STRONG SHOCK METAMORPHISM AND A CRATER: EVIDENCE OF A HOLOCENE METEORITE IMPACT EVENT NEAR NALBACH (SAARLAND, GERMANY).

Nico Berger[1], Werner Müller[2] and Kord Ernstson[3], [1]Formerly University of Trier, Germany (nicoberger1085@yahoo.de), [2]Diefflerstr. 217, 66809 Nalbach, Germany (edumueller@t-online.de) [3]Faculty of Philosophy I, University of Würzburg, Germany (kernstson@ernstson.de).

Introduction: A few years ago finds of peculiar samples by one of the authors (W.M.) initiated a few analyses of glass fragments that were speaking in favor of a Holocene possible new meteorite impact site in the Saarland region near the town of Saarlouis [1, 2]. More finds of rocks and glasses with typical impact features strengthened the impact hypothesis [3] and initiated comprehensive new mineralogical analyses at the university of Trier [4]. Here we report on the most significant results and a crater that has only recently been identified by LiDAR topographic mapping.

Geology: Stratigraphically, the area is located in Rotliegend and Buntsandstein sediments widely covered with Quaternary sands, gravels and loam. Tectonic overprint of the region is insignificant. Geologically peculiar finds that originally established the idea of a meteorite impact are monomictic and polymictic breccias, melt breccias with rock and metallic components, aerodynamically shaped glass bodies, aggregates with spherulitic texture, carbon spherules, pumice particles, vitrified sandstone and quartzite cobbles, silicate cobbles with glass-filled tensile fractures indicative of shock spallation, massive glassy carbon, and pumice-like glassy carbon.

Shock metamorphism: From thin-section analyses strong shock metamorphism in rock samples from the area is evident. Whole quartzite cobbles are more or less completely transferred to diaplectic glass (Fig. 1), embedded sanidine crystals included (Fig. 1). In 13 out of 23 investigated thin sections shock-produced ballen structures in quartz [5] are very common (Fig. 2A), and in several thin sections ballen structures were observed together with cristobalite merging into tridymite. Moreover "toasted" quartz [6] occurs as evidence for shock (Fig. 2B). Planar deformation features (PDFs) are rare, but quartz grains with spotty diaplectic glass and sets (up to seven per grain) of multiple planar fractures (PFs) that are considered as in proof of shock [7] are abundant (Fig. 2D). Strongly kinked biotites show a high frequency of closely spaced kink bands (Fig. 2C) and multiple sets of planar features crossing the basal cleavage, which are also attributed to shock overprint, since in the Nalbach region an origin from strong tectonics can basically be excluded. Spallation is a very common shock effect in the form of macroscopic open, tensile, glass-filled fractures in Nalbach cobbles as well as on a microscopic scale in individual quartz grains Fig. (3A). Such is the case also for the abundant occurrence of heavily damaged quartz grains frequently nearly pulverized although remained coherent (Fig. 3B).

Rock fragments exhibiting the same strong shock effects are dispersed through multicolored green, blue and black glasses that show schlieren texture and contain metallic Fe spherules.

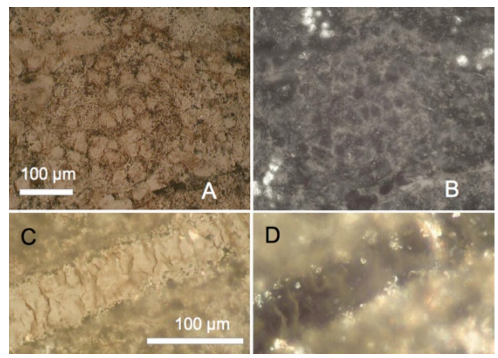

Fig. 1. Shock effects in rocks from the Nalbach area. A, B: Quartz grains in a quartzite cobble completely transferred to diaplectic glass. C, D: Diaplectic sanidine crystal embedded in a diaplectic quartzite cobble. - Photomicrographs, plane pol. light (left) and crossed polarizers.

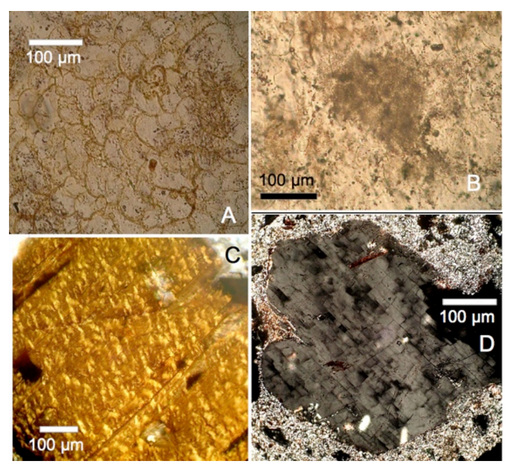

Fig. 2. Shock effects in rocks from the Nalbach area. A: ballen structures in quartz. B: "toasted" quartz. C: strong kink banding in biotite. D: multiple sets of planar fractures (PFs) and spotty diaplectic glass in quartz. Photomicrographs, plane pol. light (A, B) and crossed polarizers (C, D).

