Anatomy of Young Meteorite Craters in a Soft Target (Chiemgau Impact Strewn Field, SE Germany) from Ground Penetrating Radar (GPR) Measurements

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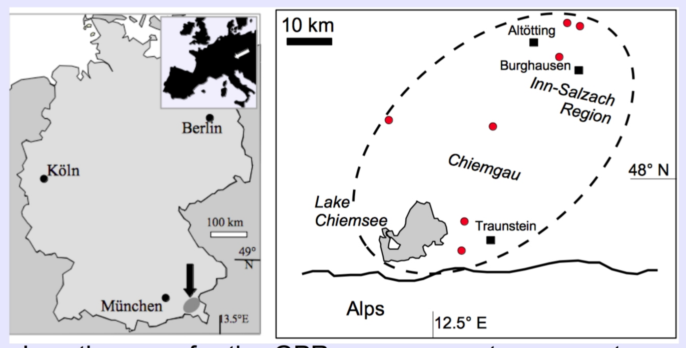
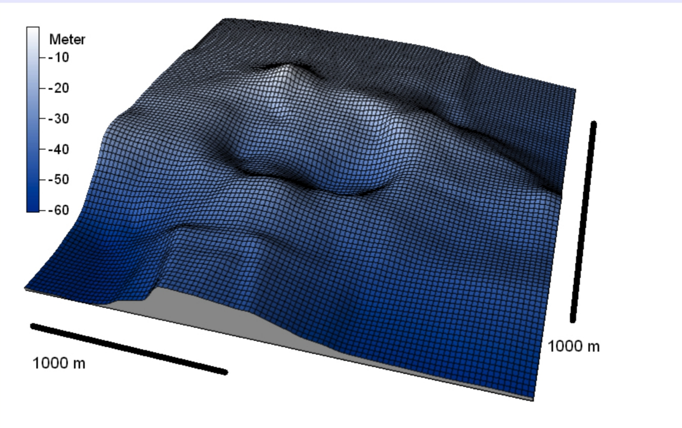


Location map for the GPR measurements over craters (red circles) within the roughly elliptically en-circled Chiemgau meteorite impact strewn field.

The Chiemgau Meteorite Impact Event

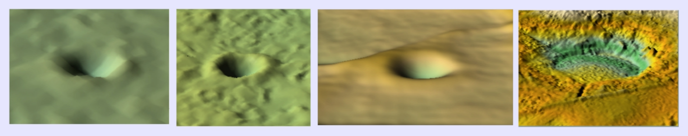
The Chiemgau strewn field discovered in the early new millennium and dated to the Bronze Age/Celtic era comprises as much as 100 mostly rimmed craters scattered in a region of about 60 km length and ca. 30 km width in the very South-East of Germany. The crater diameters range between a few meters and a few hundred meters. 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.

The Tüttensee meteorite impact crater. 600 m rim crest diameter.



The doublet meteorite impact crater at the bottom of Lake Chiemsee. From echo sounder measurements.

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 geophysical (gravity, geomagnetic, sediment echo sounder) anomalies. Impact ejecta deposits in a catastrophic mixture contain polymictic breccias, shocked rocks, melt rocks and artifacts from Bronze Age/Celtic era 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. Physical and archeological dating confines the impact event to have happened most probably between 900 and 300 B.C. The impactor is suggested to have been a roughly 1,000 m sized low-density disintegrated, loosely bound asteroid or a disintegrated comet in order to account for the extensive strewn field.



Smaller craters in the Chiemgau impact strewn field: Mitterhauserweg (9 m rim crest diameter) Einsiedleiche (15 m), Engelsberg (45 m), Windschnur (80 m) . Surface plots from Digital Terrain Model (DTM).

