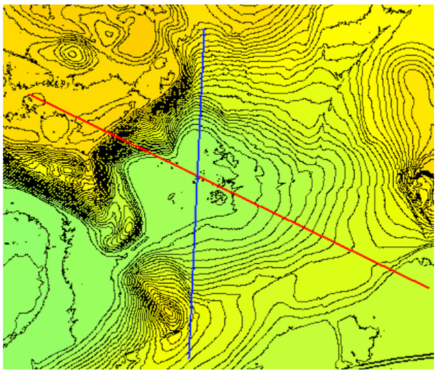
Archeological artifacts from the Mühlbach catastrophy impact layer excavations; probably young neolithic, early Bronze age, disproving all ice age claims against the impact.

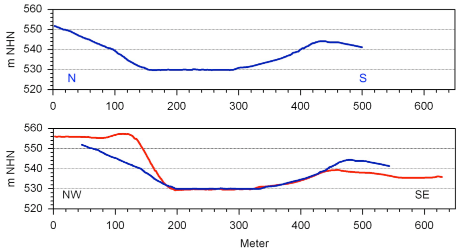
RESULTS: THE TÜTTENSEE COMPANION CRATER AND THE HIENSDORF CRATER

The Tüttensee companion crater



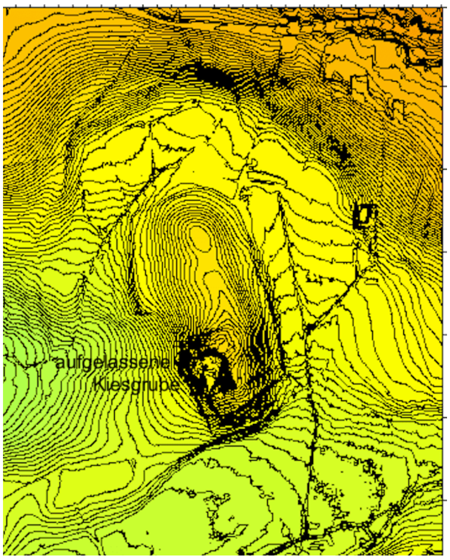
The Tüttensee impact crater as DTM 1 – topography; contour interval 1 m. As with many craters in the Chiemgau strewn field, the impact of a fragmented projectile is assumed here.



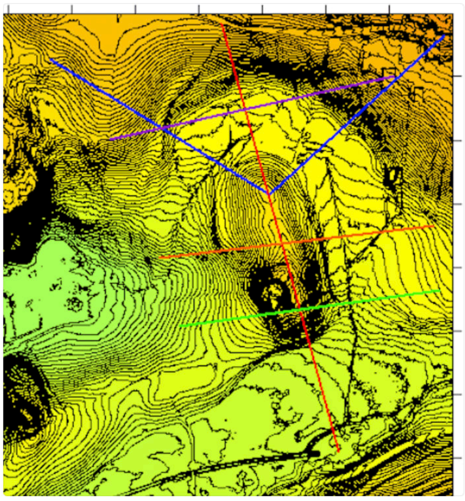


DGM 1-profiles through the accompanying crater. The absolute congruence of the two crossing profiles over a distance of 250 m requires crater formation from above and in recent geological time without subsequent sedimentation and erosion.

