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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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, Motersan, [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. Høyland 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

The Tüttensee crater: 600 m rim cross diameter.

Geologically, the craters occur in Pleistocene loess and fluvo-glacial sediments. The craters and surrounding areas are featuring heavy deformations of the Quaternary cohesive beds and boulders, impact melt rocks and various glasses, strong shock-metamorphic effects, and geophysical (gravity, geomagnetic, and sediment echosounder) 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, keratophyres and of strange, probably meteoritic matter in the form of iron silicates like silexite, silexite, talcite, and linkeite, various carbides like, e.g., reosirinite, SAN and kumakhovite (T.I.Y.O.C), and calcium-aluminium-rich inclusions (CAI), minerals krotite and didymium diammite. Physical and archeological dating confirm the impact event to have happened most probably between 900 and 300 B.C. The impact is suggested to have been a roughly 1.000 m sized low-density disintegration, loosely bound asteroid or a disintegrated comet in order to account for the extensive strewn field.

Results

The early and so far best investigated small crater. Impressive impact inventory: extreme temperature and shock effects (melting, shock effects PDF, diaplectic glass). The extreme temperature effects on the rocks, >1500°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.

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.

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 overlooked mineralogical expertise.

References