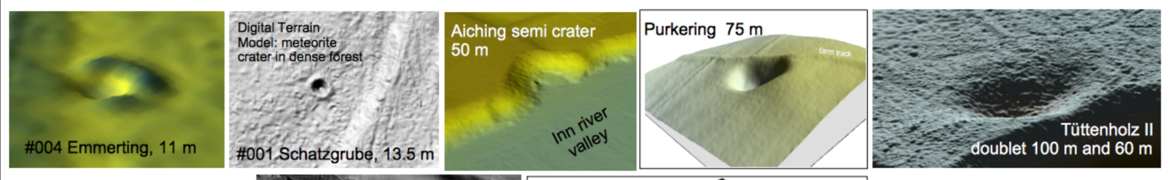
References. - Ernstson, K. (2010) Journal of Siberian Federal University Engineering & Technologies 1/3, 72-103. Ernstson, K. et al. (2013) Proc. (Yushkin Memorial Seminar - 2013), 369-371, Syktyvkar. Ernstson, K. et al. (2011). *Medit. Archaeology and Archaeometry 12/2*, 249-259. Liritzis, I. et al. (2011): *Medit. Archaeology and Archaeometry 10/4*,17-33. Rappenglück, B. et al. (2010) *Antiquity 84*, 428-439. Hiltl, M., et al. (2011) - 42nd LPSC, Abstract #1391. Neumair, A., Ernstson. K. (2011) - AGU Fall Meeting 2011, Abstract & Poster ID GP11A-1023. Ernstson, K., Neumair, A. (2011) - AGU Fall Meeting 2011, Abstract & Poster ID NS23A-1555. Shumilova, T. G. et. al (2012) - 43rd LPSC, Abstract & Poster #1430. Isaenko, S. I. et al. 2012) - Abstracts Eur. Min. Conf. Vol. 1, EMC 2012-217. Rappenglück, M.A. et al. (2013) 76th Annual Meteoritical Society Meeting, Abstract #5055. Bauer, F. et al. (2013) - 76th Annual Meteoritical Society Meeting, Meteoritics & Planetary Science, Abstract #5056. Neumair, A., Ernstson, K. (2013) 76th Annual Meteoritical Society Meeting, Abstract #5057. Ernstson, K., et al. (2014) - 45th LPSC, Abstract #1200. Rappenglück, M A., et al. (2014) Yushkin Memorial Seminar - 2014), 106-107, Syktyvkar. Ernstson, K. (2016) - 47th LPSC, Abstract #1263.

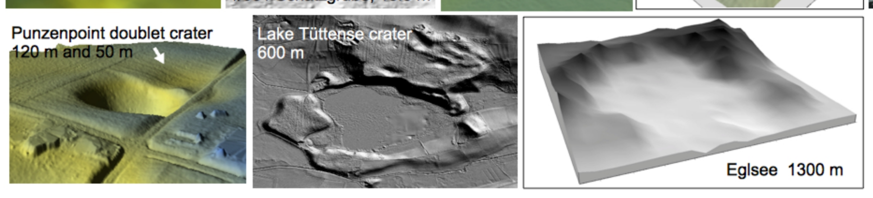
Introduction

GPR is a widely used geophysical method for the exploration of near-surface structures and has also been successfully used in the investigation of some meteorite impact structures. In the larger craters investigated (Bosumtwi, Barringer, Mistastin, [1-3]), the depths of the crater floors can hardly be reached even at very low antenna frequencies (e.g. 25 MHz at Bosumtwi), so that the measurements are usually limited to the marginal areas and their geological structures (ejecta, layer deformations). The situation is different with smaller craters (e.g. Haviland crater [4]) or with small structures for which an impact is discussed [5, 6]. We report here on a program of GPR measurements over some craters of different size in the soft Quaternary target of the Chiemgau impact strewn field in southeast Bavaria (Germany).

Field work

Used GPR equipments: bistatic 25 MHz, monostatic 200, 300, 400 MHz.





Chiemgau impact craters for GPR measurements.

