THE CHIEMGAU CRATER STREWN FIELD: EVIDENCE OF A HOLOCENE LARGE IMPACT EVENT IN SOUTHEAST BAVARIA, GERMANY

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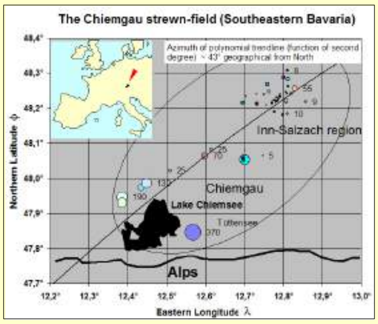

The Chiemgau impact strewnfield was discovered in the early new millennium by a group of local history researchers (W. Mayer and co-workers) who were confronted with the abundant finds of exotic metallic matter frequently associated with rimmed craters in a roughly elliptically shaped area with about 60 km and 30 km axes (Fig. 1). Currently, the field is interdisciplinarily investigated by a group of researchers (Chiemgau Impact Research Team, CIRT) comprising the early discoverers together with earth scientists, astronomers, impact researchers, archeologists and historians (#).

Fig. 1. The Chiemgau impact strewnfield comprises more than 80 craters. The size of the craters as shown is not to scale.

CRATER MORPHOLOGY

Hohenwart, 6 m — Murshall, 16 m — semi-crater, Inn river embankment, 50 m — Bergham, 150 m; now filled — Tüttensee, ~ 500 m rim-to-rim diameter

Fig. 2. Typical morphology of craters in the Chiemgau strewnfield with increasing rim-to-rim diameter.

The size of the craters in the strewnfield ranges between a few meters and a few hundred meters. For well preserved craters, the diameter-to-depth ratio has been determined to be r = 7.5 on average. Quite a few craters have been leveled by e.g. farming activities, but they may be seen on satellite imagery or aerial photographs (Fig. 3). From echo (sonar) soundings and underwater rock sampling there is evidence of craters also in Lake Chiemsee. The largest crater so far established is the 500 m-diameter Lake Tüttensee crater (Fig.2) exhibiting a pronounced 8 m-height rim wall (Fig. 4) and an extensive ejecta blanket.

Fig. 3. Leveled craters may be seen in satellite imagery or aerial photographs (upper) especially when image processed (lower).

Fig. 4. The 8 m-hight rim wall of the Lake Tüttensee crater. To the left: seen from inside during a gravity survey on the frozen lake. To the right: cross section in an artificial gap.

TARGET GEOLOGY - TARGET ROCKS

Fig. 5. Geologically, the craters occur in Pleistocene moraine and fluvio-glacial sediments (gravel plains) of the Alpine foreland (to the left). Dead-ice moraines and glacial lakes (to the right) have been confused with true meteorite craters by critics of the impact. Many impact craters, however, have been formed also in the ice free gravel plain target. The bowl-shaped depression (to the left) may be the result of secondary cratering.

DEFORMATIONS

Fig. 6. Typical material sampled from crater floors (to the left) strongly contrasting with target material from outside the craters (to the right).

The craters in the strewnfield are typically characterized by strong mechanical deformations of the affected target cobbles (Figs. 6, 7). The occurrence of heavily fractured however coherent cobbles in a soft, uncemented matrix proves *in situ* deformation or deposition under high confining pressure and excludes any normal sedimentary deposition from fluvio-glacial transport.

Fig. 7. Typically deformed and sharp-edged fractured but coherent clasts from various craters in the strewnfield.

CORROSION

Fig. 8. Deep-reaching corrosion and rock dissolution of silicate and carbonate clasts from the Chiemgau impact strewnfield.

Carbonate and silicate cobbles and boulders exhibiting strong and deep-reaching corrosion right up to skeletal formation (Fig. 8) are abundant in the impact crater strewnfield. The corrosion is explained by the action of high temperatures (decarbonization, melting) or/and the action of strong acid dissolution (nitric acid precipitation from the impact explosion cloud).

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IMPACT MELT ROCKS AND IMPACT GLASS

Melt rocks and glass give abundant evidence of extreme temperatures in the Chiemgau strewnfield (Fig. 9). Both heating from impact shock release and impact explosion volatiles are considered.

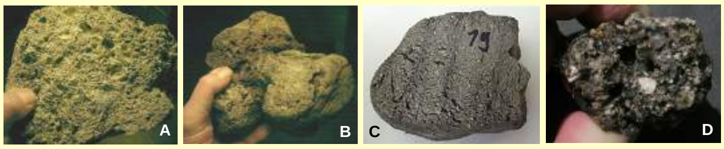

Fig. 9. Various impact melt rocks from the Chiemgau strewnfield. A: Pumice-like melt rock from the Lake Tüttensee crater area. B: Two glass-coated cobbles welded by cindery glass from crater 004. C: Sawed surface of a silicate cobble from crater 004. Extremely vesicular and fissured rock where, except for quartz, all minerals are more or less transformed to glass giving the dark color to the rock. The widely open fissures may result from shock spallation. D: Typical cindery glass ("scoria"; mixed with rock fragments) from the strewnfield.

