Metallic Artifact Remnants in a Shock-Metamorphosed Impact Breccia: an Extended View of the Archeological Excavation at Stöttham (Chiemgau, SE-Germany)

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Introduction

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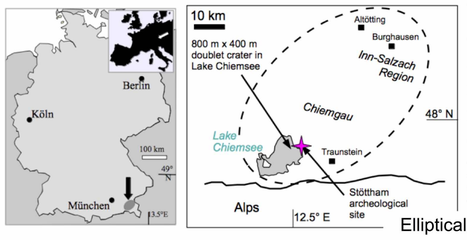
In 2008/2009 a routine archeological excavation at the town of Chieming-Stöttham in the Chiemgau region in Southeast Germany revealed an exotic layer sandwiched between Neolithic and a Roman occupation layer (see Figure below). The exotic diamictic (breccia) layer showed all evidence of a deposition in a catastrophic event that was rapidly attributed to the Chiemgau meteorite impact [1, 2, and references therein] that happened in the Bronze Age/Iron Age.

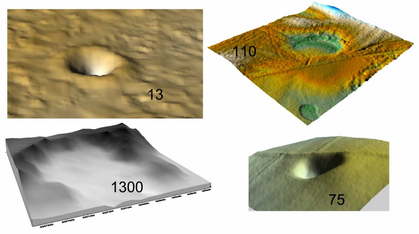


Elliptically shaped Chiemgau impact strewn field.

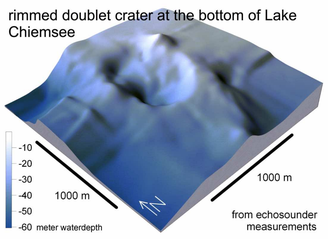
The ample occurrence of extreme destruction, extreme temperatures and highest pressures including impact shock effects proved incompatible with an undisturbed colluvial depositional sequence as postulated by archeologists and pedologists-geomorphologists [3].

Following their argumentation the Bavarian Office for Geology (LfU) and the Bavarian Monuments Preservation Office (BLfD) declared the unparalleled Stöttham exposure as a normal colluvium which continously developed since the end of the last Ice Age and let it fill up and overbuild. A recent inspection of the depot of archieved samples from the excavation revealed a key to an unexpected scenario, and **we report highlighting results of both archeological and meteorite impact relevance.**

The Chiemgau meteorite impact event: Elliptically shaped strewn field (figure above) * around 100 rimmed craters, diameters between a few meters and a few 100 meters * distinct morphology from precise Digital Terrain Model (DTM) analyses * a rimmed doublet crater at the bottom of Lake Chiemsee [1] * abundant evidence of impact signature: impact melt rocks * impact glasses * shock metamorphism like PDF and diaplectic glass - quartz and feldspar * shatter cones * geophysical (geoelectrical, ground penetrating radar, gravity) anomalies * meteoritic matter [1, 2, 4-8]).



Digital Terrain Model DGM 1: Typical craters that formed in the Chiemgau impact event. Figures denote rim crest diameters in meters.



The excavation of the doublet impact crater is considered responsible for the emplacement of the Stöttham catastrophe layer.

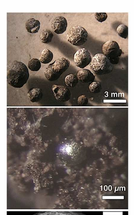
The Stöttham exposure - early research: Because of the short distance and the considerable size, the Lake Chiemsee doublet crater was reasonably considered the source for the Stöttham catastrophe layer, which is interpreted as impact ejecta sustained by a big, now established Lake Chiemsee tsunami [9]. A short overview of the archeological and impact-related inventory is shown in the figures below and in more detail described in [10].

Part of the Stöttham excavation with the sandwiched impact layer. The geologic/ archeological stratigraphy. a: moraine, b: lower colluvium/lower occupation layer, c: diamictite/catastrophic layer, d: upper colluvium/upper occupation layer with indication of a paving, e: soil.

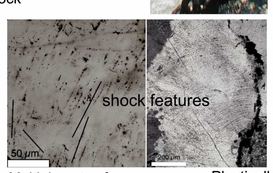
Details of the diamictic texture of the impact layer.

Strongly corroded (heat, acid) and fractured cobbles (gneiss, quartzite) from the catastrophe layer.

Silica limestone melt rock



Carbonaceous, metallic and glass spherules

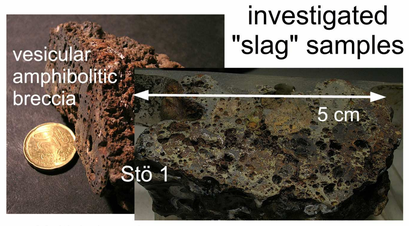


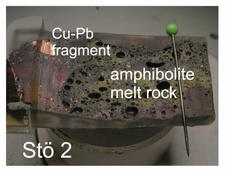
Multiple sets of PDFs in quartz

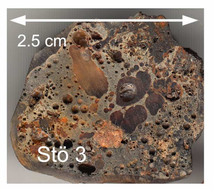
Plastically deformed quartz and PDFs

Archeological objects (bronze burins, quartzite hammerstone) and fragments of bones, a tooth and pottery from the Stöttham exposure.

