High-resolution digital terrain models, Rayleigh-Taylor/Kelvin-Helmholtz instabilities, and hydrocode modeling: evidence of a Holocene low-altitude "touchdown" airburst iimpact event over Central Europe from the French border to the Czech Republic

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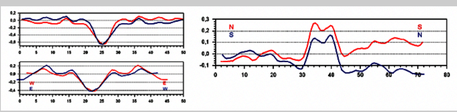
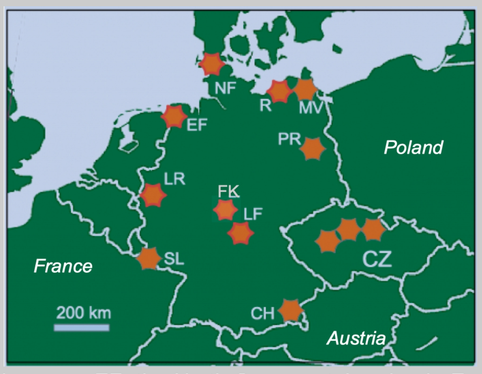
ANNOTATIONS This poster was designed in the format used for the MetSoc's Meeting presentation and created as a PDF in the same size. It can be downloaded here in this format and, at the same time, significantly enlarged on your computer monitor, so you can examine the text and image details in high quality.
-- You may notice that the figure presentations and captions lack a certain degree of systematic organization. This is due, on the one hand, to the fact that it is essentially a compilation of previous publications (marked with DOI numbers); on the other hand, it also serves to highlight the extent to which new insights into impacts have been made possible by the enormous diversity of data processing and graphical representation in this new field of impact research.
--The wondrous world of digital terrain models, with their extremely high-resolution maps and the terrain profiles derived from them, with resolutions down to the centimeter.This is the central point of an airburst-impact interpretation that rules out normal geogenic or anthropogenic origins, when mirror-image symmetries of profiles along crater stretches of up to hundreds of meters can be derived from the DGM with differences often amounting to only a few centimeters—evidence of central deformation from above. To avoid having to provide this explanation repeatedly for all the craters discussed, the following image shows examples of crater profiles (undulating crater rim and mushroom-shaped crater) with typical mirrored and superimposed diametrically opposed crater profiles.



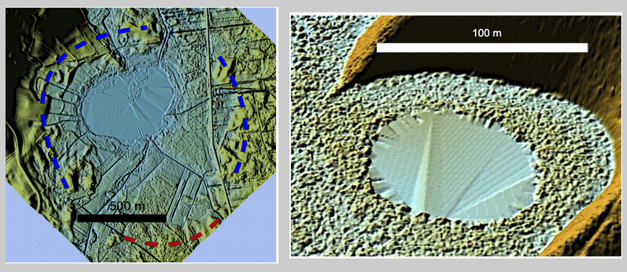
--Please note that for the majority of the fields and profiles, a terrain trend (by 2D moving-average low-pass filtering) has been subtracted, thereby centering the data at zero, which brings out morphological crater details much more clearly.

Introduction: Since the discovery of the Chiemgau impact field over 20 years ago, nine additional impact fields have been documented in Germany and several scattered across the Czech Republic (see location map below), for which the following impact signatures have been identified to date. Strong shock metamorphism Saarland (SL), Chiemgau (CH), Lower Rhine (LR), Czechia (CZ); shatter cones SR, CH; hydrocode modeling SL, CH; geophysics LF SR, CH; Rayleigh- Taylor and Kelvin-Helmholtz instability structures: all strewn fields [1-6]. A significant characteristic of a low-altitude airburst impact in all fields is the high-resolution Digital Terrain Model DGM 1 (m to dm horizontally, dm to cm vertically), which describes even very complex impact structures in detail - such as known from RTI and KHI fluid dynamics - and, in most cases, definitively rules out geological (e.g., ice age) and anthropogenic origins. First hydrocode modelings (see below), obviously for the first time for a "touchdown" impact, are in good agreement with observations. Here, we show DGM 1 examples of impact features from the so far documented strewn fields, underlining the strong impact variabilities and the enormous potential of the DGM 1 analyses and computer graphics.



