The Chiemgau Impact (Germany) meteorite crater strewn field and the role of Digital Terrain Models. - Model craters, Part 2: the Bergham, Riederting, Seeon Natural-Monument, Purkering and Windschnur medium-sized craters

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Kord Ernstson[1] and Jens Poßekel[2]

Abstract

As in Part 1, which dealt with the three most notable crater strewn fields around Emmerting 004, Kaltenbach, and Mauerkirchen, the focus here is also on the extremely high-resolution digital terrain models with horizontal resolution down to the meter and decimeter range and vertical resolution down to the decimeter and centimeter range, with medium-sized crater diameters ranging from roughly 50 m to 200 m. We repeat the statement from Part 1 that this extreme resolution brings impact research close to a paradigm shift, which in turn is a key aspect of this article. This is particularly relevant in the case of the Chiemgau impact, as the now documented low-altitude touchdown airburst impact is a matter of fact.

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1 Introduction

For readers who do not have quick access to Part 1 with the study of the areas of the small craters, here is a copy of that introduction with the most important current knowledge about the Chiemgau impact.

The Chiemgau strewn field discovered and established in the early new millennium (Schryvers and Raeymaekers, 2004; Schüssler et al., 2005; Rösler et al. 2005, Rappenglück, M. et al., 2005,Hoffmann et al., 2005, 2006; Yang et al 2008), extensively investigated in the following decade until today (Ernstson et al. 2010, 2011, 2012, 2013, 2014, 2017, 2020, 2023, 2024, Hiltl et al. 2011,Isaenko et al. 2012, Rappenglück, B. et al. 2010, 2020 a, b, c, 2021, Rappenglück M.A, et al. 2013,2014, Bauer et al. 2013, 2019, 2020, Shumilova et al. 2018, Ernstson and Poßekel 2017, 2020 a, b,2024, Ernstson and Shumilova 2020, Poßekel and Ernstson 2019, 2020), and dated to 900-600 BC in the Bronze Age/Iron Age (Rappenglück, B. et al. 2023) comprises far more than 100 mostly rimmed craters scattered in a region of about 60 km length and ca. 30 km width in the very South-East of Germany. The crater diameters range between a few meters and 1,300 m. The doublet impact at the bottom of Lake Chiemsee is considered to have triggered a giant tsunami evident in widespread tsunami deposits around the lake (Liritzis et al. 2010, Ernstson 2016).

Geologically, the craters occur in Pleistocene moraine and fluvio-glacial sediments. The craters and surrounding areas are featuring heavy deformations of the Quaternary cobbles and boulders, impact melt rocks and various glasses, strong shock-metamorphic effects, and multiple geophysical (gravity, geomagnetic, electromagnetic, GPR and seismic) evidence. Impact ejecta deposits in a catastrophic mixture contain polymictic breccias, strongly shocked rocks, melt rocks and artifacts from Bronze Age/Iron Age people. The impact is substantiated by the abundant occurrence of metallic, glass and carbonaceous spherules, accretionary lapilli, microtektites and of strange, probably meteoritic matter in the form of iron silicides like gupeiite, xifengite, hapkeite, naquite and linzhite, various carbides like, e.g., moissanite SiC and khamrabaevite (Ti,V,Fe)C, and calcium-aluminum-rich inclusions (CAI), minerals krotite and dicalcium dialuminate. The impactor is suggested to have been a roughly 1,000 m sized low-density disintegrated, loosely bound asteroid or a disintegrated comet to account for the extensive strewn field, while a low-altitude touch-down airburst is meanwhile suggested for the Chiemgau impact event.

A new situation for impact research on the Chiemgau impact has arisen in recent years in that the Digital Terrain Model DGM 1 is available online free of charge for the whole of Bavaria and thus for the entire Chiemgau impact field in the form of tiles measuring 1 km x 1 km, which can be downloaded in a matter of minutes as ASCII (x, y, z) files. 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 into the decimeter and centimeter range using the SURFER program. SURFER data processing can be used to generate topographic maps with isolines of any density, shaded relief maps and pseudo 3D models of the surface in any view orientation and color scaling. In the same extremely high resolution, profiles of any orientation can be extracted from the generated maps, which enables a completely new approach to the analysis of crater morphologies.

A further step towards a completely new approach to impact crater research is made possible by the DGM 1, which eliminates buildings and all vegetation, including the densest forests, in the LASER processing of the digital terrain model, so that only the bare ground is registered and included in the data. These new possibilities for impact research have led to the gradual systematic examination of the tiles for promising morphological signatures. While the original documentation of the discoverers of the Chiemgau impact around 20 years ago already included around 80 craters, the number has been multiplied several times with the help of DGM 1 and the "thinning out" of the widespread forests and inaccessible swamp areas.

We report here in the second part in a summary of our research on a selection of the group of medium-sized craters of the Chiemgau impact (Fig. 1), and we would like to highlight the impressive possibilities of data processing and graphical representations as the basis for the new approaches in impact research mentioned above.

In an Appendix we present a short compilation of a few medium-sized crater as additional highlighting illustrations without further descriptions and comments.

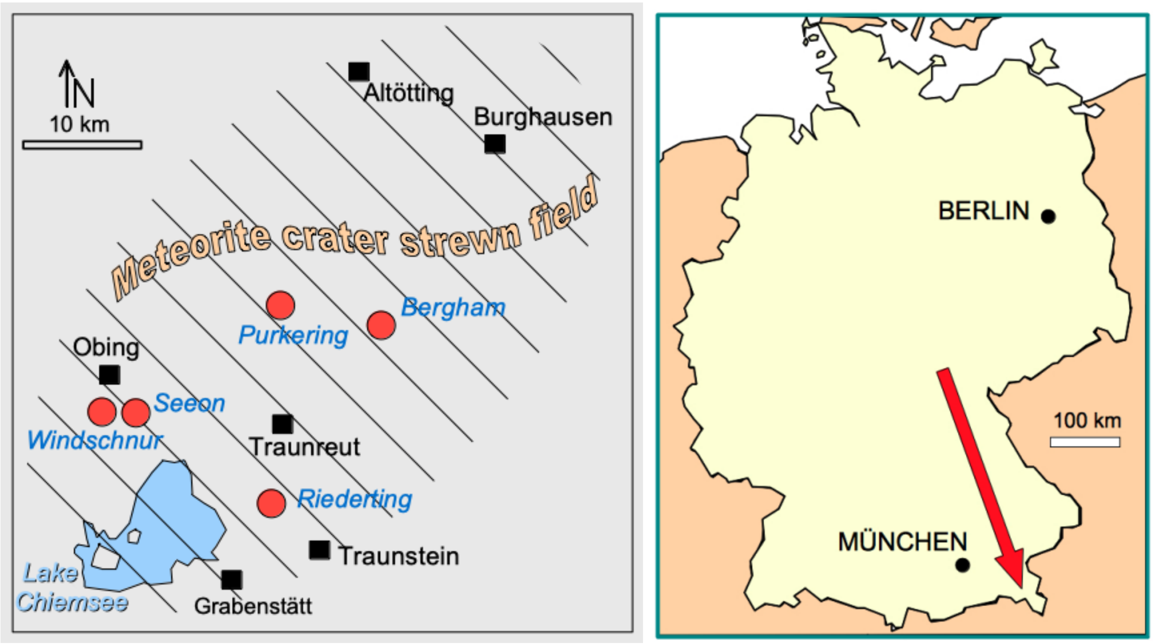


Fig. 1. Location map of the Chiemgau impact strewn field and the craters under discussion.

Preliminary remark for the following texts

This article describes many results for which it appears important that the overview is not lost in their compilation. For this reason, the accumulation of figures is not integrated into a connecting text. Instead, only the corresponding illustrations are arranged in a row, each of which is commented on with more or less lengthy texts as "captions".

2 Two of a kind: The Riederting and Bergham craters

The Riederting crater

Fig. 2. The Riederting crater. The Bavarian Prealps in the background.

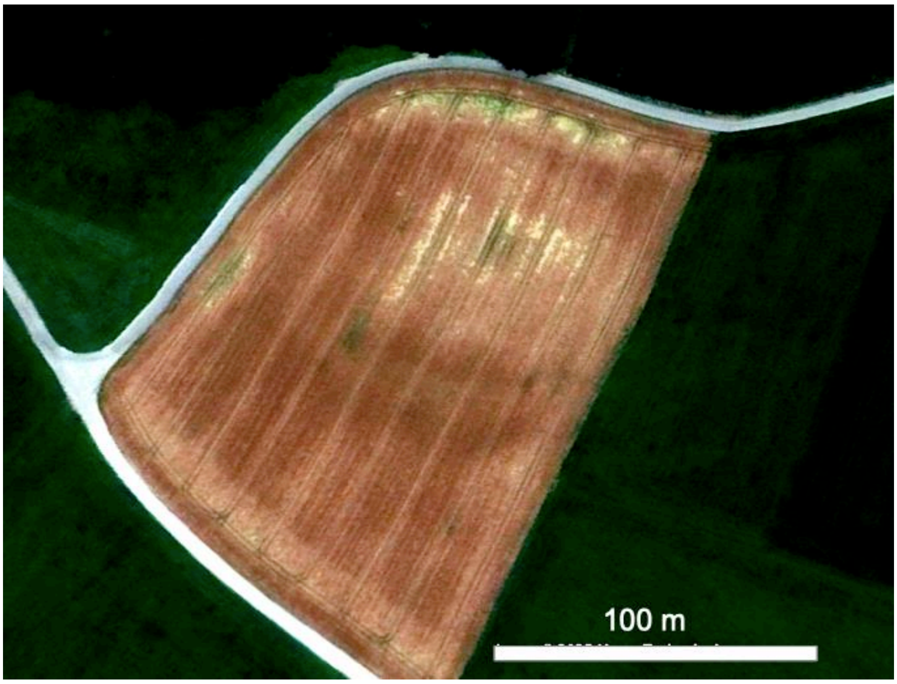


Fig. 3. Google Earth image of the Riederting structure. Multi-ring signature and a slight central uplift of light gravel.