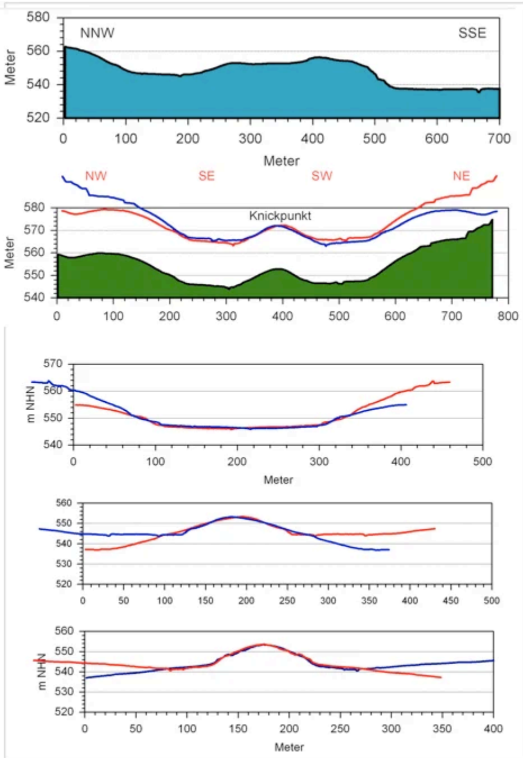
Hiensdorf crater



DGM 1 topography of the Hiensdorf crater, which is located farthest to the east. The distance between the contour lines is 50 cm. The difference to the other craters with the elongation and the pronounced central mountain is significant. An initial consideration that it could be a narrow former river bend was rejected in favor of an impact based on the findings of DGM 1. Here, in the high-resolution topography, it can be seen that a river in this loop would have had to flow partially uphill. The profiles in the next figures also exclude a river loop in principle.

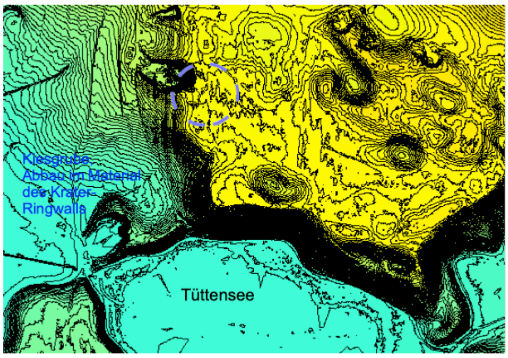


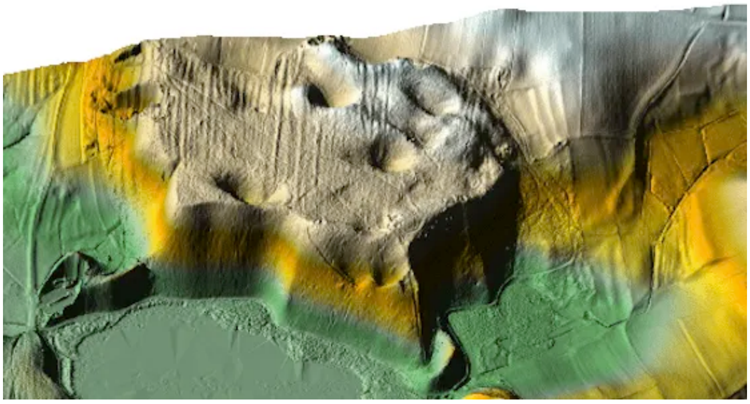
The Hiensdorf crater with the DGM 1 profiles that cross the crater basin and the central elevation. The profiles themselves are shown below-



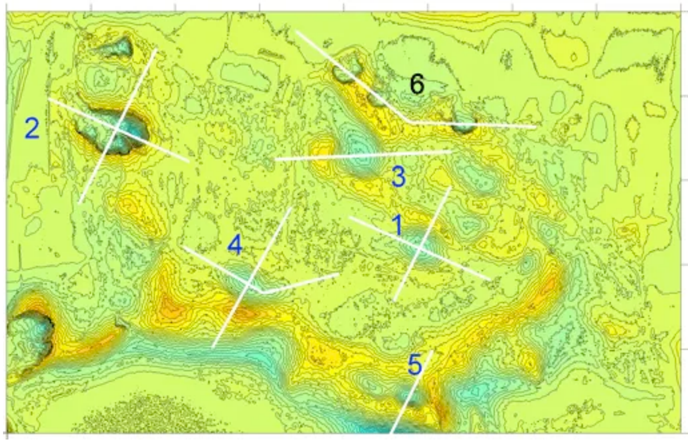
The DTM 1 profiles through the Hiensdorf crater. Top: The NNW – SSE profile shows the longitudinal structure of the central elevation in the basin with apparently several lined up impacts. – Below: The buckled profile shows a remarkable congruence of the two radial sections when the profile (red) is superimposed on its mirror image (blue). Over 200–300 m, the two lines are practically congruent. This allows us to rule out the possibility that this is a geogenic or anthropogenic structure. – Below: Three DGM 1 profiles as marked in the above figure. The lateral resolution is about 1 m and the vertical resolution is 10 cm. In all three profiles, the superimposition with the respective mirror images impressively illustrates the absolute morphological symmetry of these structures, which once again emphasizes that geological processes or anthropogenic activity can be ruled out. In the case of the approximately 300 m long, almost punched-out central elevation, the deviation in the superimposition does not exceed 1 m (over a length of 300 m). The two profiles crossing the ridge also show absolute symmetry over a central length of 200 m.