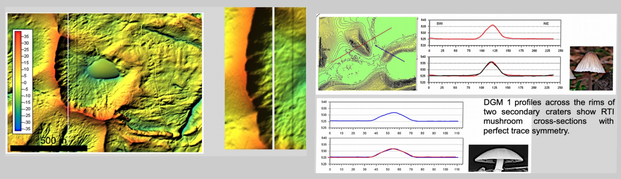
Location map; EF: the North Sea coastal region in East Frisia; NF: the North Sea coastal region in North Frisia; R, MV: the Baltic Sea coastal region in Mecklenburg-Western Pomerania, R Rostock SL: Saarland, PR Premnitz, LR Lower Rhine, CH Chiemgau, FK Fulda Kauten, LF Lower Franconia, CZ Czechia.

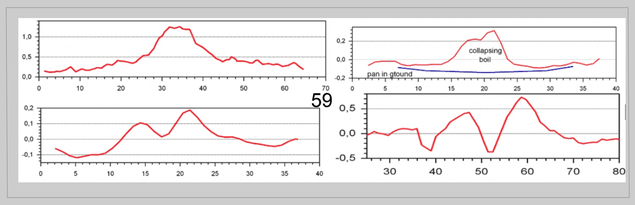
Rayleigh-Taylor instabilities



Chiemgau impact: splashed blocky rim (blue) and RT finger structures (red) - Right: The Schernsee Crater as a DGM 1 3D block model of the terrain surface, viewed at a slight angle. - The sawtooth pattern along the lake's edge turns out to be a circumferentially periodic arrangement of roughly equidistant, roughly equal-sized boulders, which almost perfectly document a RTI movement structure that originated from a central circular impact load.

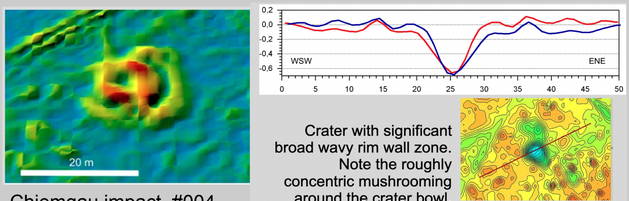
Rayleigh-Taylor finger... ... and mushroom cratering





Various stages of increasing mushrooming from bowl- shaped impact.

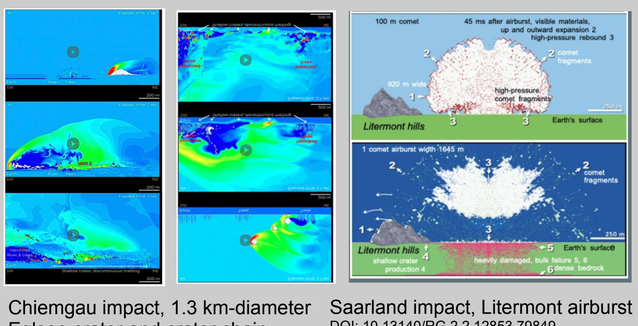
Kelvin-Helmholtz instabilities, wavy cratering



Chiemgau impact, #004 Emmerting crater.

Crater with significant broad wavy rim wall zone. Note the roughly concentric mushrooming around the crater bowl. The superposition of the red profile and its blue mirror shows remarkable trace symmetry over 50 m