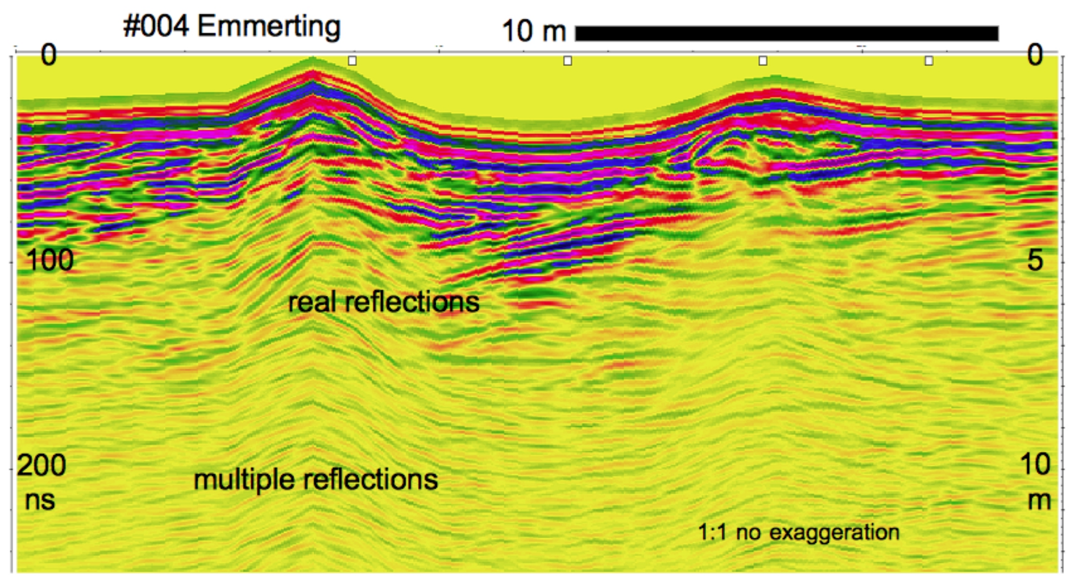
Surface 3D images are from the Digital Terrain Model DGM 1. Note the strong exaggeration. Meter specifications are rim wall diameters. The Emmerting, Aiching, Punzenpoint, Lake Tüttensee and Eglsee craters are discussed here on the poster.

Results

#004 Emmerting

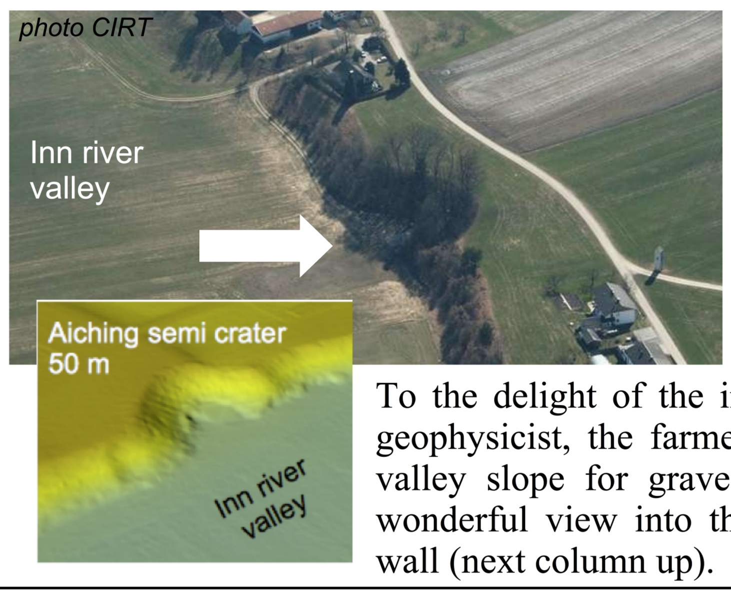
The early and so far best investigated small crater. Impressive impact inventory: extreme temperature and pressure effects (melt rocks, shock effects PDF, diaplectic glass).

The extreme temperature effects on the rocks, >1,500°C, within a 20 m measuring halo cannot be attributed to the impact of a projectile, but suggest a near-surface heavy impact explosion [8]. The strong radar reflections which are good with a drill core in the center of the crater that has proven horizons of extreme sintering of the conglomeratic subsurface, fit well with this assumption.



Radargram across the #004 crater (25 MHz center frequency with modulated 200 MHz; data from P. Kalenda and R. Tengler).