The Tüttenholz craters

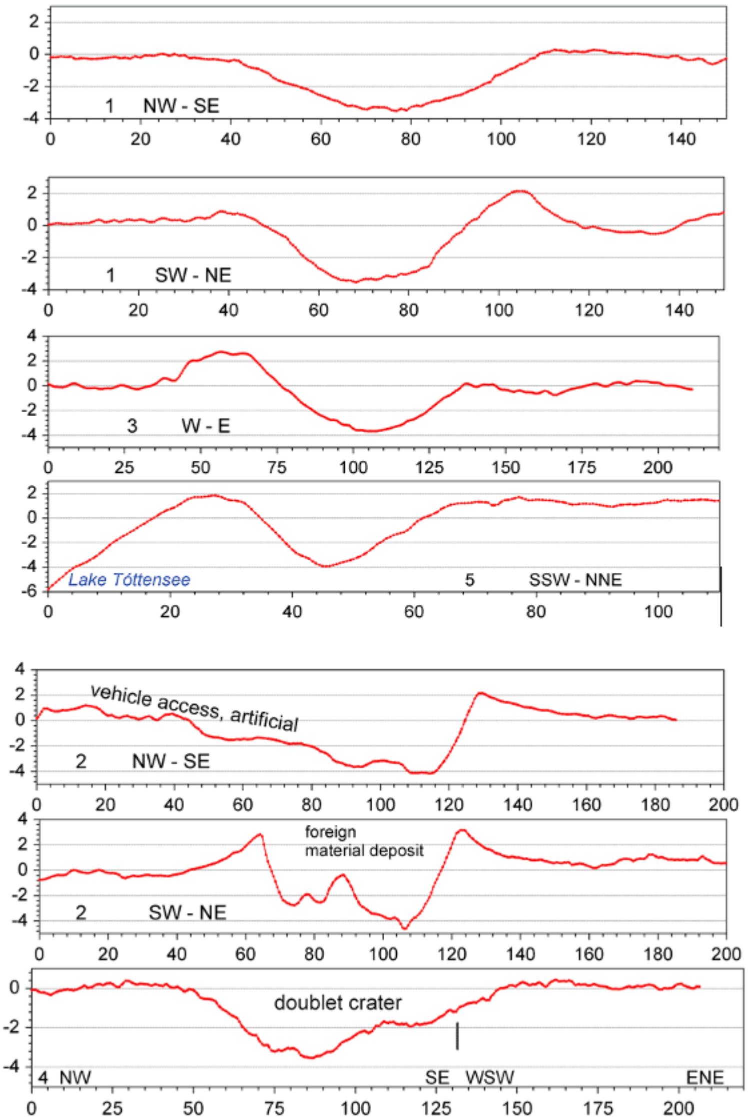




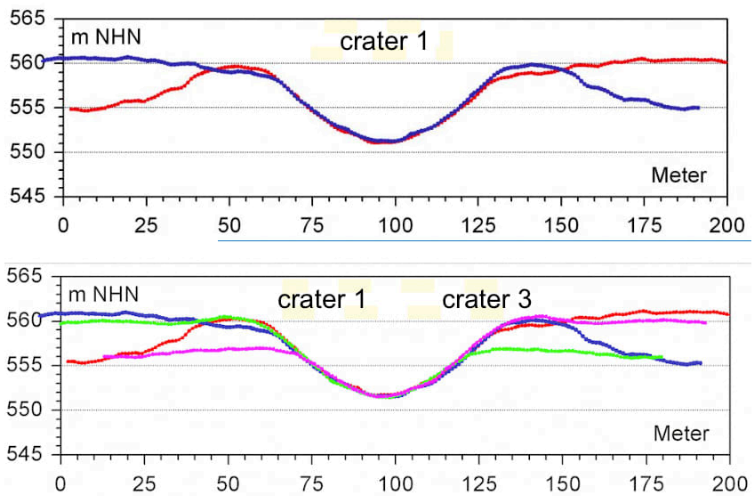
The cluster of smaller walled impact craters on the moraine ridge in DGM 1 – topography and 3D surface. They are relatively similar to each other, and it is noticeable that they almost all appear elongated in the same WNW direction, indicating a common impact trajectory at a shallow angle.



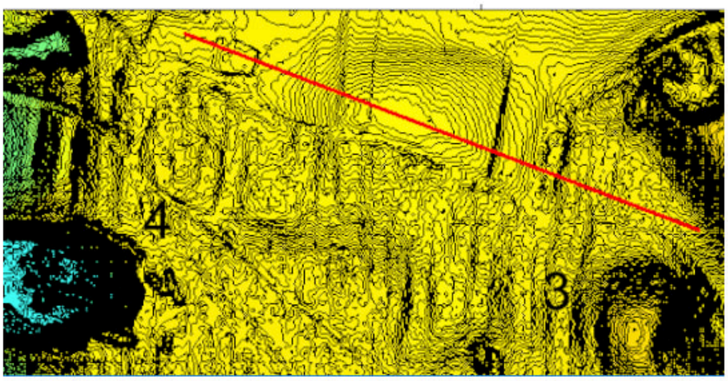
The Tüttenholz crater cluster after data processing, in which a general terrain trend is calculated and subtracted by means of a thorough low-pass filtering of the elevation data, thus centering the heights on a zero level. The DGM 1 elevation map reduced in this way is the basis for generating the crater-crossing elevation profiles drawn in the next figures.

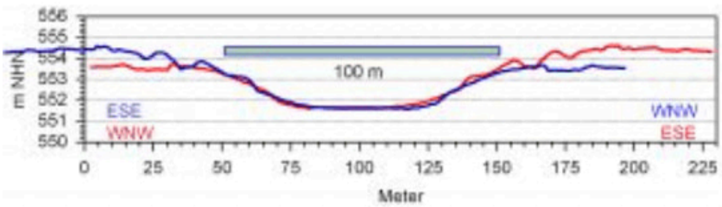


DGM 1-profile in 10 cm height resolution over the craters marked in the above figure. The diameters are roughly 50-80 m (wall crests) with depths of 3-5 m and wall heights between roughly 0.5 and 2 m.



Partially identical crater morphologies and perfect mirror symmetries (original terrain heights). Above: profile of crater 3 with superimposed mirror image and elevation differences in the decimeter range over the entire crater basin of around 60 m in diameter. – Below: the same for crater 1 and at the same time the superimposition with the profiles of crater 3. Geological processes and human intervention can be absolutely ruled out here as well.