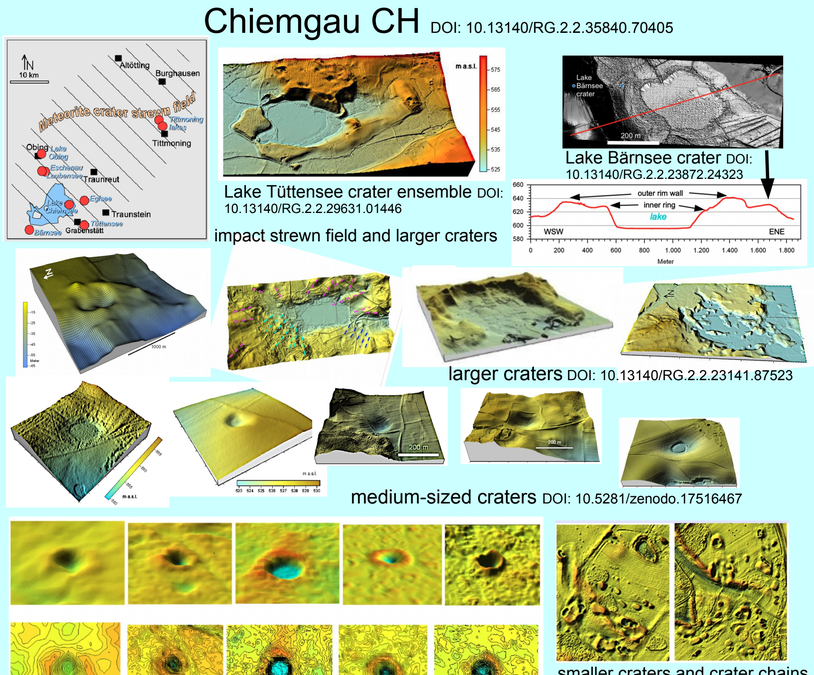
Hydrocode modeling of low-altitude touchdown airburst impacts



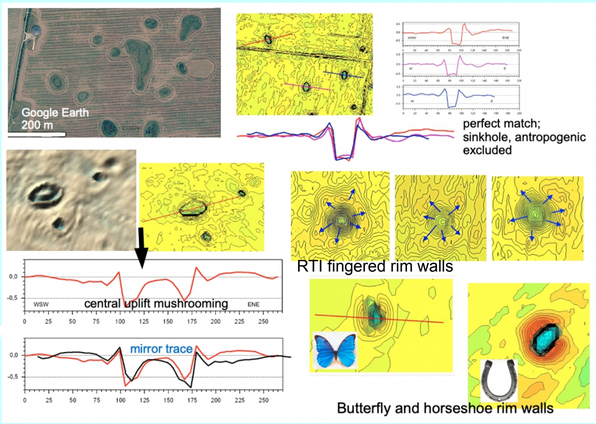
Chiemgau impact, 1.3 km-diameter Eglsee crater and crater chain
DOI: 10.13140/RG.2.2.17385.76649

Saarland impact, Litermont airburst
DOI: 10.13140/RG.2.2.12853.79849

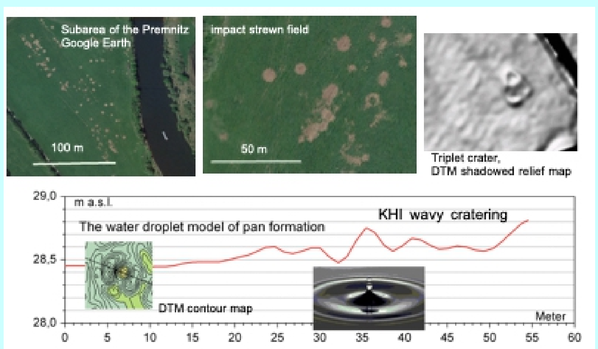
Chiemgau CH DOI: 10.13140/RG.2.2.35840.70405



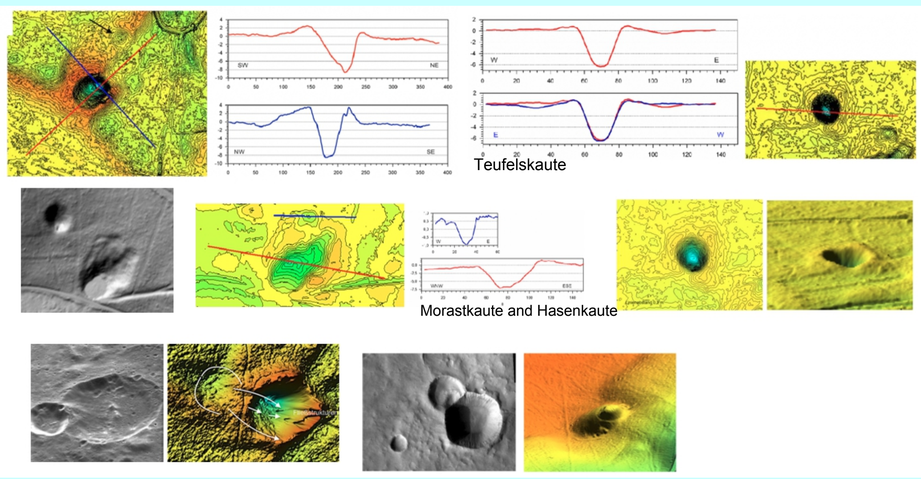
Baltic Sea coastal region, R MV



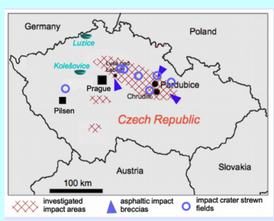
Premnitz PR DOI: 10.13140/RG.2.2.16846.22089