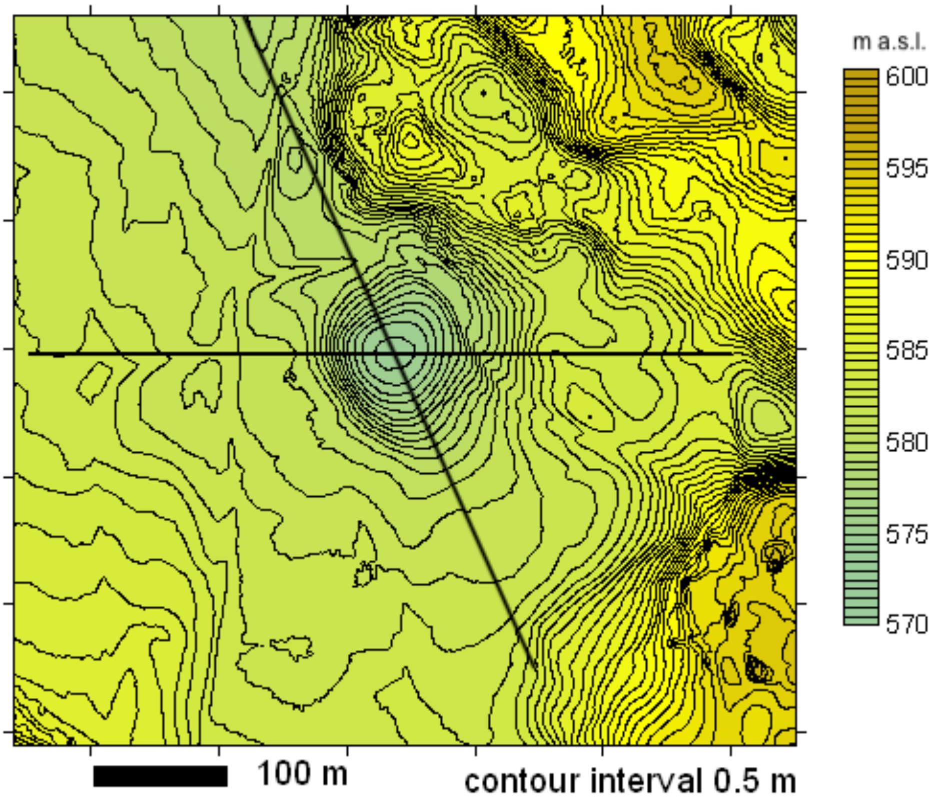


Fig. 4. Digital Terrain Model DGM 1 of the Riederting impact crater; topographic map.

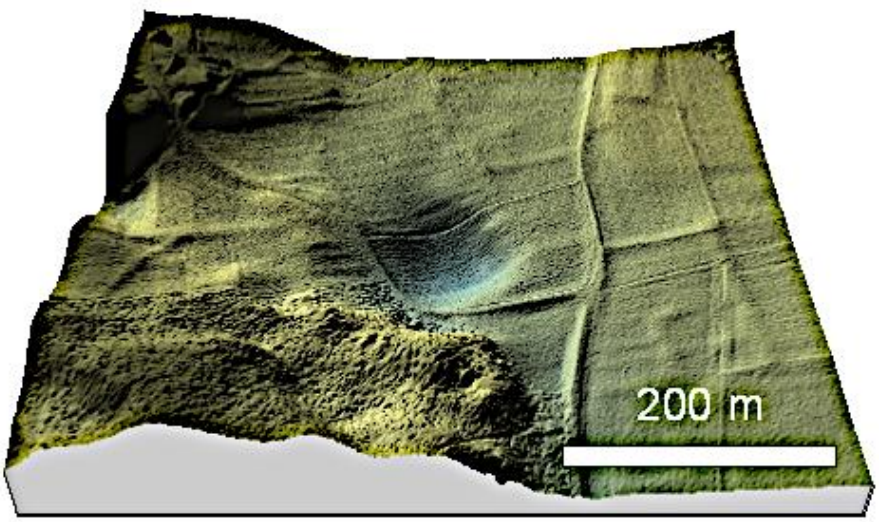


Fig. 5. The DGM 1 of the Riederting crater, 3D surface map; strongly enhanced.

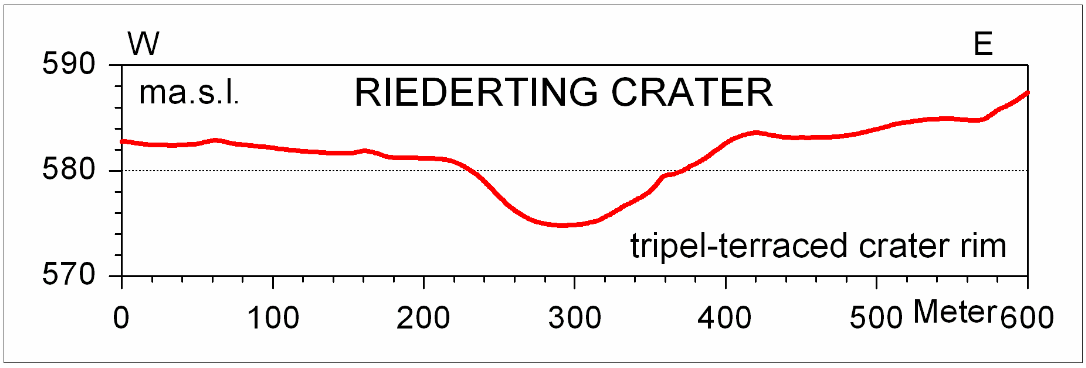


Fig. 6. DGM 1 profile; 8 m deep central bowl, multiple terraced-framed.

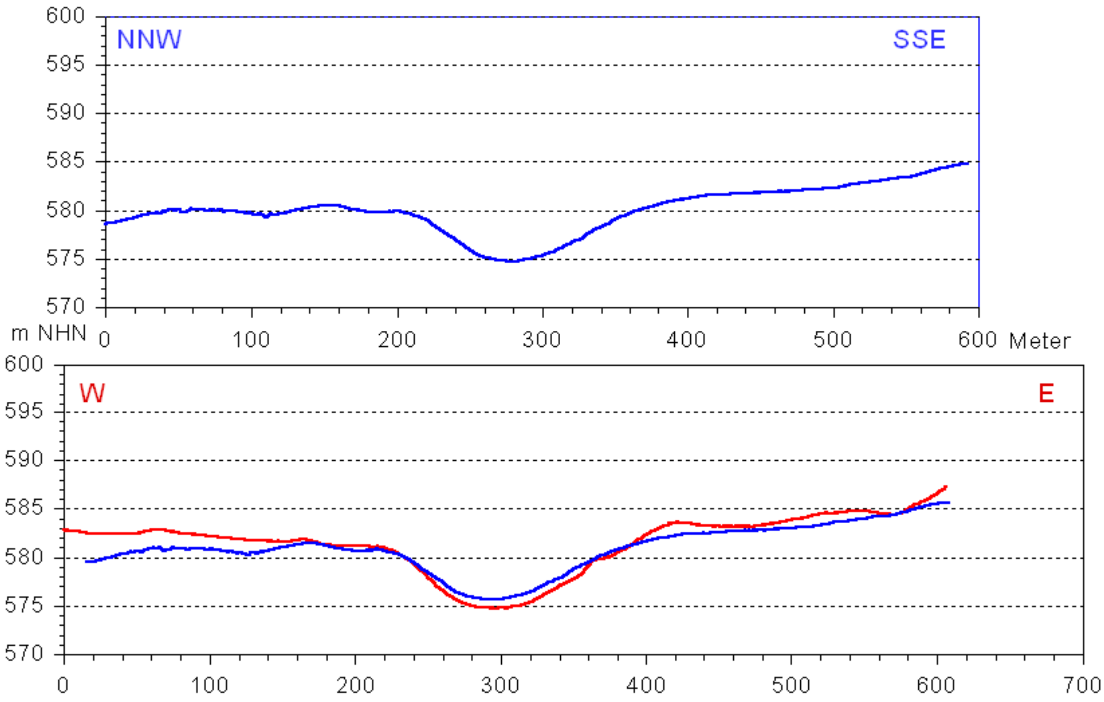


Fig. 7. Diametral profiles from Fig. 3. Elevation profiles through the Riederting crater structure. The almost identical overlap of the two profiles illustrates the nearly circular morphology.

Fig. 8. Riederting crater: Shock spallation of quartzite cobbles; impact into a Quaternary gravel target. - Experimentally, it is impossible to split the quartzites with a heavy hammer blow, and no farming equipment could have broken and split them. Clear evidence of shock spallation.

The Bergham crater

Fig. 9. The Bergham crater with an inner-ring signature.

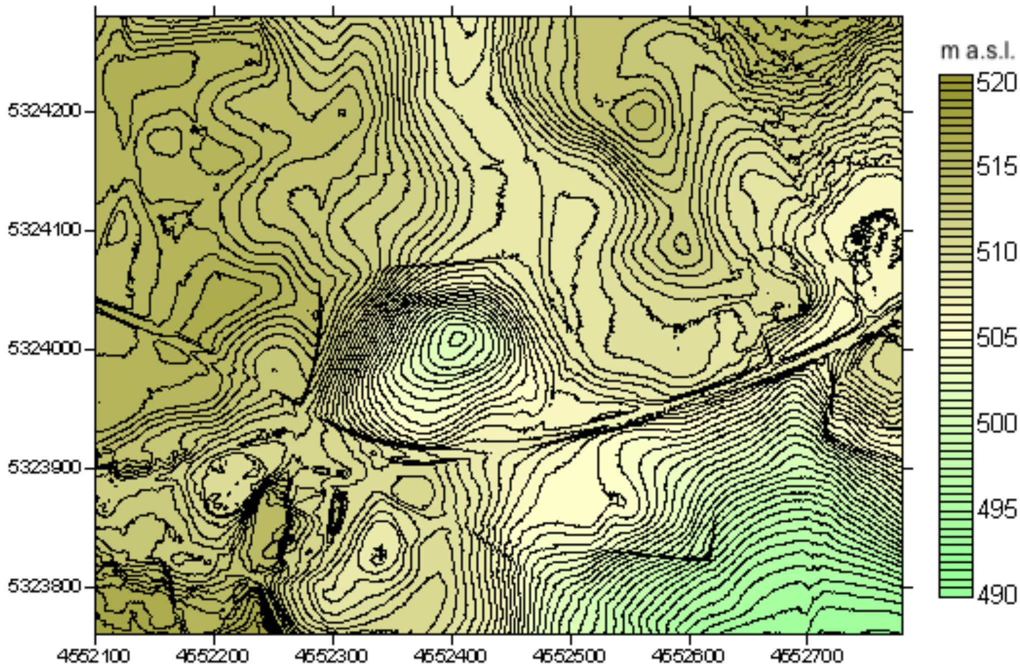


Fig. 10. The DGM 1 Digital Terrain Model of the Bergham crater; topographic map. Contour interval 0.5 m.