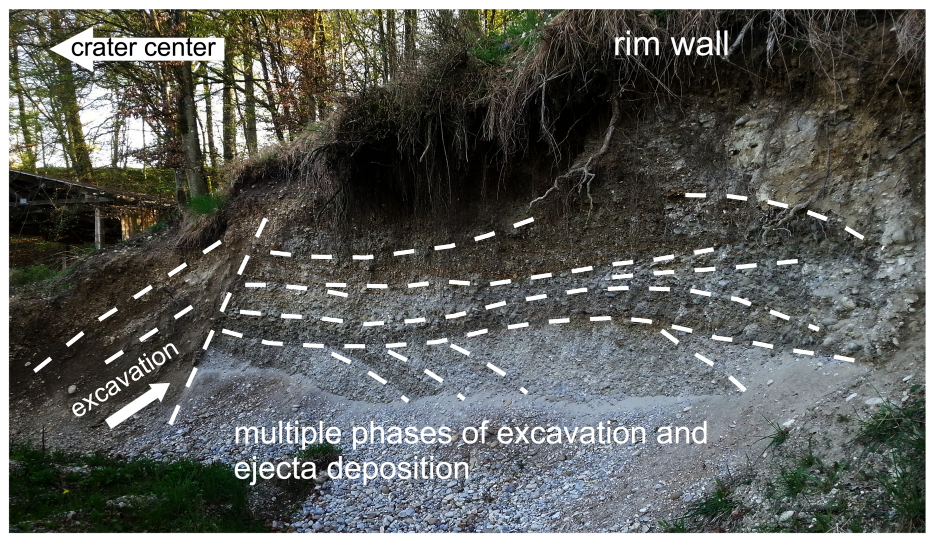
Aiching semi crater

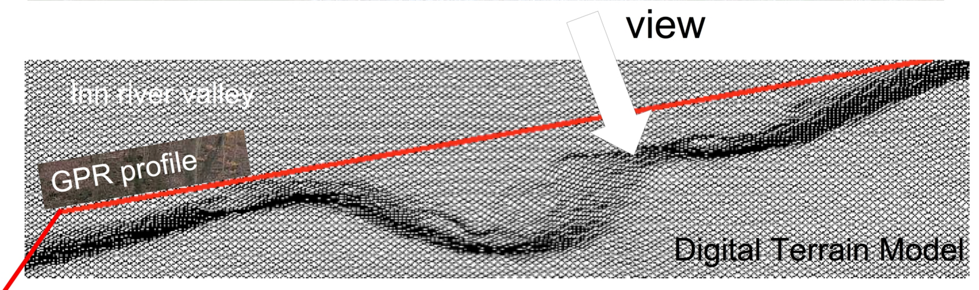


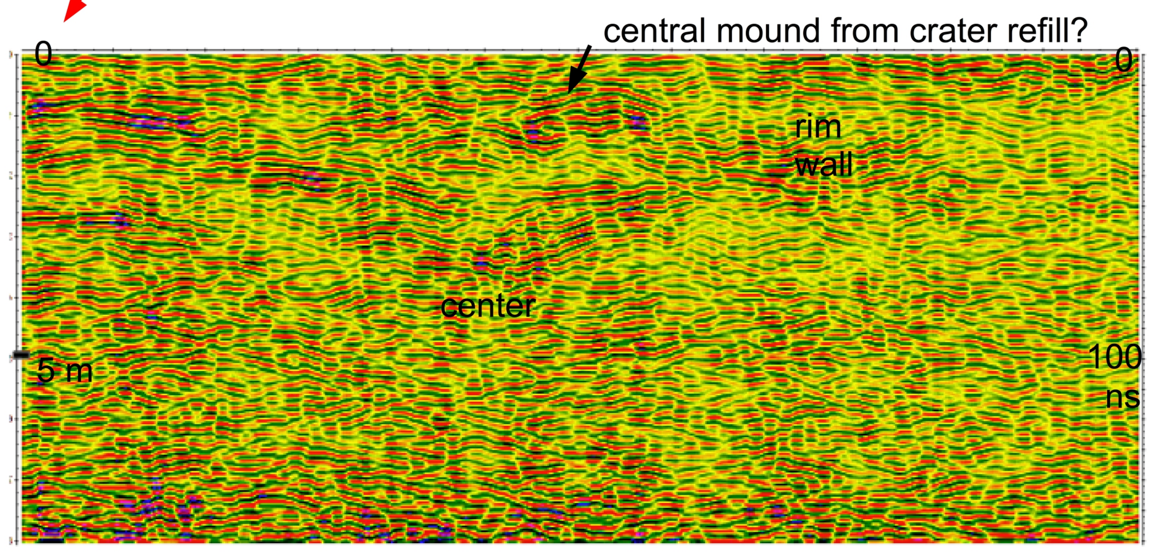
The semi crater Aiching appears punched into the embankment of the Inn river valley, and the flanks of the DGM 1 (lower left) show its unmistakable contours of a 50 m diameter crater with a ring wall.