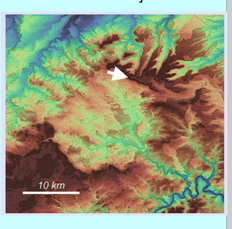
Fulda Kauten DOI: 10.13140/RG.2.2.33409.36963

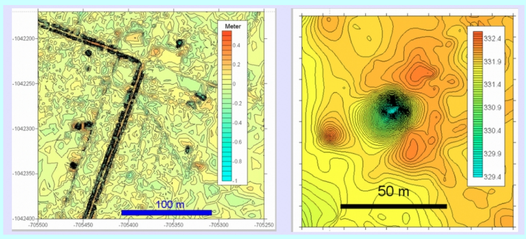


Czech Republic CZ [DOI: 10.13140/RG.2.2.17849.65123]

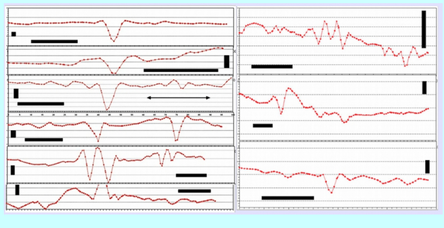


This rough overview deliberately shows only eye-catching label-like references for the many subject areas, which can be clicked on (the numbers in the headings) to access links to the existing comprehensive poster contributions to the LPSC, AGU, and MetSoc conferences..