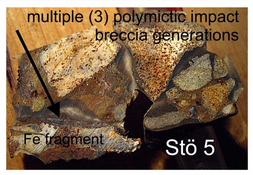
The "slag" breccias from the Stöttham excavation

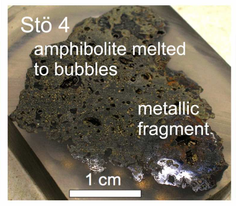






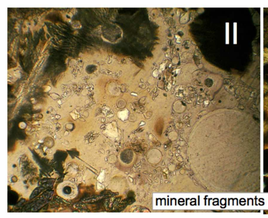
Multiple breccia generations (here three) are a characteristic geologic impact feature and rarely known from "normal" geological processes

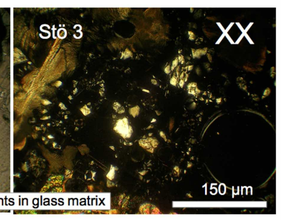


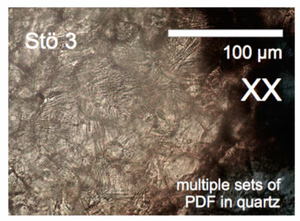


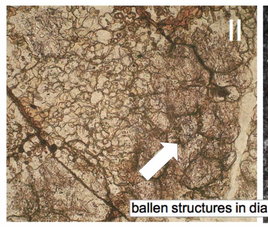
The breccia samples are composed of metallic as well as stony components. Most of the samples are taken by vesicular amphibolite with gas bubbles from strong heating.

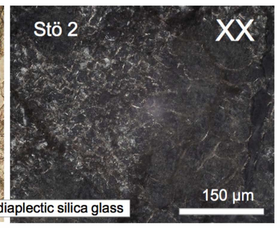
Thin section photomicrographs - shock metamorphism

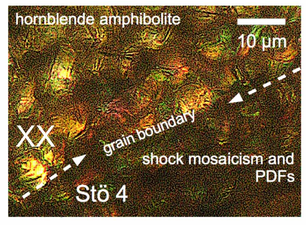






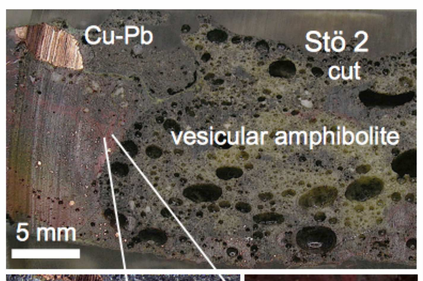


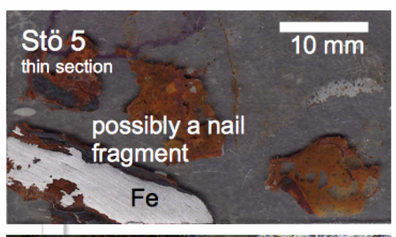


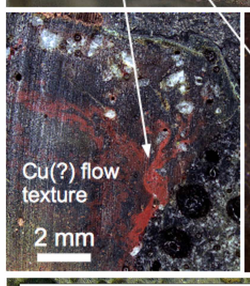


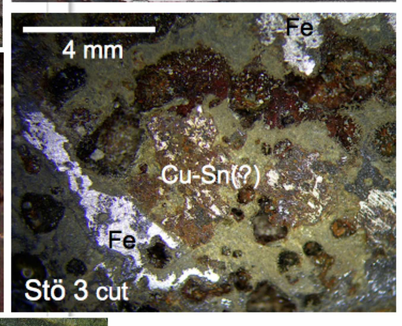
Shock effects in thin section photomicrographs - II = plane light, XX = crossed polarizers. The diaplectic glass from shocked quartz is in proof of high pressures >5 GPa. According to common impactite nomenclature the occurrence of cogenetic melt glass and shock metamorphism attributes a **suevite** designation to the Stöttham "slag" breccias.

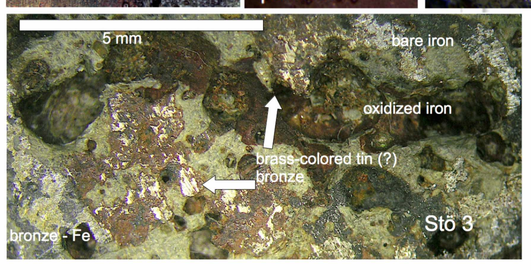
Polymictic suevite breccias - metallic inclusions







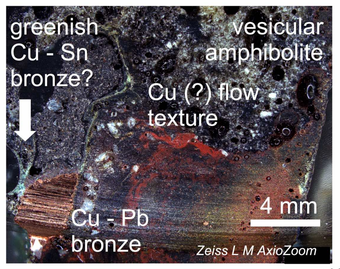




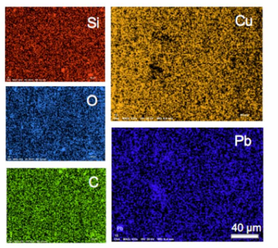
Stöttham suevite breccias

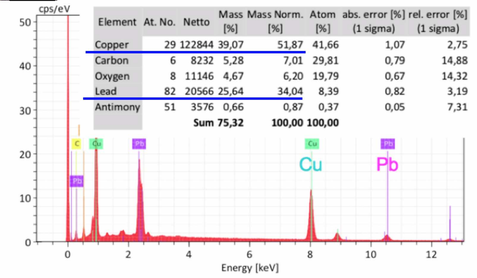
Finely disseminated polymetallic inclusions in suevite breccia Stö 3.