To the delight of the impact researcher and GPR geophysicist, the farmer excavated a cut into the valley slope for gravel extraction and created a wonderful view into the crater rim with the ring wall (next column up).

Aiching: meteorite impact cratering approachable.

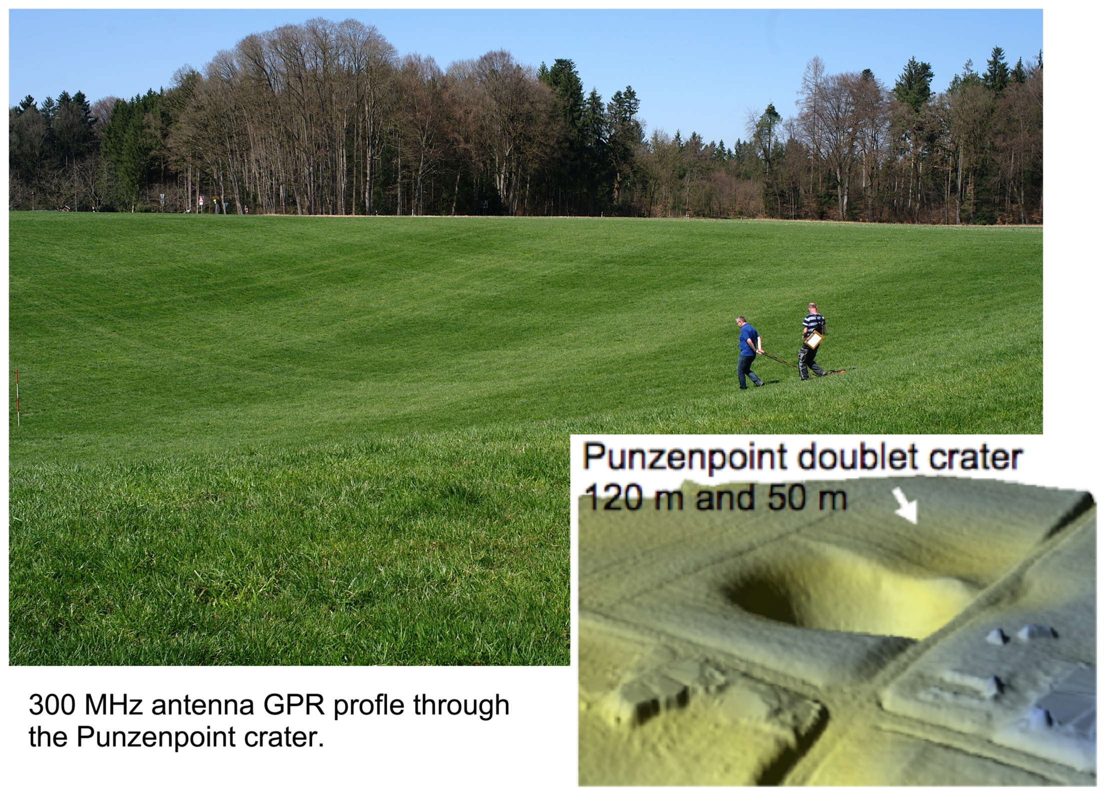






The radargram reveals in beautiful resolution the structure of the crater below its second half eroded and leveled by the Inn river, which allows an exemplary reconstruction of the formation of a meteorite crater with the diameter of some decameters in a soft target.