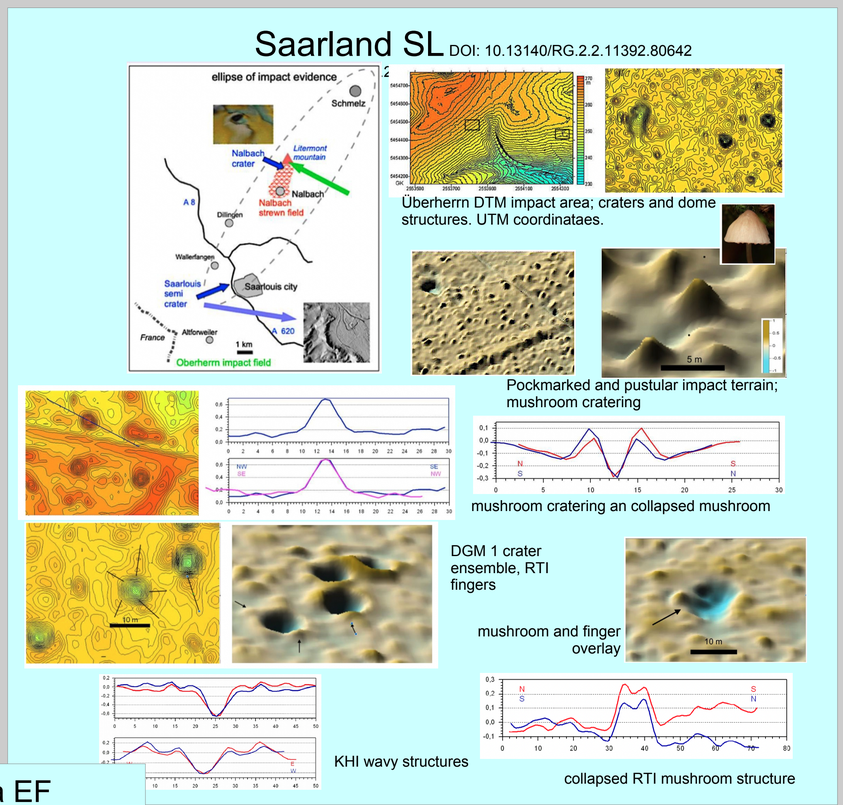


cluster of smaller craters and a double crater

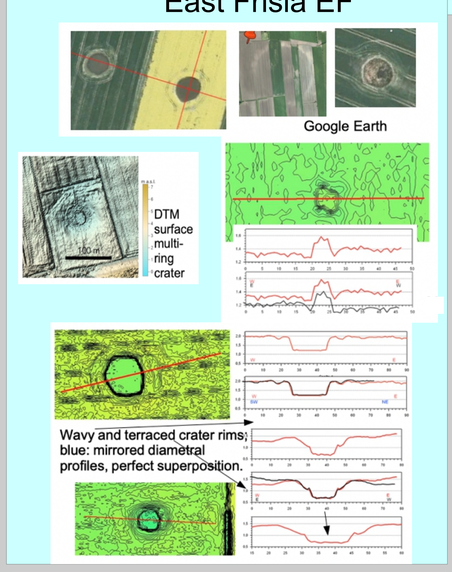


various shapes of RTI and KHI craters, diametral profiles.

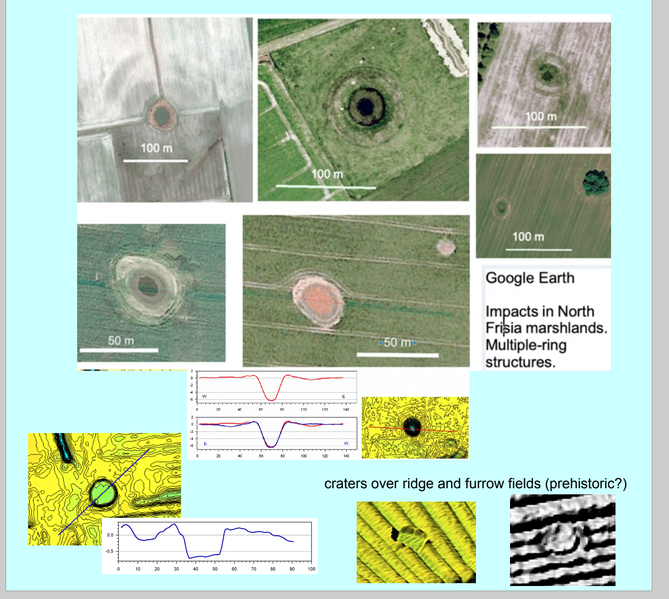
Saarland SL DOI: 10.13140/RG.2.2.11392.80642