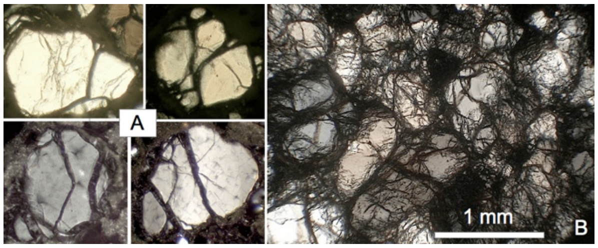

Fig. 3. A: Open, glass-filled shock spallation fractures typically revealing mirror symmetry to the grain surface. Size of the quartz grains between 0.5 and 0.8 mm. B: Heavily fractured however coherent quartz grains are abundant in the shocked Nalbach rocks.

Crater: With regard to the strong and abundant shock effects and the other significant impact features the absence of an impact crater proved to be enigmatic and suggested the sampled impact rocks could be reworked material from a more distant impact or from a crater meanwhile modified by young fluvial erosion and sedimentation. Also, a possible impact airburst without crater formation was discussed. Now, there is ample evidence of at least one related crater. In part hosting an abandoned sand pit exploited for about 20 years, W.M. encountered it only recently in the extended forestlands. The very importance of this "hole" in the forest became obvious only from the digital map produced from LiDAR data (Fig. 4). The crater is surrounded by a rim wall that has in part been removed by the sand exploitation and has a rim-to-rim diameter of almost 200 m. Preliminary field work revealed strongly fracture rocks and melt rocks surrounding the crater up to larger distances, which are interpreted as ejected material. More field work will be done. The selection of exactly this location for a sand pit may be explained by heavy impact shattering of exposed sandstones. Very old trees and undisturbed soil layers in larger parts of the crater prove its existence already well before the exploitation began.

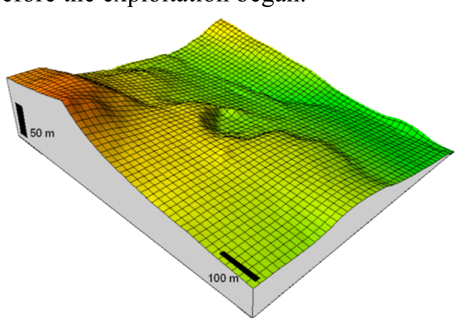

Fig. 4. The Nalbach crater from digital LiDAR data.

Discussion and conclusions: The widespread occurrence of peculiar samples in the Nalbach area covering many square kilometers and exhibiting convincing indications of high temperatures and high pressures, in particular the mineralogical evidence of strong shock, establishes a meteorite impact event in the Holocene as a matter of fact according to the generally accepted opinion that shock metamorphism in rocks proves a meteorite impact. The young Holocene age is concluded from the concentration of the peculiar finds in the upper soil layers, the very fresh status of the impact glasses and the young appearance of the now discovered probable impact crater. Using impact scaling laws an impactor to have produced this 200 m-diameter crater may have had a size of the order of only a few decameters. Hence, doubts may be raised whether such a relatively small impact was able to produce these widespread highest shock levels indicated by e.g. many quartzite cobbles transferred to diaplectic glass all through, and the many various impact glasses containing for their part strongly shocked rock fragments with diaplectic glass, ballen structures, toasted quartz and high-temperature SiO_2 modifications. Further investigations will possibly show whether the area under current investigation is only part of a much larger impact overprint of the region.

During the investigations it soon became evident that the peculiar findings in the Nalbach area revealed remarkable similarities to impact features in the Holocene large Chiemgau impact strewn field in southeast Germany [8-11], and meanwhile the possibility that the Nalbach impact is a companion to the Chiemgau impact has seriously been discussed [3]. Hence, it could be interesting and important to consider a coincidence in a much extended impact event that affected a distance of at least 500 km.

References:

[1] Buchner, E. et al. (2011) Abstract #5048. *74th Annual Meteoritical Society Meeting*. [2] Schmieder, M. et al. (2011) Abstract #5059. *74th Annual Meteoritical Society Meeting*. [3] Ernstson, K. et al. (2013) *Meteoritics & Planet. Sci., 48, s1,* Abstract #5058. [4] Berger, N. (2014) Diploma thesis, University of Trier. [5] Ferrière, L. et al. (2009) *Eur. J. Min*., 21, 203-217. [6] Whitehead, J. et al. (2002) *Geology*, 30, 431-434. [7] French, B. & Koeberl, C. (2010) *Earth Sci. Rev*., 98, 123-170. [8] Ernstson, K. et al. (2010 *Journal of Siberian Federal University, Engineering & Technologies*, 3, 72-102. [9] Rappenglück, M.A. et al. (2014) *Problems and perspectives of modern mineralogy (Yushkin Memorial Seminar–2014 Syktyvkar, Komi Republic, Russia),* Proc., 106-107. [10] Bauer, F. et al. (2013) Meteoritics & Planet. Sci., 48, s1, Abstract #5056. [11] Rappenglück, M.A. et al. (2013) Meteoritics & Planet. Sci., 48, s1, Abstract #5055.