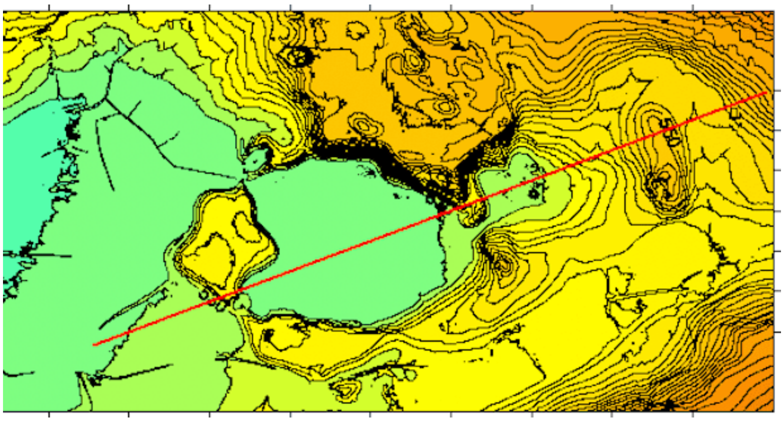


Also part of the Tüttenholz crater cluster, but with a slightly different shape and not particularly conspicuous at first. It can only be identified by using the DGM 1 with a height resolution of 10 cm between the contour lines, even in the middle of the forest. The contrast to the neighboring craters 3 and 4 becomes significant in the topographic map. Also significant is the longitudinal profile below with the now familiar mirror image and deviations of only up to 10-20 cm over a 100 m distance.

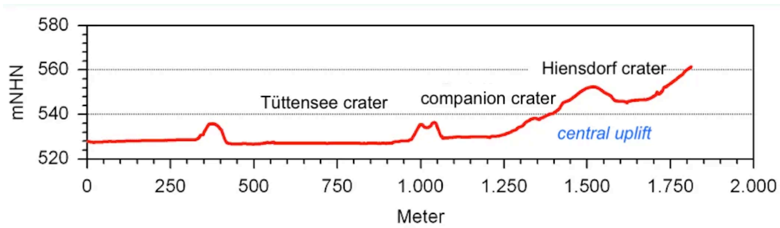
DISCUSSION

For the Chiemgau impact as a whole, this Lake Tüttensee finding with the DGM 1 has important significance in that the assumption already expressed earlier that this was a huge surface-near airburst impact (low altitude touchdown airburst impact) is further significantly supported. While CIRT researchers assumed early on, based on the large strewn field and the approximately 80 craters documented in the initial phase, together with model calculations, that the impactor was either a large comet or a very loosely bound asteroid, the model has not changed in principle, but rather to the effect that that the impact did not consist of a largely staggered raining down of fragments of the comet or asteroid that had broken apart, but, as is to be assumed, consisted of an airburst consisting of a vast number of powerful explosions close to the surface, which, distributed over the large impact ellipse, caused a mixture of direct meteoritic impacts, impacts by explosive fragments and secondary impacts from the larger craters.

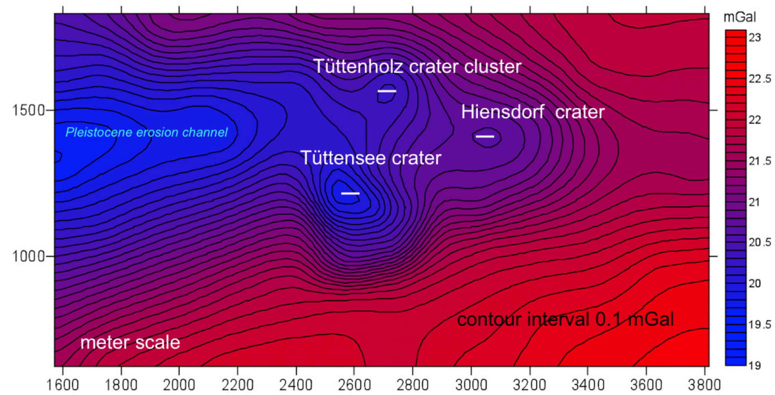
Meanwhile, numerical calculations of impact processes using hydrocode modeling have also led to very important insights into near-surface touchdown airburst impacts (e.g. [12]), which can also explain a great deal about the observations of the Chiemgau impact, which has become possible above all with the new application of the digital model DGM 1. Finally, and representative of an enormous number of new DGM 1 findings, the last images in Figs. 15 – 18 show how the previous single Tüttensee crater has become an entire ensemble of large and small craters of various shapes with the DGM 1.