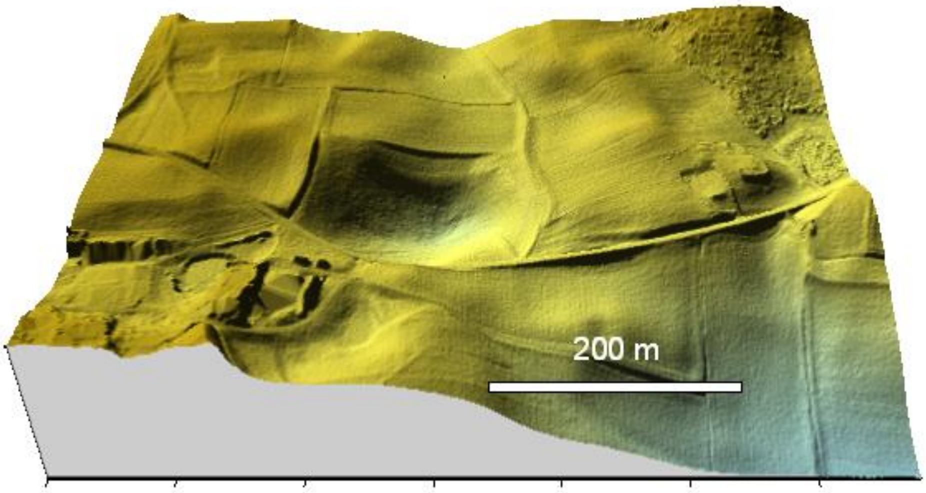
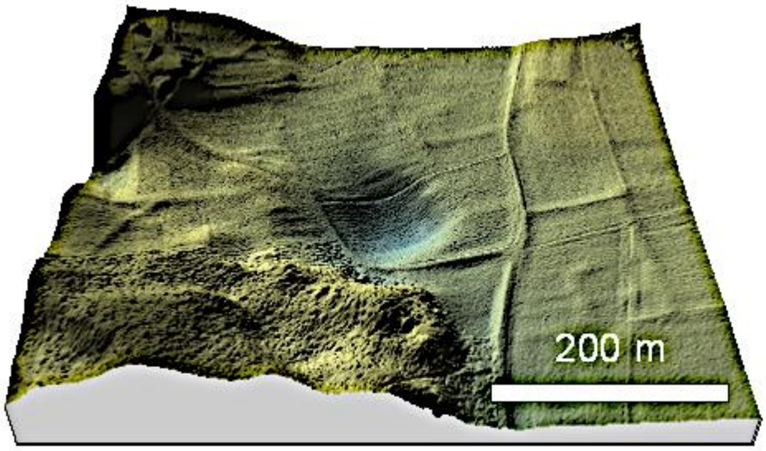


Fig. 11. The DGM 1 of the Bergham crater, 3D surface map; strongly enhanced.

Two of a kind

Fig. 12. Photos of the Riederting and Bergham craters.



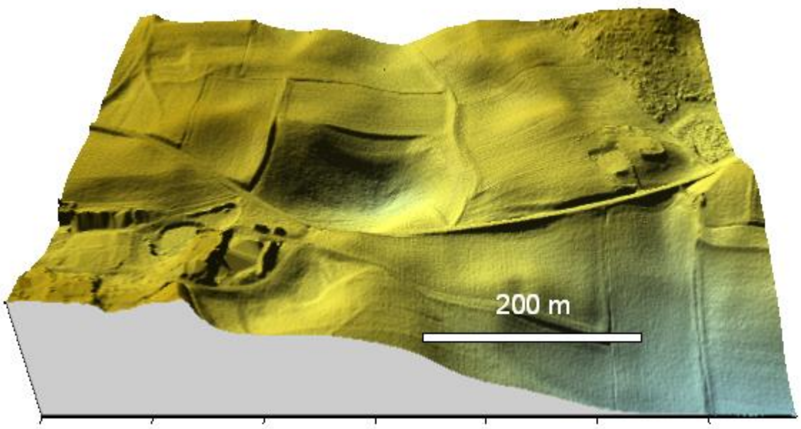
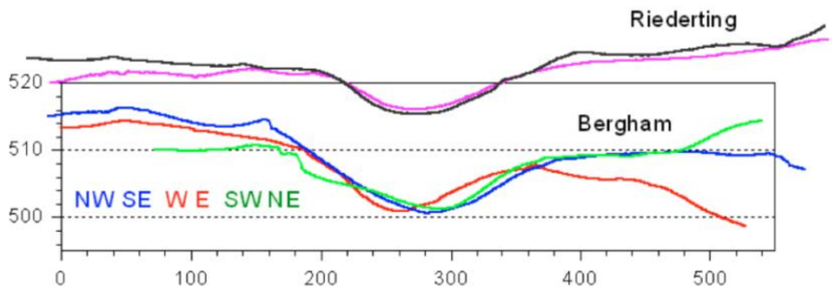


Fig. 13. DGM 1 surface maps; Riederting and Bergham craters.



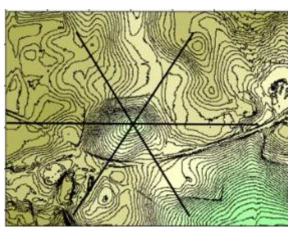


Fig. 14. There is a striking similarity between the Riederting crater (Fig. 7) and the Bergham crater (Fig. to the right), The same length and height scale applies to both structures.

3 The Seeon Natural-Document crater

Fig. 15. This natural monument near Seeon, which has its own Wikipedia article, has always been described by geologists and geomorphologists in maps and descriptions as a relic of the last ice age, a dead ice hole. Officially, it is also listed by the Bavarian State Office for the Environment (LfU) as a geotope that is particularly worth seeing. Google Earth 2017. - The DGM 1 data clearly shows that this dead ice interpretation cannot be upheld and that this photo of the natural monument is only the inner hollow form of a much larger impact structure.

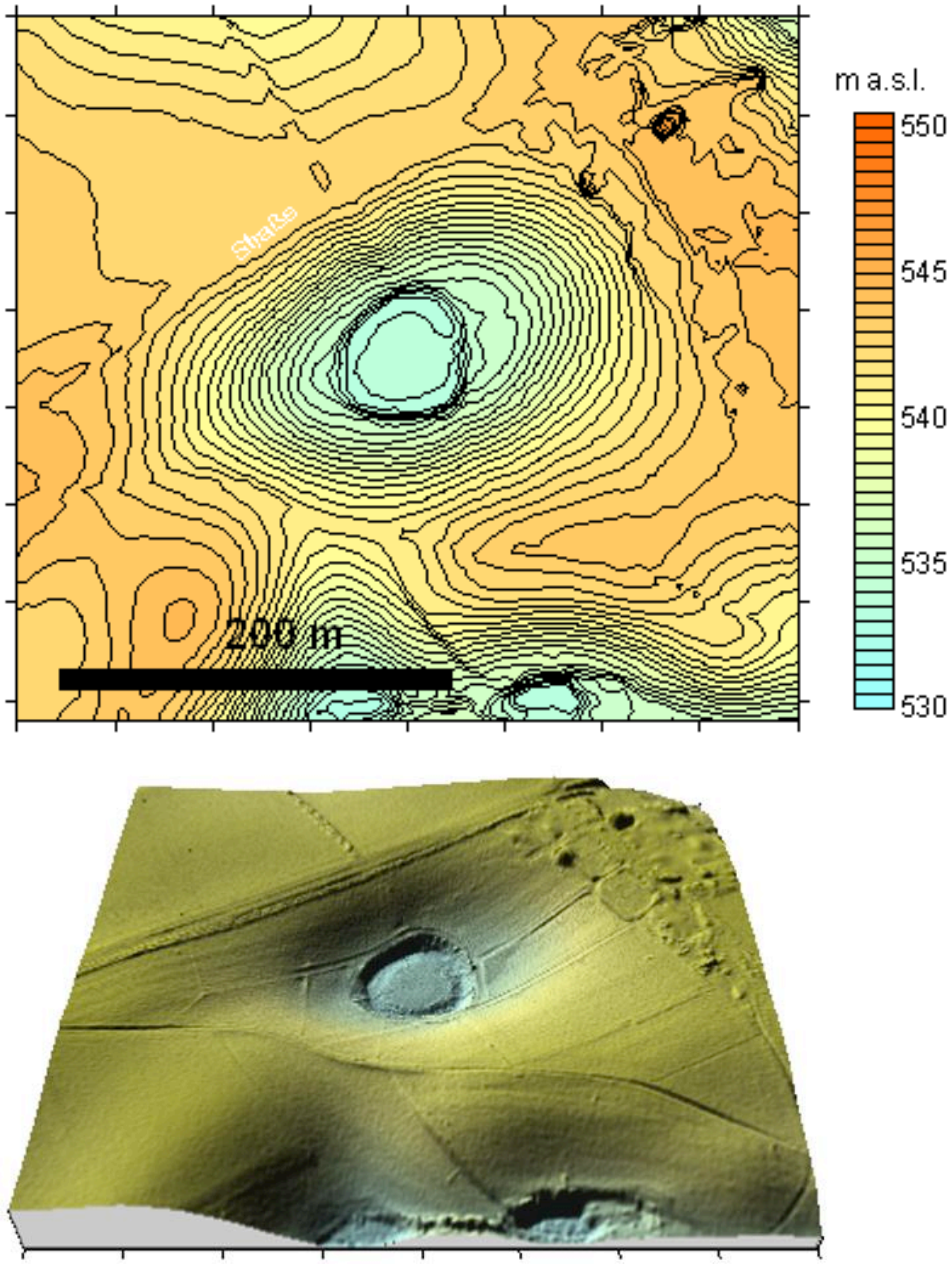


Fig. 16. The DGM 1 as topographic map and 3D surface map. The images prove that the dead-ice explanation is fundamentally incorrect in favor of a complex impact structure.

