NEAR-GROUND AIRBURST CRATERING: PETROGRAPHIC AND GROUND PENETRATING RADAR (GPR) EVIDENCE FOR A POSSIBLY ENLARGED CHIEMGAU IMPACT EVENT (BAVARIA, SE-GERMANY). K. Ernstson[1], J. Poßekel[2] and M.A. Rappenglück[3], [1]University of Würzburg, 97074 Würzburg, Germany (kernstson@ernstson.de), [2]Geophysik Poßekel Mülheim, Germany, (jens.possekel@cityweb.de) [3]Institute for Interdisciplinary Studies, D-82205 Gilching, Germany (mr@infis.org).

Introduction: The asteroid impact near the Russian city of Chelyabinsk in 2013 was the largest airburst on Earth since the 1908 Tunguska event. Meanwhile, there are scientists who consider airburst as much more dangerous for mankind than direct projectile impacts to form meteorite craters [1]. In the geological past impact cratering accompanied by giant airbursts must have hit Earth periodically, whereby the term cratering refers to the fact that projectiles exploding in the atmosphere may leave their traces also on the ground to form shallow craters. Here we report on effects of a suspected large airburst event, the traces of which are documented by small craters, shock effects, an extended superficial melt rock sheet and significant evidence from GPR investigations.

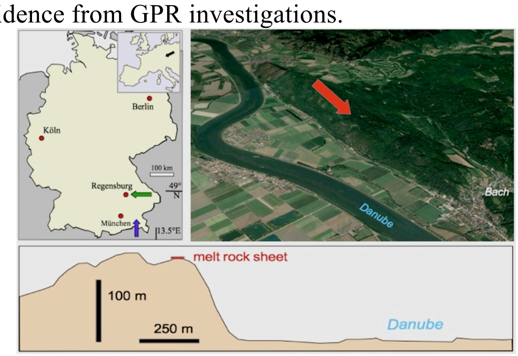

Fig. 1. Location map for the Bach melt rock sheet near Regensburg (green arrow and red arrow top right) and the Chiemgau impact strewn field (blue). Lower: Sketch of the exposure of the melt rock sheet.

The Regensburg/Bach melt rock sheet: In the early new millennium, a ca. 500 m x 50 m sheet of surficial melt rock granite with abundant glass formation down to a depth of roughly 1 m (Fig. 3) exposed along the highest point of the granite massif above the Danube valley (Fig. 1) was discovered by a local mineral collector, raised some interest of a geologist, initiated early unpublished mineralogical work and practically fell into oblivion. Man-made and volcanic activities can be (and were) absolutely excluded, and the phenomenon had obviously escaped geologic mapping in the forest. In the absence of plausible anthropogenic or geological causes, a meteorite impact event was soon considered, and since no impact crater of some size was known far and wide, superficial melting of the granite by an airburst was discussed as a possible explanation. An extensive surface glass formation was considered in analogy to the formation of the famous Libyan desert glass and to the Trinity nuclear weapons experiment and the formation of the trinitite glass [2], and new petrographic analyses confirm an impact shock event as very likely cause for the granite melting (Fig.2).

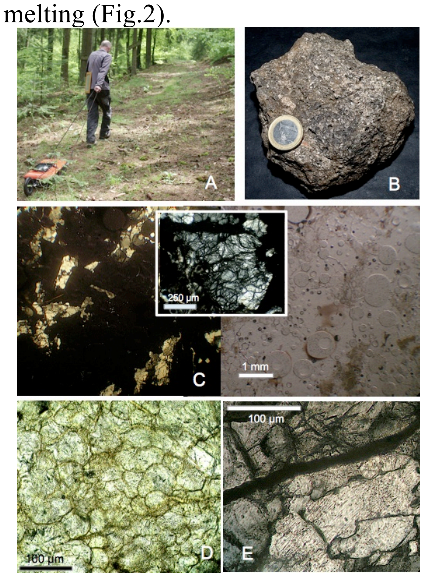

Fig. 2. A: 300 MHz GPR on top of the melt rock sheet. B: Granitic vesicular melt rock. Photomicrographs, C: Quartz grains in glass from the melt rock sheet, crossed polarizers and plane light. D: Silica ballen structures. E: PDF in quartz.

Shock effects in the melt rock sheet: In terms of impact nomenclature the material of the melt rock sheet may be considered impact melt rocks, in which relics of granites coexist with a strongly vesicular glass matrix (Fig. 2 B, C). The granite must obviously have been heated to such a degree that only quartz grains could survive (Fig. 2C). These quartz grains must have experienced extreme shattering (Fig. 2C, insertion), possibly from thermal shock. Shock effects like those well-known in quartz from impact cratering are observed throughout analyzed samples, and we state planar deformation features (PDF, Fig. 2E), open, tensile shock spallation fractures and diaplectic glass passing over to ballen structures (Fig. 2D).