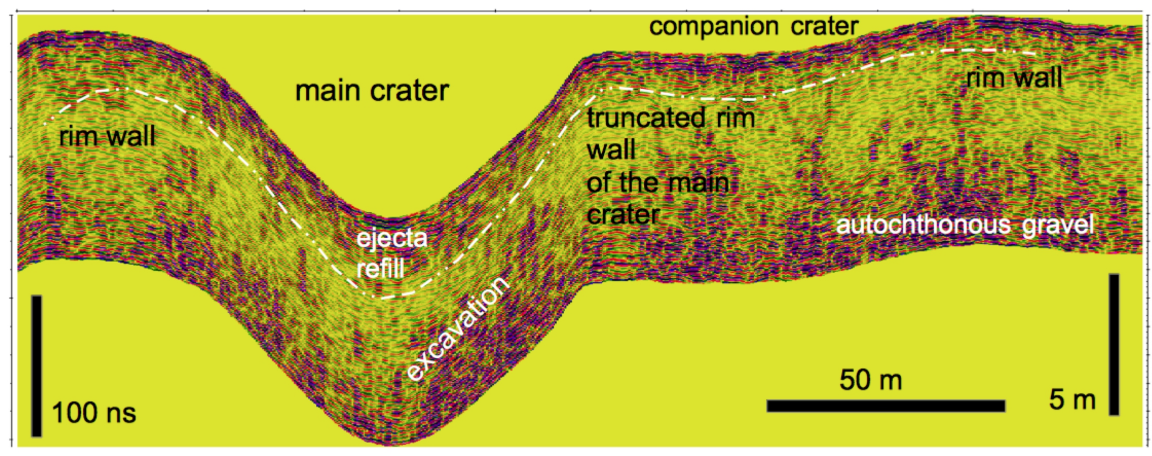
Punzenpoint doublet crater



300 MHz antenna GPR profile through the Punzenpoint crater.

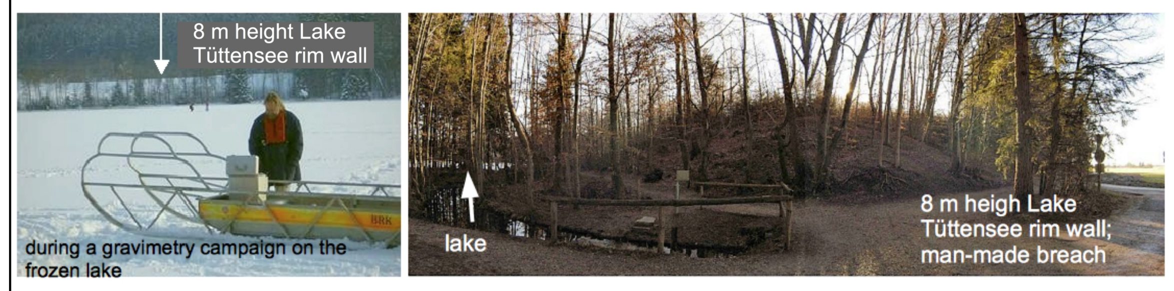
Punzenpoint was conspicuous as a flat depression in the Quaternary gravel subsoil but had become a candidate for an impact genesis only after a data analysis of the DGM 1. In the DGM 1, but only in this high resolution, it becomes clear that it is a walled doublet structure in which a smaller, 50 m measuring crater has dug itself into the ring wall of the larger, 120 m measuring circular structure, i.e. a tiny time later.

An ice age formation (e.g. a dead-ice hole) could therefore be ruled out, and the most recent GPR measurements (this poster) have definitely excluded such a formation and taught a meteorite impact as the most plausible explanation.