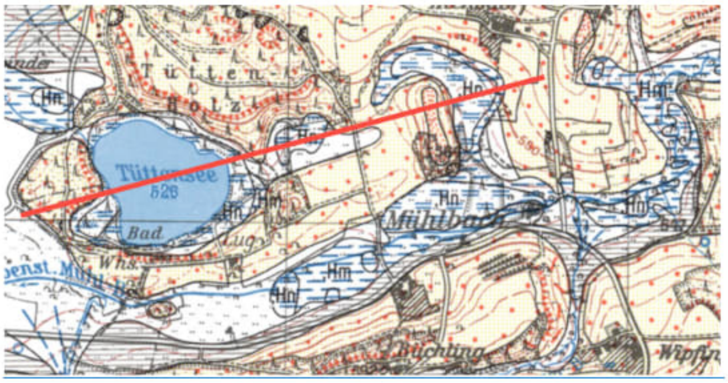
The Tüttensee crater ensemble with a DGM 1 topographic profile (Fig. 16).

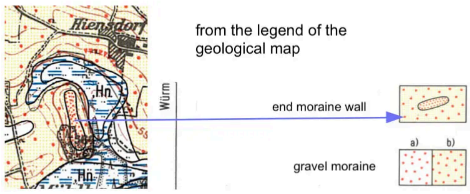


The DGM 1 profile across the three lined up craters makes it clear that the outermost easterly elongated crater is significantly higher. This could indicate a different geological substrate that reacted to the impact with a different crater formation (distinct central mountain).



The gravity map of gravimetry [13 – 15] with the individual relatively negative gravity anomalies is well compatible with the newly recognized extension of the Tüttensee impact.





The geological map 1 : 25,000 from 1977 [16] illustrates the almost 50-year-old geological ideas about the post-glacial landscape of the Alpine foothills, which, understandably, often conflict with the new findings of impact research. The upper image shows an example of this with the valley floor of the Mühlbach stream passing south of Lake Tüttensee with the two tributary valleys branching off to the north. With DGM 1, this can no longer be correct for the simple reason that the stream or river would then have to have flowed uphill from the Mühlbach stream to the north in connection with the impact crater basin. The legend of the Hiensdorf crater image conveys that the crater central mountain is mapped as a wall-like end moraine, which supports the assumption that the impact encountered a completely different subsurface there in comparison to the Lake Tüttensee lowland. It cannot be ruled out, and is equally possible, that during the postulated low-altitude touch-down airburst impact, even closely spaced impactors hit the ground at different speeds and from different directions.

Concluding remarks

Using the example of Lake Tüttensee crater, which is now one of many comparable impact investigations with the DTM, it becomes clear how much the predominantly free online access to the extremely high-resolution of the DTM 1 data has brought impact research to a level previously not thought possible, which in the Chiemgau impact strewn field alone has now provided us with several hundred new, mostly smaller impact structures that had not been recognized before. Particularly impressive is the case of the Lake Tüttensee impact with the new finding that the crater, which was originally always described as a single structure, probably also formed by a multiple projectile, actually belongs to a whole ensemble of larger and smaller structures. With regard to the DTM, it is noteworthy that the larger direct companion crater of the Lake Tüttensee crater, shown in Fig. 2, did not exist at all because it was covered by dense vegetation. A special and important aspect of the application of the extremely high-resolution DTM to the identification of smaller and very shallow craters arises in view of the increasing realization that, contrary to earlier and still held and published that meteorite airbursts only occur at higher altitudes (e.g..[6]), the so-called low-altitude touchdown airburst impacts, which can now also be described using hydrocode modeling methods [6], are leading to completely new statistics on the frequency of terrestrial impact events.

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