The GPR measurements: An example of typical GPR parameters like layering, thicknesses, their variations and changes of facies is shown in Fig. 3A. The most remarkable feature however are strong radar reflections from a bowl-shaped structure within the otherwise homogeneous granite tracing a segment of a perfect circle over nearly 50 m (Fig. 3B). The signal polarity suggests a low-density, highly porous, air-filled fissure produced by strong tensile forces. An explanation other than a point source of compressive stress (an explosion) some distance above ground, producing a reflected rarefaction wave of equivalent geometry and reminding of the superficial impact cratering interference zone [3], causes basic difficulties. More bowl-shaped GPR reflectors along the melt rock sheet (Fig. 4) indicate a basic connection and a common process of formation.

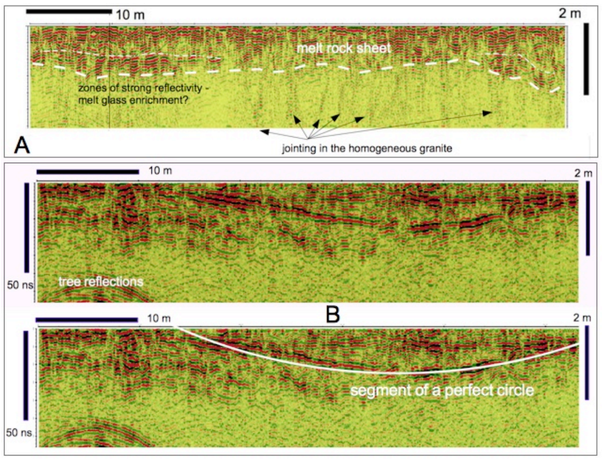

Fig. 3. A: Typical radargram from the melt rock sheet. B: The bowl-shaped GPR reflector. Note that the radargram is a 2D section of a possibly much larger structure.

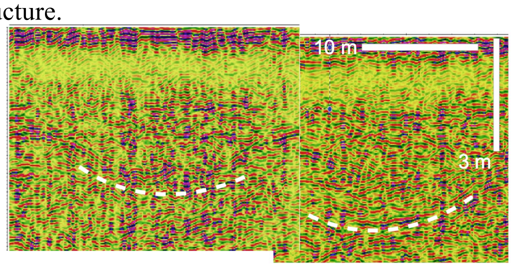

Fig. 4. Bowl-shaped and irregular strong reflectors are abundant in the melt rock sheet and below.

Discussion: After the discovery of the melt rock sheet near Bach and a presumed formation by an impact airburst, a connection with the now established Chiemgau multiple impact event ([4, 5], and references therein) with the 120 - 130 km distant crater strewn field (Fig. 1) was soon seen, because the role of strong airbursts in the Chiemgau impact in addition to crater formation (Tüttensee crater, Chiemsee double crater, etc.) became more and more evident. Considering effects of plasma formation and neutron radiation obviously being well observed and discussed in the crater strewn field, we moreover mention widespread effects of extreme heating of the ground ([5, 6], and references therein): Halos of strongly enhanced temperatures (>1,500°C) around smaller craters are observed, and anomalous distinct magnetic susceptibility peaks measured over large areas at some depth in the soil excluding industrial or geogenic origin could well be explained by an impact remagnetization due to strong temperature overprint. Unusually strongly magnetized limestone cobbles and boulders from some of the smaller craters, containing superparamagnetic nanoparticles, point to short-term high PT conditions. In particular, the formation of the chiemite carbon impactite containing diamonds and carbynes are reasonably explained by instantaneous shock carbonization/coalification of the target vegetation [6]. Hence, one or several airbursts in the Chiemgau area could well explain these observations, in particular with view to the low-density disintegrated, loosely bound asteroid or disintegrated comet proposed for the Chiemgau impact event [4, 5].

Conclusions: While impact airbursts and their threat to mankind are generally discussed for asteroids or meteoroids exploding high in the atmosphere, we present evidence that a larger dimensioned airburst was triggered close to the earth's surface, whereby not only noticeable craters were formed (Chiemgau impact), but obviously strong shock could be produced without crater formation (Bach). To our knowledge, no comparable event has yet been proven on Earth. It also puts into perspective the recent discussion about the formation of the Libyan desert glass, for which an airburst formation is once again ruled out in favor of a hitherto not found impact crater, and the above-mentioned danger from airbursts is considered exaggerated [7]. This view is contrasted by our now presented research. While the Chiemgau impact is fairly well dated between 900 and 600 B.C. [8], no dating is available for the melt rock sheet, although due to the low soil formation and the freshness of the glasses, a very young age is likely and a synchronous impact event must be seriously considered. Otherwise, it must be assumed that airbursts near the ground were much more frequent than expected.

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