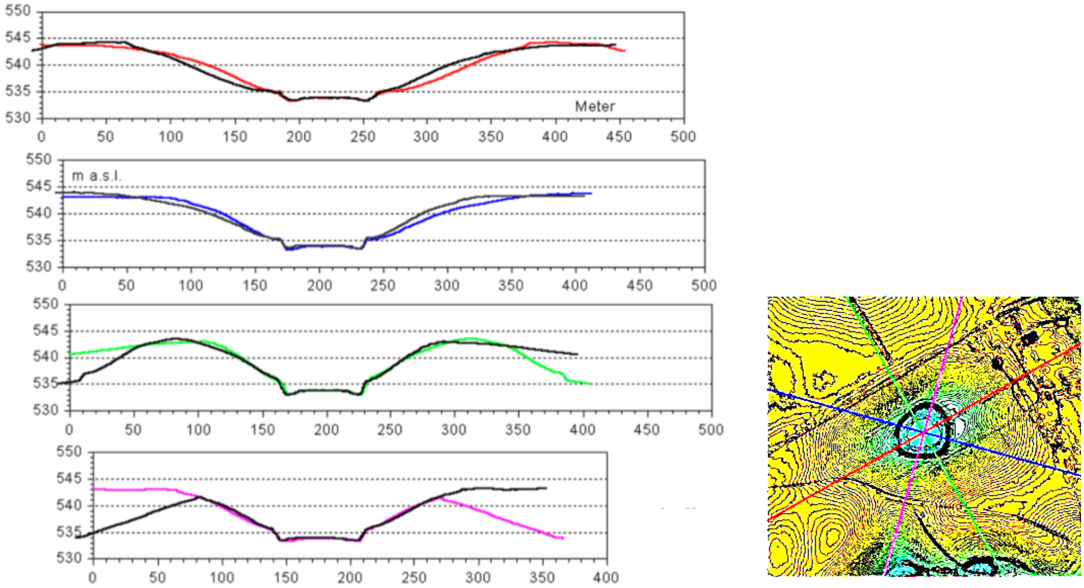


Fig. 17. Diametral DGM 1 profiles each superimposed with its mirrored profile. The precise fit over a distance of more than 200 m impressively demonstrates the circular symmetry of the structure.

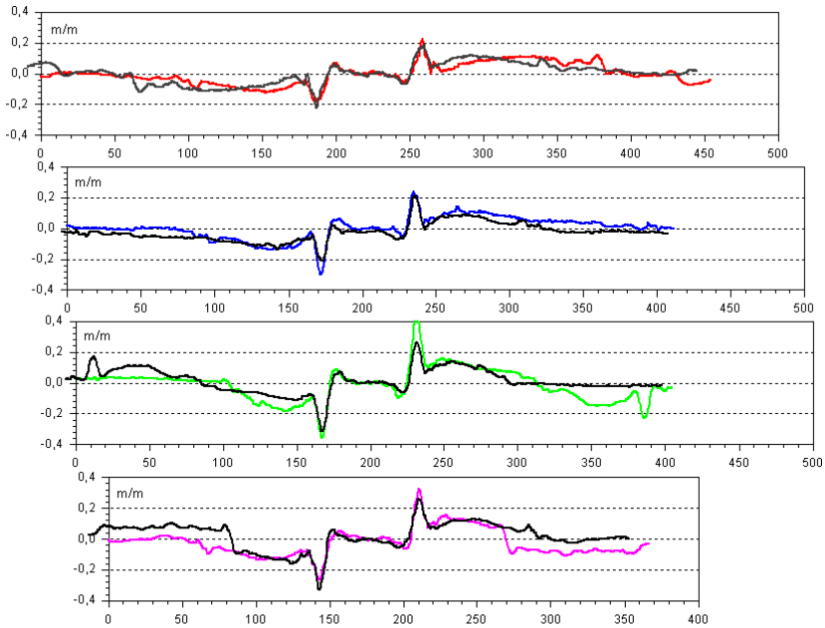


Fig. 18. Digital Terrain Model, terrain slope profiles (DGM 1 data gradient) and their mirror images (black). Even in the higher-resolution gradient profiles, the superimposition with the mirror profiles reveals the pronounced circular symmetry.

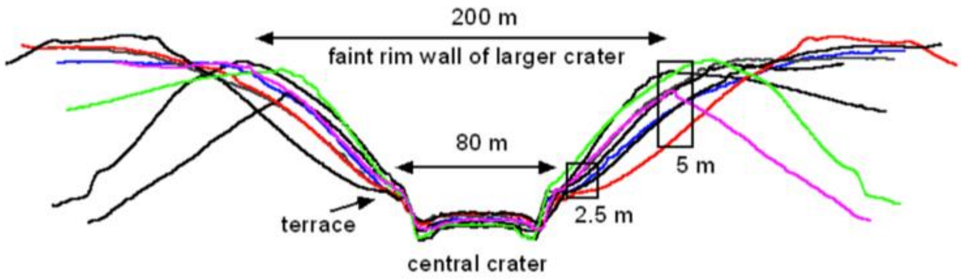


Fig. 19. Superposition of all diametral profiles and their mirror images reveal the complex terraced morphology.

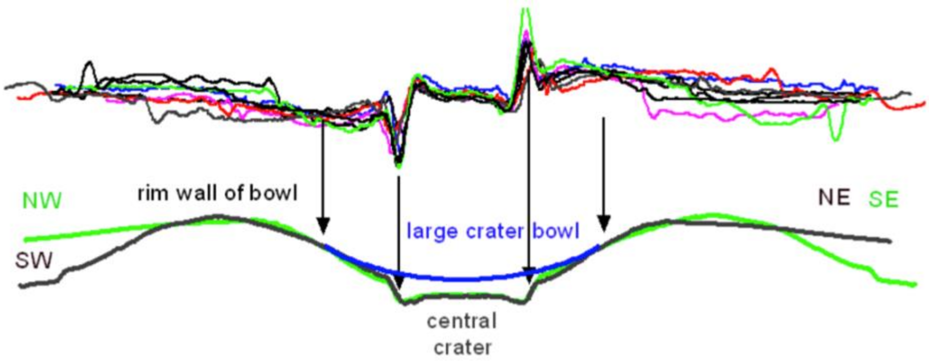


Fig. 20. The same holds true for the gradient profiles and the overlapping large crater bowl with the smaller central crater bowl.

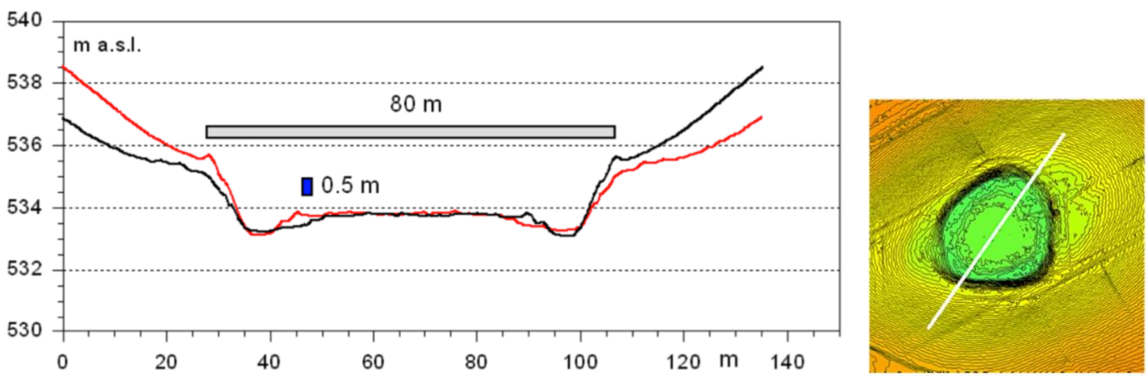


Fig. 21. DGM 1 diametral detail profile and its mirror image across the central "Natural Monument".

4 The Purkering doublet crater

2009

2011

Fig. 22. Google Earth maps 2009 and 2011 and topographic gradient map. The white spots are uplifted and excavated limestone and quartzite cobbles having penetrated the younger loess cover layer from below with the impact. The difference between uplift in the center and the ring of ejecta in the two years is explained by different agricultural procedures.