SHOCK METAMORPHISM

Shock effects (multiple sets of planar deformation features, PDFs, in quartz and feldspar, planar fractures, PFs, in quartz, diaplectic glass [maskelynite] in feldspar, strong kink banding in mica, and multiple sets of planar features in calcite [microtwinning]) have so far been established in rocks from the Tüttensee crater rim wall, from the Tüttensee crater ejecta layer (Fig. 10) and from crater 004. Although the shock stages are in general moderate, the abundant occurrence of shock effects in the Lake Tüttensee rocks is surprising and may be explained by the roughly spherically shaped clasts in a soft matrix having possibly enabled focusing of shock energy.

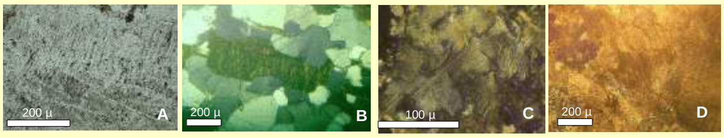

Fig. 10. Shock metamorphism in rocks from the Chiemgau impact crater field. A: "Toasted" quartz with multiple sets of PDFs in quartz. "Toasted" quartz is a common feature in shocked grains and is explained by tiny fluid inclusions. B: Two sets of strong kinkbanding in mica. C: Twin lamellae, multiple sets of PDFs and spots of maskelynite in feldspar. D: Multiple sets of microtwinning and a few kinkbands in calcite.

GEOPHYSICS

A few ground penetrating radar profiles and some measurements of magnetic anomalies over smaller craters without clear evidence of the causative bodies have been carried out so far. A gravity survey of the Lake Tüttensee crater and its environs has revealed a somewhat surprising result of a ring of relatively positive anomalies surrounding the crater gravity negative anomaly (Fig. 11). We explain the positive anomalies outside the rim wall by impact shock densification of the highly porous target rocks.

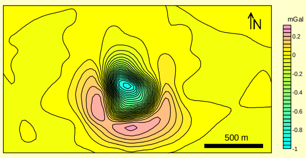

Fig. 11. Bouguer gravity residual anomaly of the Lake Tüttensee crater.

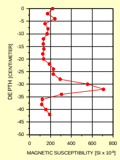

Fig. 12. Soil magnetic susceptibility profile near Lake Tüttensee.

Anomalous soil magnetic susceptibility anomalies (Fig. 12) were measured at some distance of Lake Tüttensee at a few decimeter depth not compatible with man-made or geogenic input. A related horizon is enriched in small rock fragments, strange carbonaceous matter and cindery glass and is interpreted as the fossil soil surface at the time of the impact.

STRANGE MATTER

The impact is substantiated by the abundant occurrence of metallic, glass and carbon spherules (Fig.13), and of exotic matter in the form of iron silicides like gupeiite and xifengite, and various carbides (Fig. 14). A gupeiite analysis from the Chiemgau strewn field closely resembles meteoritic suessite (Fig. 15). The find context for the exotic matter is in most cases hardly compatible with an industrial production, and an origin from the impact process or/and as constituents of the impactor must be considered.

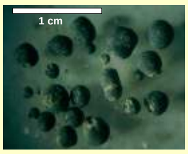

Fig. 13. Carbon spherules typically found in the Chiemgau strewnfield.

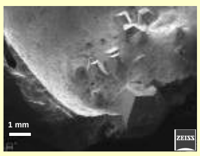

Fig. 14. SEM image of silicon carbide crystals in iron silicide matrix.

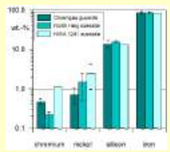

Fig. 15. Comparison of analyses of Chiemgau gupeiite and meteoritic suessite

EJECTA BLANKET OF THE LAKE TÜTTENSEE CRATER - AGE OF THE EVENT

Roughly 50 excavation pits around Lake Tüttensee have revealed a detailed insight into an extensive ejecta layer of the so far largest crater of the Chiemgau strewnfield. Below the recent soil, the general stratigraphy comprises a decimeter to roughly 1 m thick polymictic breccia composed of multicolored Alpine lithologies, organic material like wood, charcoal, animal bones and teeth, tufts of (possibly human) hair and archeological Stone and Bronze Age artifacts (Fig. 16). This impact layer is underlain by a fossil soil containing excellently preserved wood and reed. Below the fossil soil, target Pleistocene moraine material and lake sediments make up the stratigraphy.

Fig. 16. Impact ejecta of the Lake Tüttensee crater: polymictic breccia with multicolored rock fragments ...

... wood ... ... bones ... ... teeth ... tufts of hair ...

... and archeological artifacts: a fragment of a center-drilled Neolithic or Bronze Age stone ax.

The stratigraphic context of the ejecta deposit, radiocarbon dating and the dating by Stone and Bronze Age artifacts exclude any relation with Alpine glaciations, and since any Holocene geological endogenetic processes can be eliminated, too, a meteorite impact to have formed Lake Tüttensee, the surrounding breccia layer as its ejecta blanket, and the whole crater field is most reasonable. Additional thermoluminescence and radiocarbon dating in the field of the other craters, and further dating by archeological finds confine the impact event to have happened in the first millennium B.C., most probably between 600 and 400 B.C.