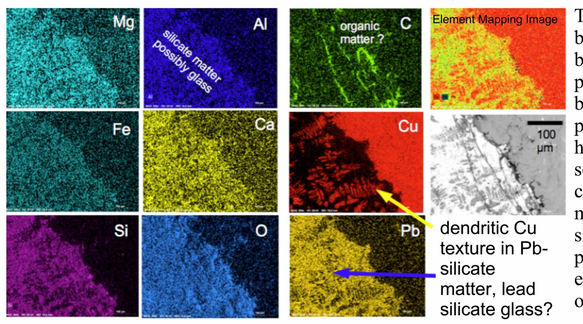
Stö 2 and the copper/lead bronze - SEM-EDS



Remarkable: copper - lead bronze fragment with strikingly high amount of lead. These values (see SEM-EDS figures and spectrum below) show that the specimen must have originated from human production and has been part of some artefact.

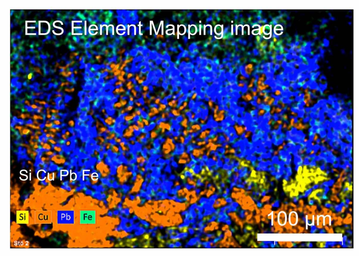


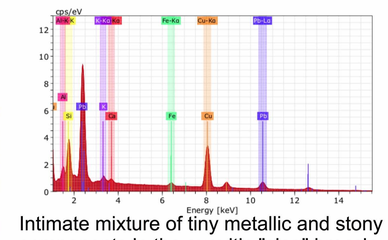




dendritic Cu texture in Pb-silicate matter, lead silicate glass?

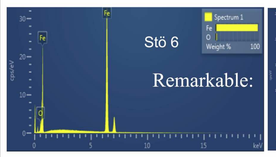
The formation of the breccia with the embedding of the metal particles must have been a very complex process, which must have led to the partial separation of the metal components and their mobilization within the silicate rock components and possibly enabled the formation of a kind of lead glass.

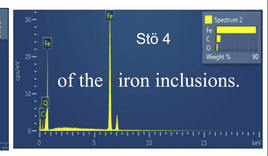




Intimate mixture of tiny metallic and stony components in the suevitic "slag" breccia.

SEM-EDS: Iron particles in the Stöttham suevite breccias





Conclusions: A worldwide novelty and the age of the Chiemgau meteorite impact event

The new investigations demonstrate once more impressively that the Stöttham archeological site had been involved in a meteorite impact invent, the Chiemgau impact. The original finding of a meteorite impact layer between two archeological horizons was to be classified as unique worldwide. From the point of view of both archeology and impact research, the new analyses have put the crown on it by revealing human objects and impact shock intimately intertwined in the same samples - a worldwide novelty.

An exacter dating of the Chiemgau impact, based on the metallic components, is a significant side effect of these unusual samples and their investigation. From the first known Central European occurrence and dissemination of the alloys and metals (highly leaded bronze, iron) present in the Stöttham artefacts, we conclude ca. 900 BC as *terminus post quem* for the meteorite impact. Hence, the Chiemgau impact can be re-dated to ca. 900-300 BC. An even tighter time-frame is under discussion with regard to the iron as a constituent of the samples under investigation.

References: [1] Ernstson, K. et al. (2010) *J. Siberian Federal Univ., Engin. & Techn.*, 1, 72-103. [2] Rappenglück, M.A. et al. (2017) *Z. Anomalistik*, 17, 235-260. [3] Völkel, J. et al. (2012) *Z. Geomorphologie*, NF, 56(3), 371-386. [4] Hiltl, M. et al. (2011) *42th LPSC*, Abstract #1391. [5] Bauer, F. et al. (2013) *Met. & Planet. Sci.*, 48, s1, Abstract #5056. [6] Rappenglück, M.A. et al. (2014) *Proc. Yushkin Memorial, Syktyvkar, Russia*, 106-107. [7] Rappenglück, M.A. et al. (2013) *Meteoritics & Planet. Sci., 48*, s1, Abstract #5055. [8] Ernstson, K. et al. (2014) *LPSC 45th*, Abstract #1200. [9] Ernstson, K. (2016) *47th LPSC*, Abstract #1263.[10] Ernstson, K. et al. (2012) *Medit. Archaeology Archaeometry*, 12/2, 249-259.