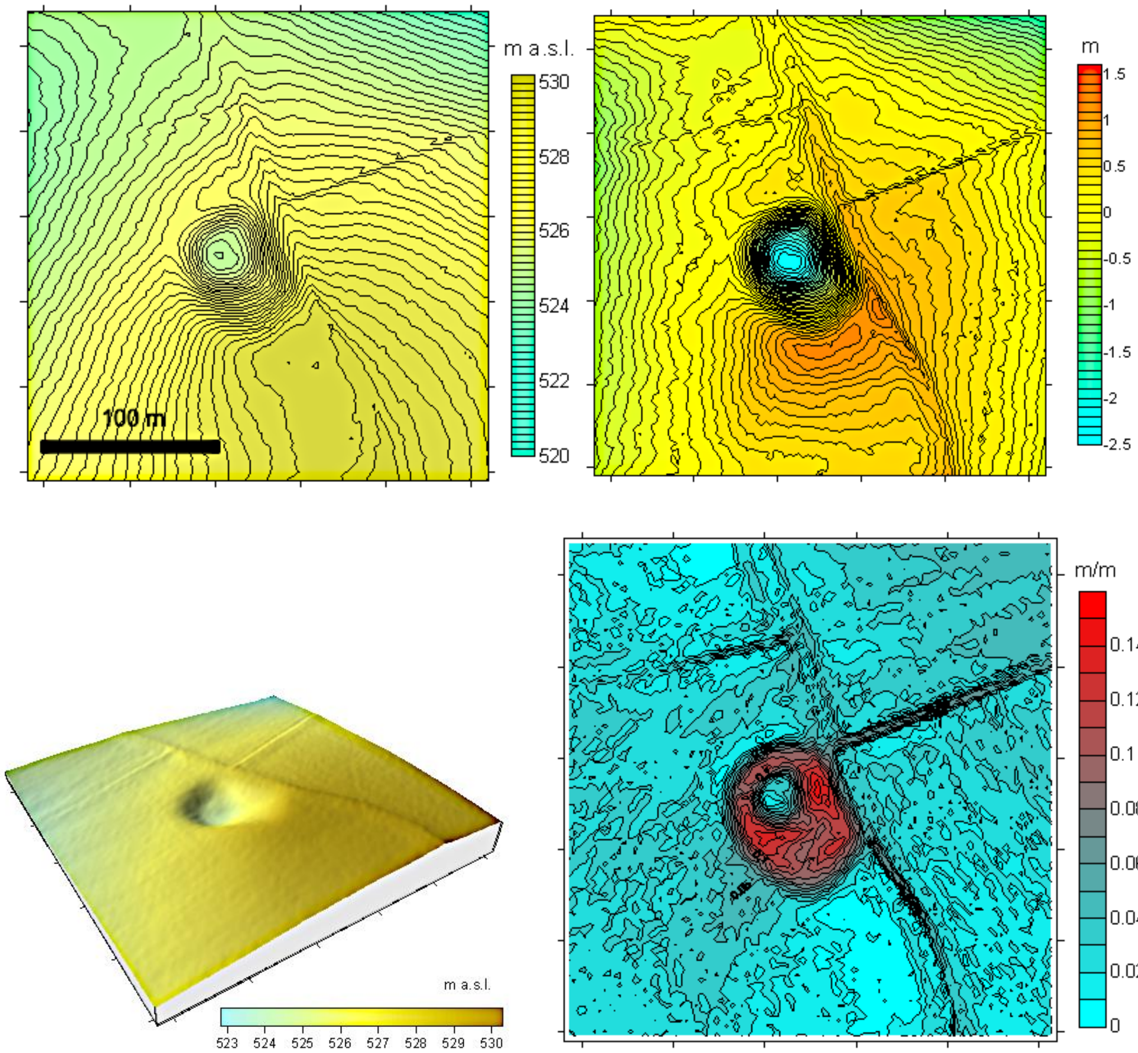


Fig. 23. DGM 1 SURFER data processing of the Purkering crater. Top left to lower right: Topographic map, contour interval 0.2 m. - Topographic map after subtraction of a trend field (moving average low-pass filter). - DGM 1 Surface map. - Map of DGM 1 data gradient (downhill gradient).

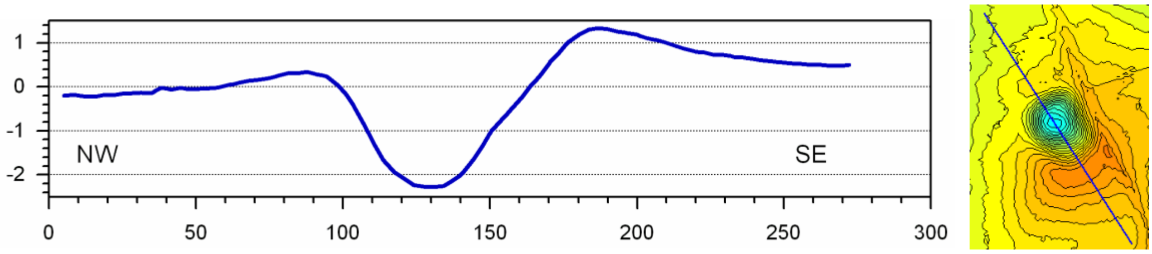


Fig. 24. Residual topography and diametral profile. The asymmetry may be explained by a doublet broken impactor or a strongly oblique impact, which has a companion feature on the Moon (Figs. 26).

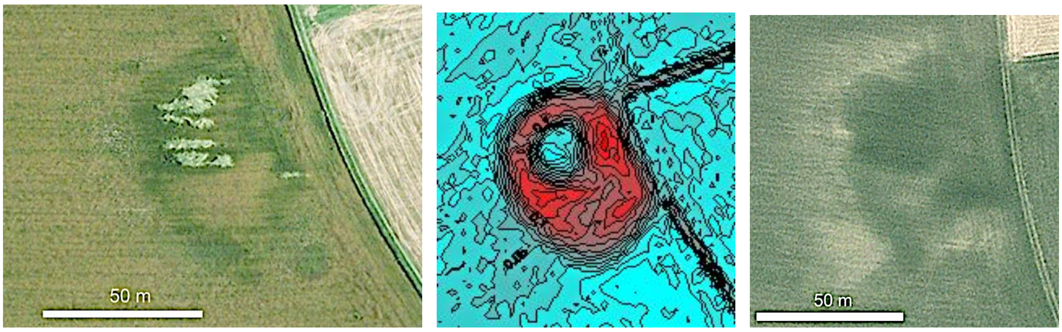


Fig. 25. Google Earth maps 2009 and 2011 and topographic gradient map. As explained in the Fig 22 caption the white spots are uplifted and excavated limestone and quartzite cobbles having penetrated the younger loess cover layer from below with the impact. The correspondence with the DGM 1 gradient map is significant.

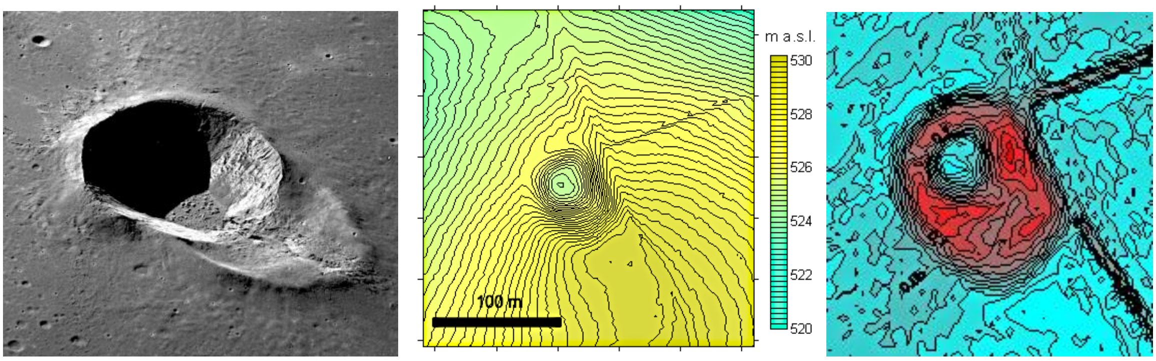


Fig. 26. The Messier A crater on the Moon has given rise to much speculation about the origin of its unusual shape. A doublet synchronous and a strongly oblique impact are most discussed. Apart from the strongly different size (11 km for Messier A, NASA photo) the similarity is unmistakable.

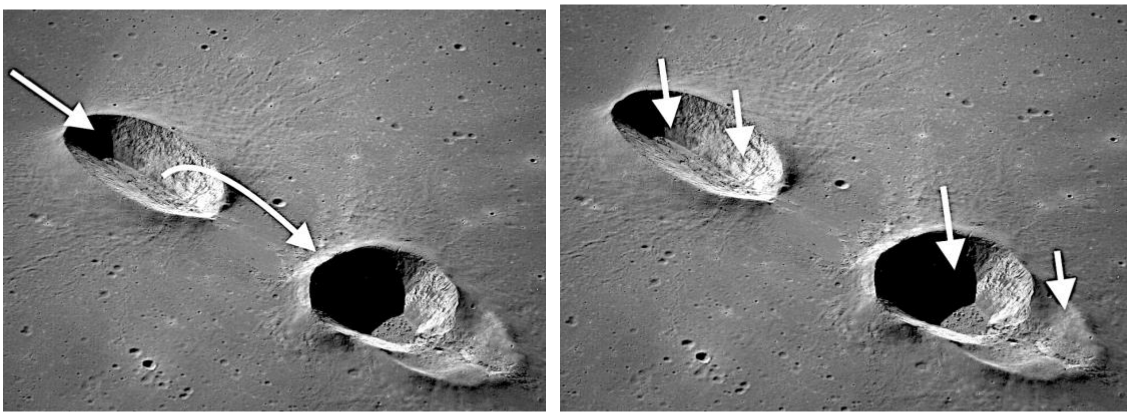


Fig. 27. Messier and Messier A craters. NASA photos. A third hypothesis suggests that Messier A is a secondary impact from the impact of Messier. (our left image). In terms of size, this is not very plausible. There is no mention of a multiple impact from a swarm of asteroids (our right image).

5 The Windschnur crater

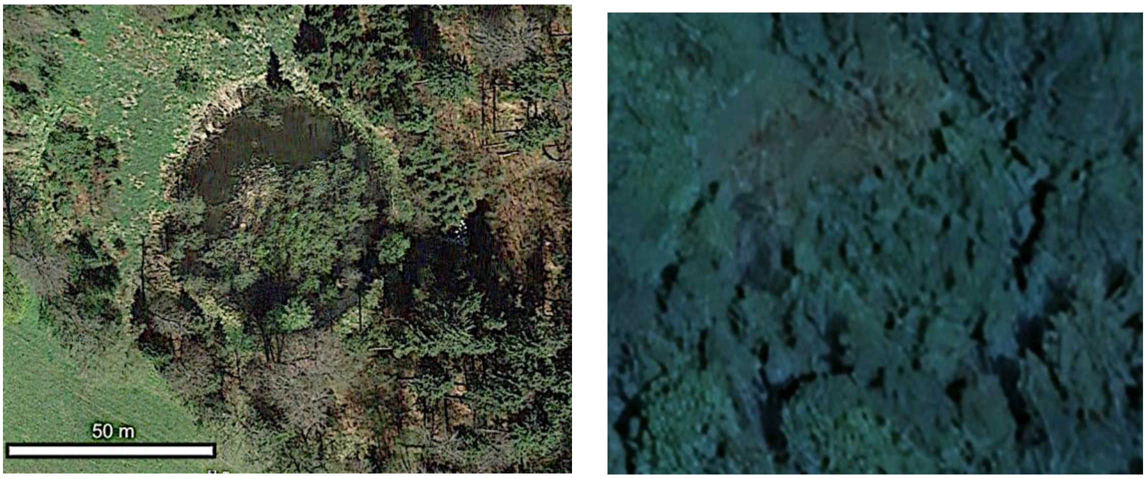


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Fig. 28. The Windschnur crater, Google Earth 2017 and 2025. In 2025, the DGM 1 completely "ignores" the crater and morphological details in the dense forest (Fig. 29-31).