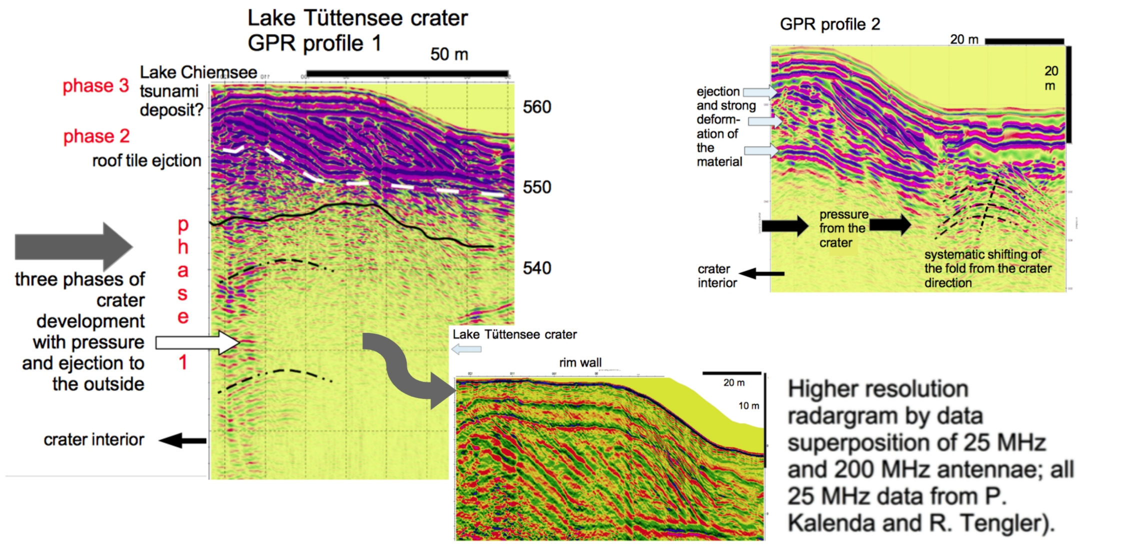


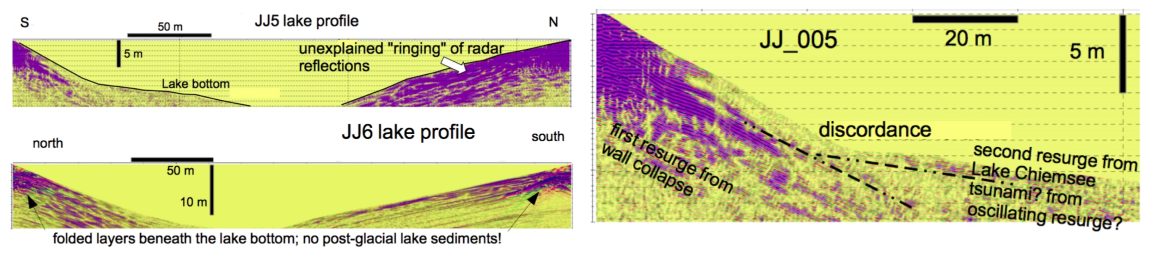
GPR profile through the centers of the two craters.

Lake Tüttensee crater

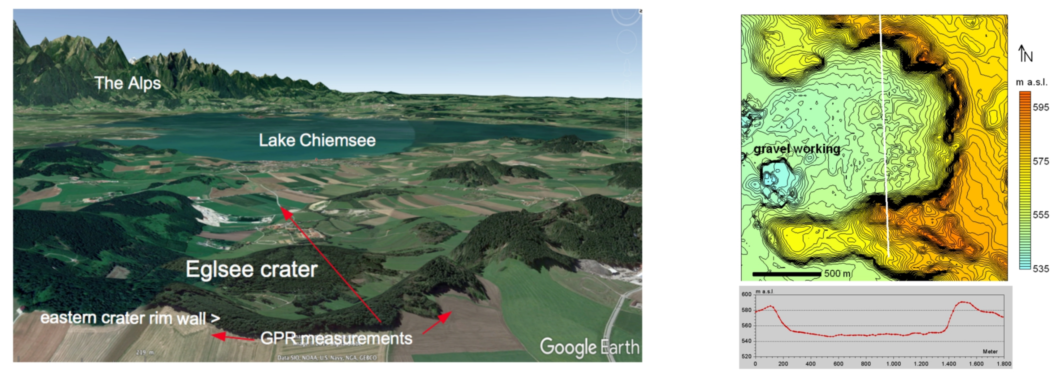


Lake Tüttensee crater: Since the beginning until today the conflict between dead ice hole (local and regional authoritative geologists) and meteorite crater (impact researchers). For years, extensive geological-geophysical-mineralogical-petrographic impact findings [8, 9] have been permanently ignored by the ice age geologists without ever having presented their own evidence. The latest brilliant results of the GPR measurements, of which the poster shows some examples, also make a dead ice genesis seem completely absurd.