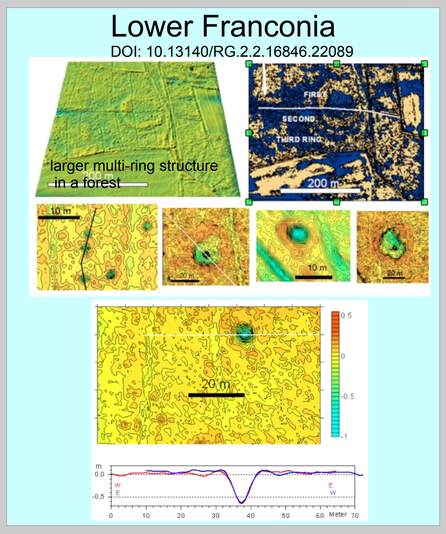
East Frisia EF



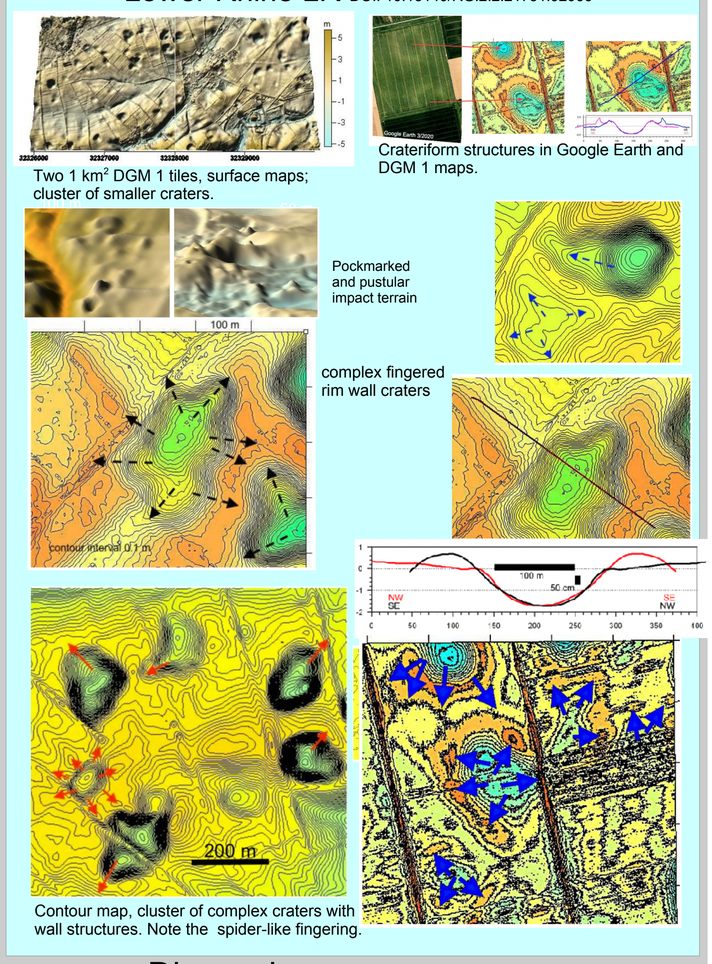
North Frisia NF



Lower Franconia DOI: 10.13140/RG.2.2.16846.22089



Lower Rhine LR DOI: 10.13140/RG.2.2.21731.92966



Discussion

- Based on findings and results over the last 20 years of research, a near-surface"touchdown" airburst impact is assumed to have occurred in central Europe. Given the current dating of the Chiemgau impact to 900–600 BC [DOI: 10.5281/zenodo.7775799] and the fact that impact structures in the strewn fields overlie the oldest Bronze Age plow marks (see NF), we consider a prehistoric single major airburst impact event over Central Europe to be likely, pending more precise dating results.
- The discovery and documentation of this new, very large number of impact structures in at least a dozen of strewn fields between the Czech Republic and France is attributable to the new capabilities of the LiDAR Digital Elevation Model (DEM, DGM 1 in Germany) ,which, with an extremely high resolution of 1 m (interpolated to decimeters) in the horizontal direction and 0.1 m (interpolated to centimeters) in the vertical direction, it can even detect craters and various impact structures in dense vegetation (e.g., in forests) and reveal complex impact morphologies with the highest possible level of detail.
- The DGM 1 shows that the impact produced not only craters but also many highly complex structures such as mushroom shapes, finger-like patterns, multiple rings, wave patterns, and fragmented rim zones.
- The formation of such complex shapes can be explained - as the central point of this poster - by impacts, a phenomenon primarily known from experiments with liquids,specifically through so-called Rayleigh-Taylor (RTI) and Kelvin-Helmholtz (KHI) instabilities.
- We apply these RTI and KHI processes to the layers in all mpact areas here under discussion, which consist of alternating layers of loose Quaternary sediments with widely varying densities and viscosities of the constituent rocks.
- Based on these highly complex crater shapes, we conclude that they rule out a normal geological origin such as sinkholes or other collapse structures.
- Anthropogenic origin must also be ruled out in the vast majority of cases due to the morphological characteristics, which include strictly circular and structurally symmetrical forms, some of which are of considerable size (up to several hundred meters) and often extend down to the decimeter and centimeter range.
- The large concentration of these very distinctive, sometimes exotic impact structures, within the numerous strewn fields proves the reality of a giant, possibly cometary, impact event involving a near-surface "touchdown" airburst, which is substantiated by hydrocode modeling of the Saarland and Chiemgau impacts.
- It also shows that databases and statistics on currently recognized terrestrial impacts, to which the impact literature consistently refers (e.g., https://impact-craters.com/), are no longer relevant and frequently even strongly misleading. Naturally, the new Holocene impact strewn fields in Central Europe do not fit into this current "worldview" of impacts

References: see the DOI numbers

All DGM 1 data were downloaded and processed (using the SURFER program) with the approval of the relevant authorities of the individual German federal states and of the authorities of the Czech Republic.