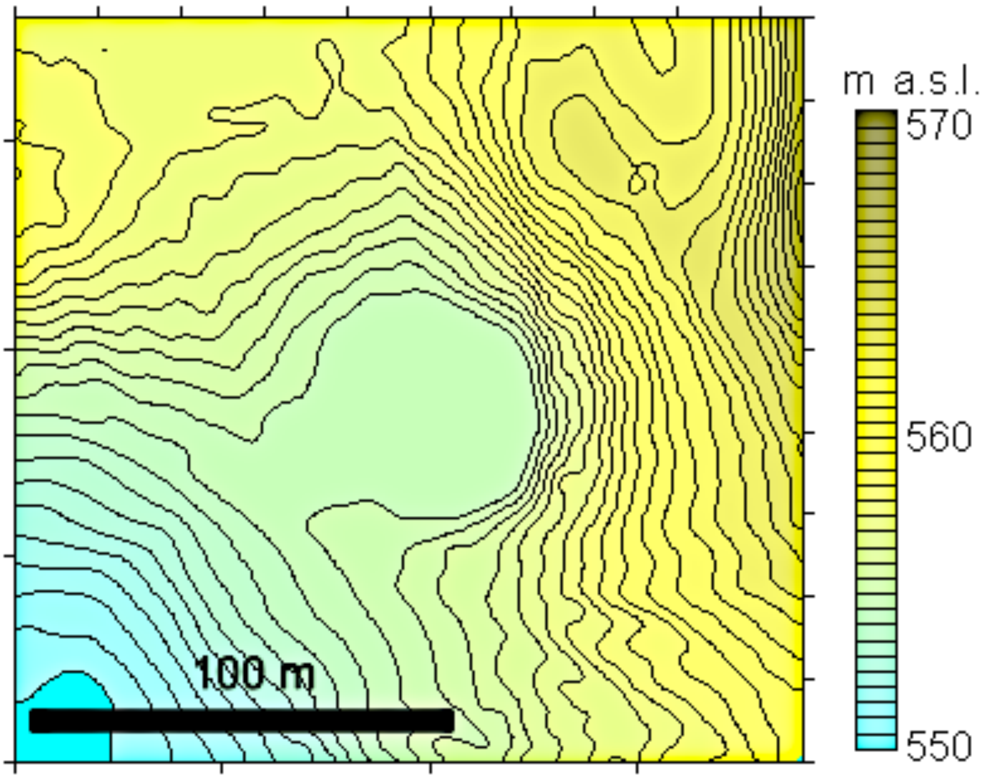

Fig. 29. DGM 1 topographic map, contour interval 0.5 m. The opening or flattening of the rim wall to the southwest can be explained by a partial collapse of the crater and reflux of wall masses downhill immediately after the impact.

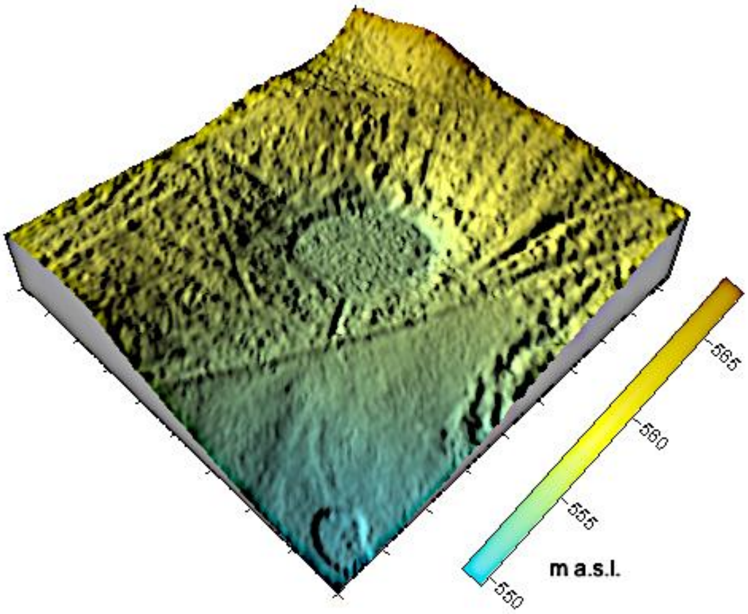

Fig. 30. The Windschnur crater as a DGM 1 surface map. Note the accumulation of larger blocks around the inner rim wall, obviously ejected with the impact cratering (enlargement in Fig. 31). The rib systems are probably man-made (early medieval plow marks?) and have nothing to do with the impact.

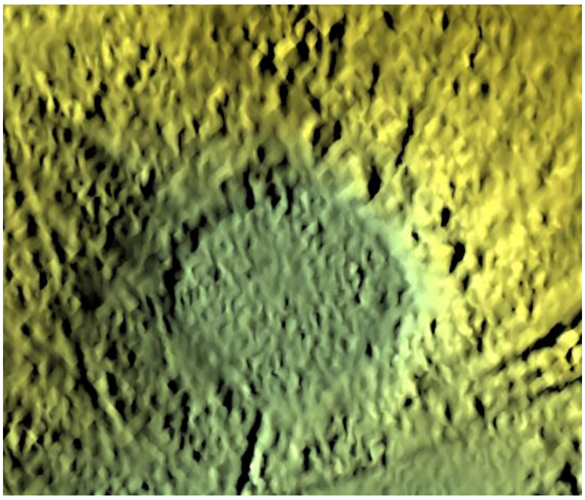

Fig. 31. The larger blocks of ejecta indicate that the impact excavation reached down into the underlying Tertiary rock. It is also possible that Pleistocene cemented conglomerate banks (Nagelfluh) were excavated. The geological mapping does not provide any information on this.

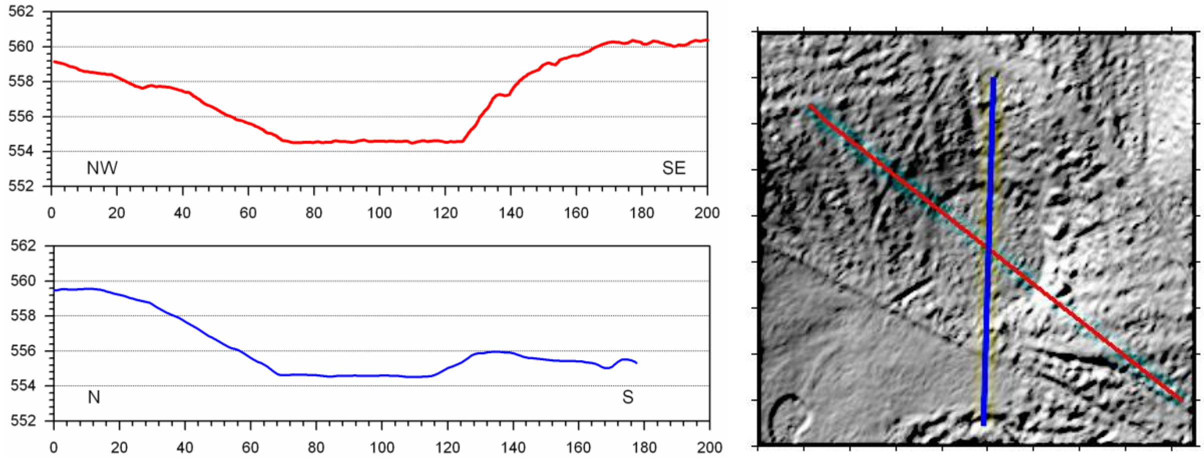

Fig. 32. DGM 1 profiles across the Windschnur crater.

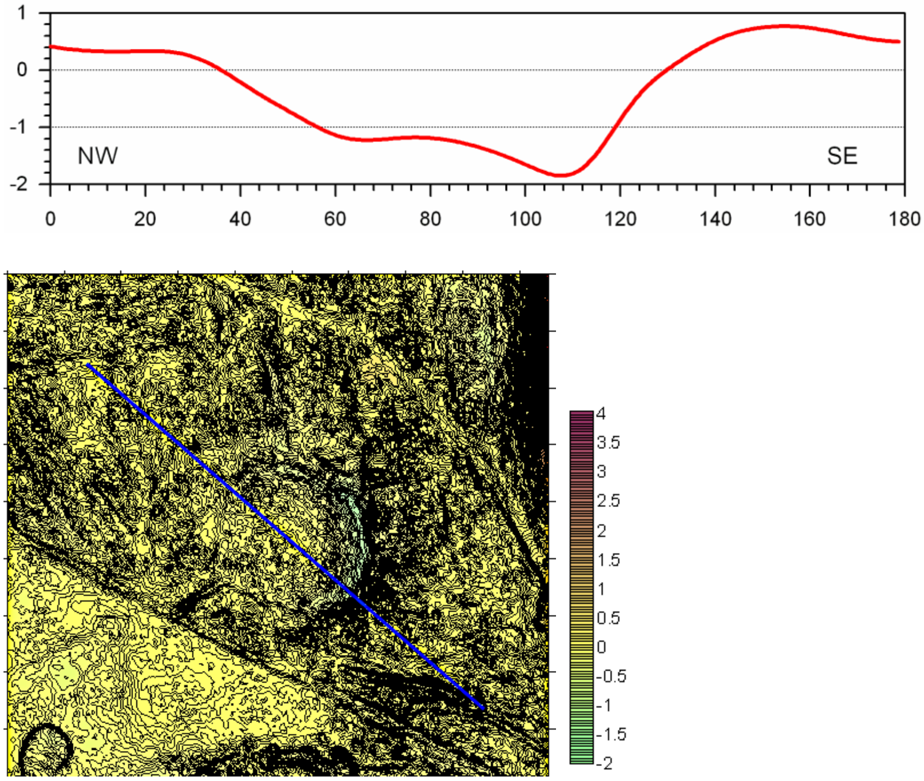

Fig. 33. The Windschnur crater after removal of a terrain trend field. The profile highlights a central elevation that may have been created when the ejected ring wall collapsed, which may correspond to the findings in Fig. 29.