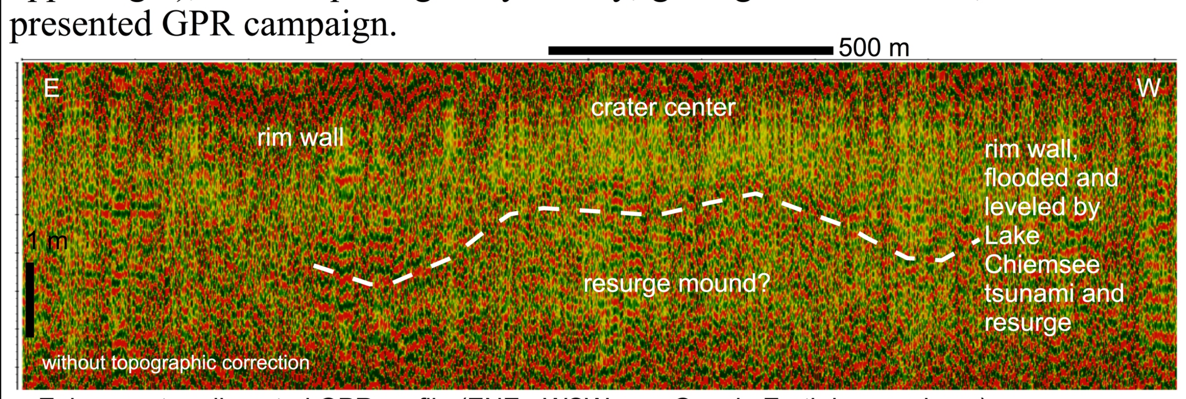




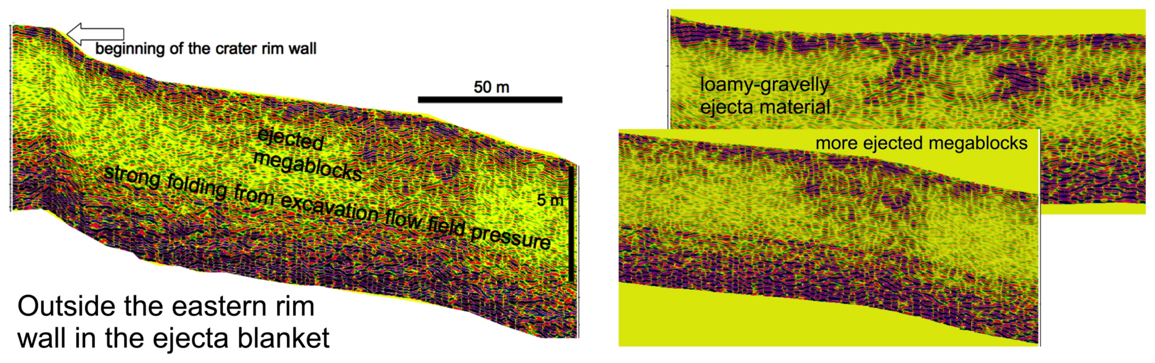
Eglsee crater



The impact nature of the Eglsee crater, which has a comparable size as the famous Barringer (Arizona) crater, was originally suspected by a group of astronomers after having visited the Chiemgau impact strewn field and then studied a satellite imagery. Their suggestion fell into oblivion and was reanimated by the study of the now available Digital Terrain Model (Fig. upper right), a subsequent gravity survey, geological field work, and the here presented GPR campaign.



Eglsee crater, diametral GPR profile (ENE - WSW, see Google Earth image above). Preliminary interpretation.



Outside the eastern rim wall in the ejecta blanket

Conclusion

The here presented results of the GPR measurements over meteorite impact craters of various size in the young soft target of the Chiemgau impact strewn field exemplify the enormous potential of this high-resolution geophysical tool of underground exploration, which may lead to a much better understanding of impact cratering processes even on remote planetary bodies. This knowledge adds to the conviction that a combination of GPR and high-resolution DTM data may also help to identify new meteorite craters (or dismiss their impact origin), apart from the often overworked mineralogical expertise.

References: [1] Boateng, C.D. et al. (2012) *IJSRA*, 1, 47-61. [2] Russel, P.S. et al. (2013) *JGR Planets*, 118, 1915-1933. [3] Beauchamp, M. et al. (2011) *42th LPSC*, Abstract #2147. [4] Click, K. et al. (2007) *GSA*, 39.3, pp. 71 (abstract). [5] Spooner, I. et al. (2009) *Met. Planet. Sci.*, 44, 1193-1202. [6] Heggy, E. & Paillou, P. (2006) *Geophys. Res. Let.*, 33, L05202, 4 p. [7] Ernstson, K. (2017) http://www.impact-structures.com/wp-content/uploads/2017/01/DGM-1-final.pdf, (accessed 25/12/18) [8] Ernstson, K. et al. (2010) *J. Siberian Federal Univ., Engin. & Techn.*, 1, 72-103. [9] Rappenglück, M.A. et al. (2017) *Z. Anomalistik*, 17, 235-260.