6 Discussion and Conclusions

Several years ago, research into the Chiemgau impact was given a huge boost by the application and analysis of the extremely high-resolution digital terrain model, which can now be acquired online free of charge in the form of the original data sets for the entire crater strewn field and the closer and wider area around the Chiemgau crater strewn ellipse. With this data and the enormous possibilities of modern graphics programs, impact research has led to a paradigm shift, which is justified in particular by the new findings on the Chiemgau impact and the widespread newly recognized impact fields in Central Europe between the Czech Republic and the Lorraine-French border (Poßekel et al. 2022). While the Canadian database mentions around 200 names worldwide as established, apparently proven impact structures (which has been repeatedly criticized, e.g., Claudin and Ernstson 2023), a paradigm shift becomes clear with the simplest geological considerations together with the results of the digital terrain models that are now increasingly available in many countries. The key lies in the extreme resolution of the terrain surface, horizontally and vertically, down to the decimeter and centimeter range, whereby the DTM removes buildings and vegetation with sophisticated data processing, so that even in the densest forests the bare ground is recorded and made available to the user in corresponding data sets (x, y, z). For impact research, it initially has the following consequences:

-- Crater or general impact traces are recognized even in the densest vegetation, such as in dense forests, probably also in jungle regions, or inaccessible swamp areas.
-- Extremely shallow crater structures with surrounding very shallow ring walls are seen.
-- Craters with completely new shapes such as central-peak craters, and terraced and wavy crater rims are described, as they are now published from the Moon and Mars (Rappenglück et al. 2021, Poßekel et al. 2022, Ernstson et al. 2024, Ernstson and Poßekel 2024).
-- Impact structures are recognized, which are observed during severe earthquakes and must therefore be attributed to the quakes triggered by impacts (Ernstson and Poßekel 2024).
-- Craters are described that are geologically very young and, due to their extreme flatness, are subject to geological erosion and sedimentation and quickly disappear again. This effect must of course be thought back into the geological past.
-- The newly conceived considerations and hypotheses on airburst impacts in connection with comets and asteroids and a focus on low-altitude so-called touchdown airburst impacts (West et al.2024) cannot be better supported than by the new observations with the digital terrain model.

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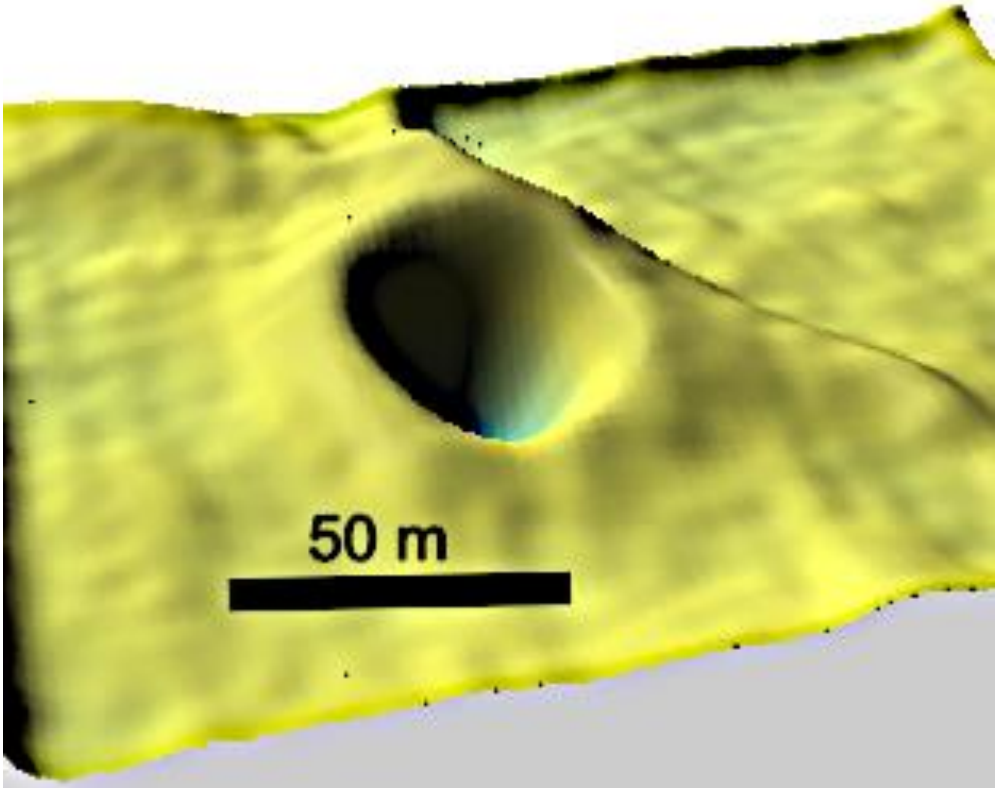
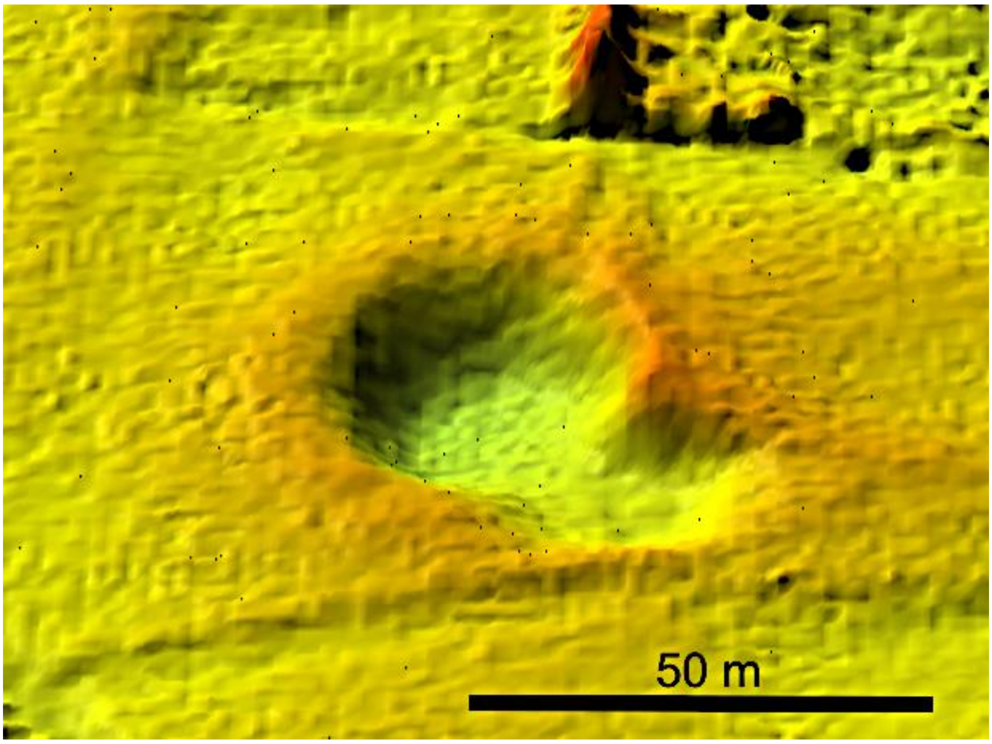
APPENDIX

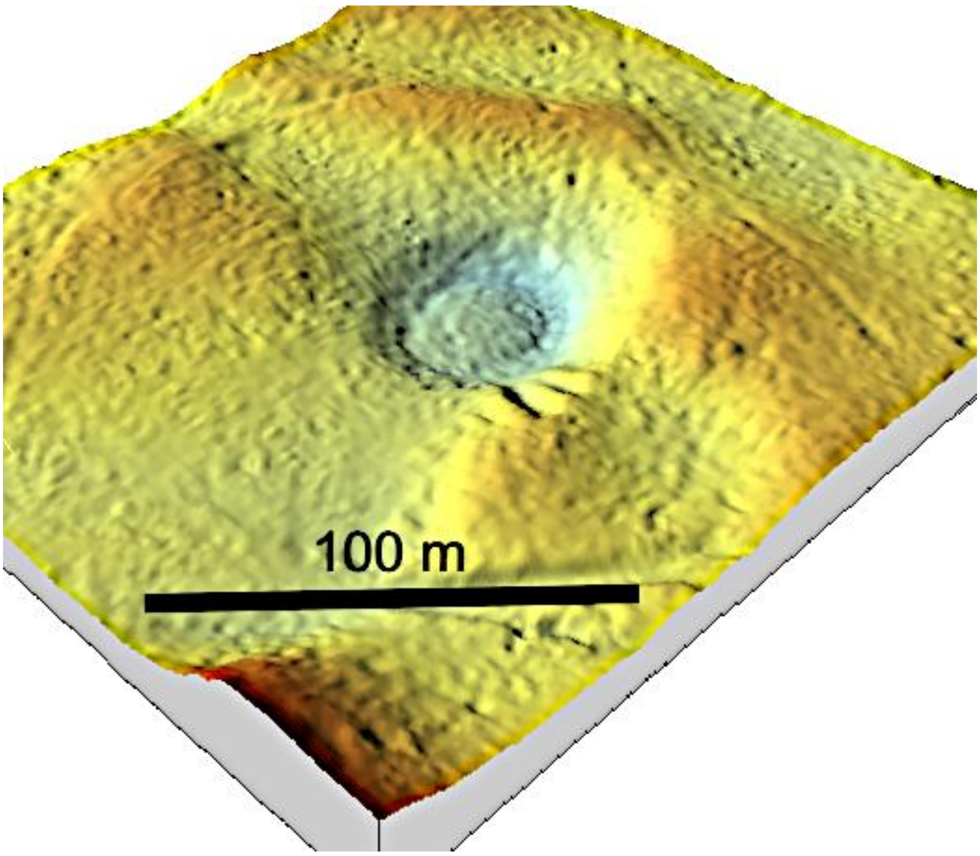
A selection of a few more medium-sized Chiemgau impact craters. Digital Terrain Models DGM 1 as 3D terrain surface maps after removal of a long-wavelength morphology trend (2D moving average low-pass filtering of the DGM 1 data). Note the strong exaggeration of the images.



Engelsberg

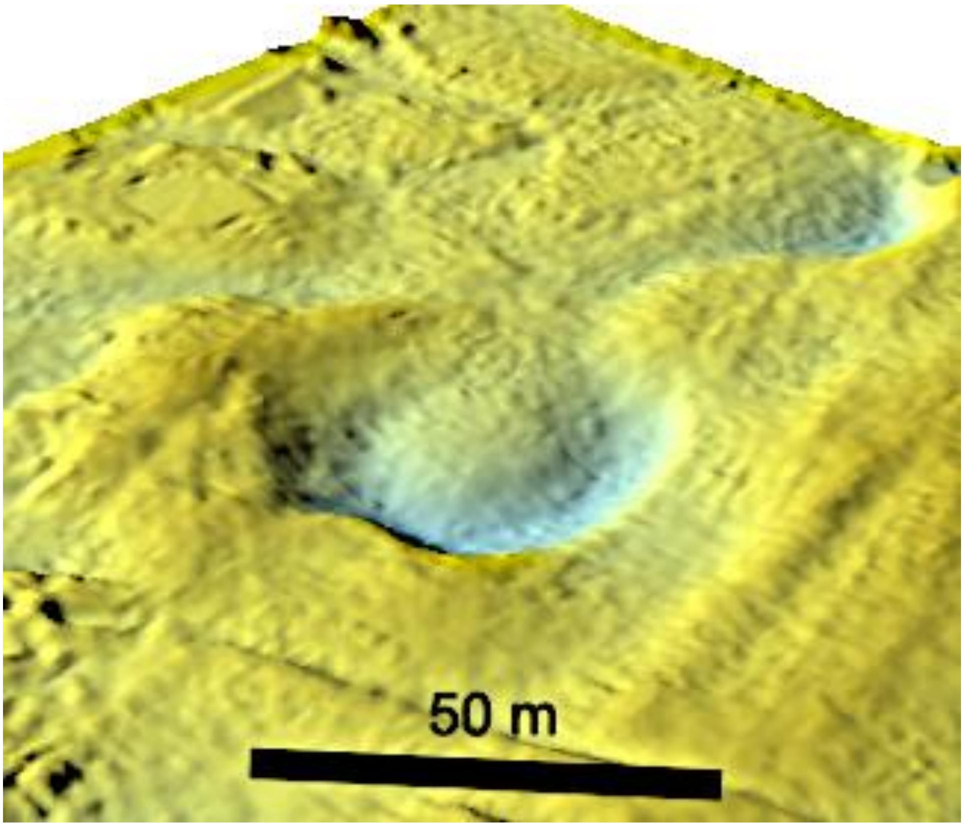


Palling SW doublet crater



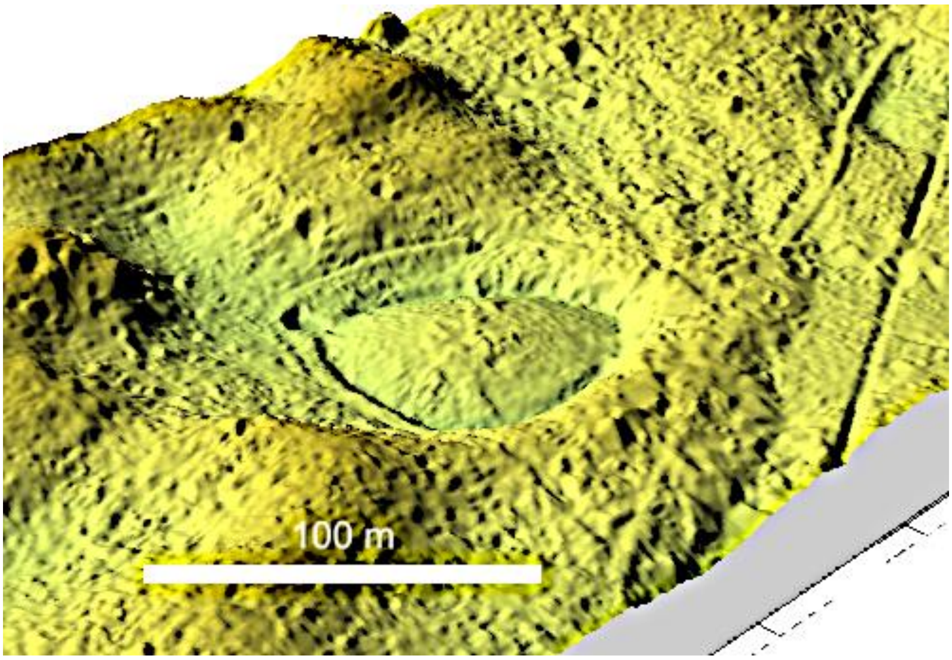
Seeon

Neubichl N

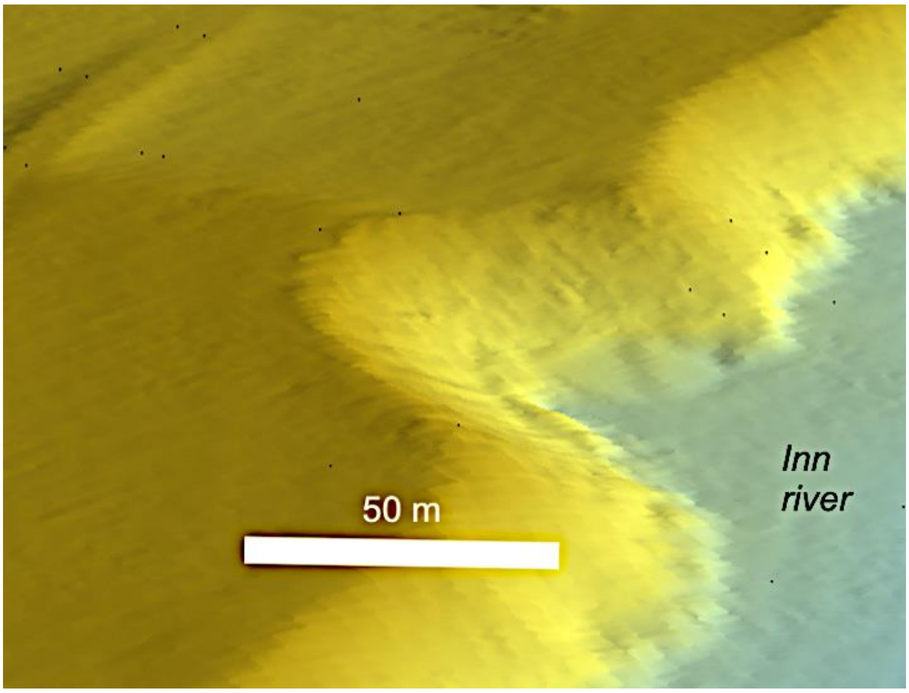


Seeon Neubichl S

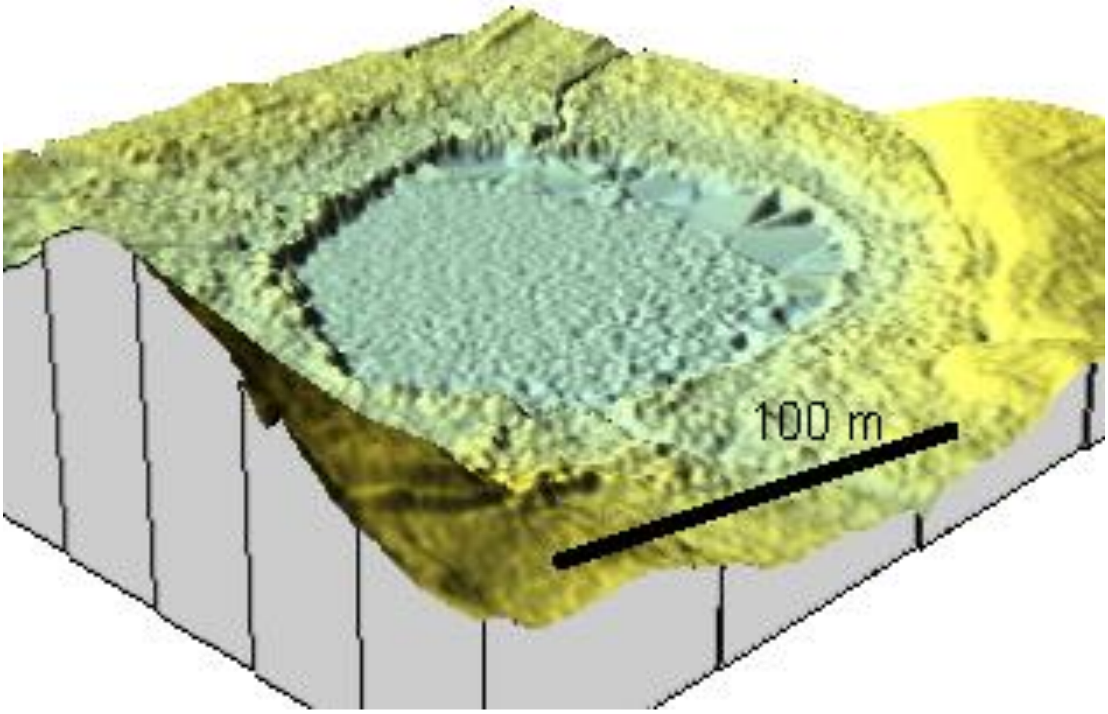
in the valley embankment of the Inn River.



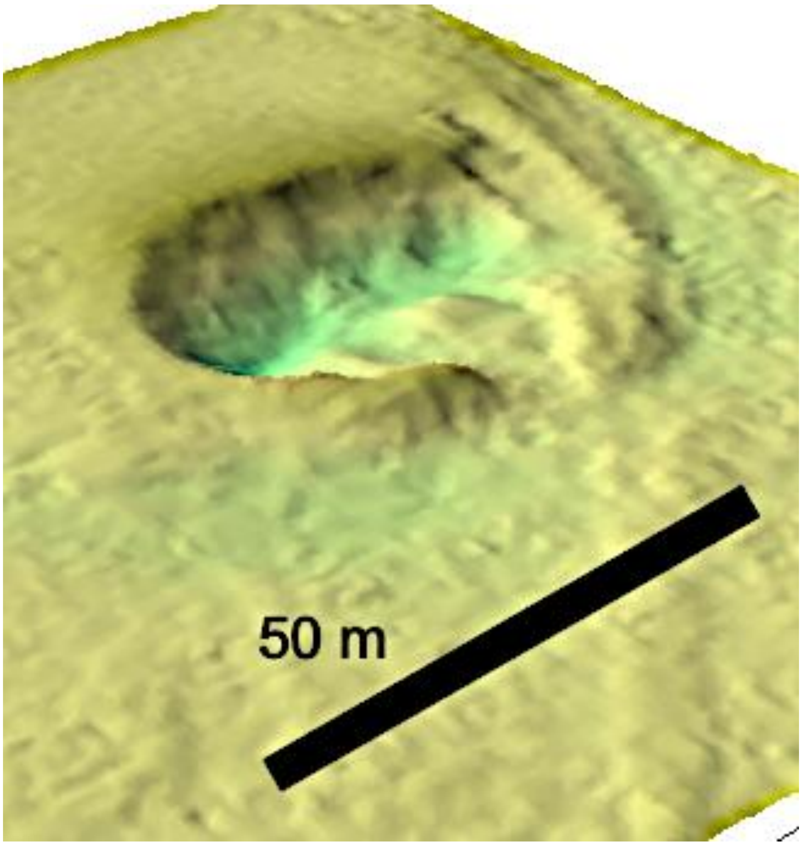
Windschnur N



Aiching semi-crater in the valley embankment of the Inn River.



Lake
Laubensee crater



small Lake Mittersee companion crater