ZHAMANSHINITE-LIKE BLACK-GLASS MELT ROCKS FROM THE SAARLAND (GERMANY) METEORITE IMPACT SITE

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Introduction: The Saarland impact (Fig. 1) has been an established event for several years with the existence of two craters with diameters of about 200 m (Nalbach) and Saarlouis (2.3 km) [1-4]. Finds of rocks and glasses in a strewn field (Fig. 1) with typical impact features (e.g. suevites) strengthened the impact hypothesis and initiated comprehensive mineralogical SEM-EDS and thin section analyses [2-4] establishing strong shock metamorphism [2, 5].

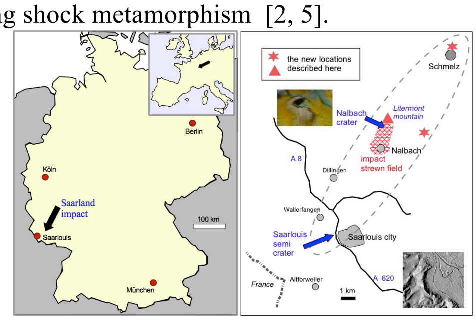


Fig. 1. Location maps. It is still unresolved whether the small elliptical distribution with a NNE - SSW strike is typically impact related as a strewn field or simply due to incomplete mapping evidence.

Here we report on new impact melt rocks from the Saarland impact region (Fig. 2), which have been discovered and sampled by authors D.P. and W.M., may define a special class of impactites, and served for the local production of stone age artifacts.

The material: Abundant black glasses in widespread distribution have been found and excavated in the impact strewn field for some time before, mostly pure glasses, but also occurring as major components of impactites (breccias) in centimeter size. SEM-EDS analyses of a black glass show SiO_2-poverty, abundant calcium and as much as 1wt.% arsenic (Fig. 2). Fe and Mn may be mainly responsible for the black color. It is unclear to what extent the mineral soil and its source rock were the source of the widespread glass formation. Carbonate rocks of the Muschelkalk and sandstones of the Buntsandstein make up the bulk in the region, and geogenic arsenic may occur in the Buntsandstein.

Besides the pure black glasses and black-glass melt rocks, special forms with admixtures of other colored glasses are found (Fig. 3). The composition is mostly more complex throughout, partly with proportions indicating original rock fragments. Admixtures of chiemite fragments are observed in many cases (Fig. 3 B, C). Chiemite is a carbon impactite composed of over 90% carbon and, according to detailed petrographic and mineralogical studies, was formed by direct shock metamorphism of target vegetation at pressures of several GPa and temperatures between 2,500 and 4000 K and with the formation of diamond and carbines [7, 8].

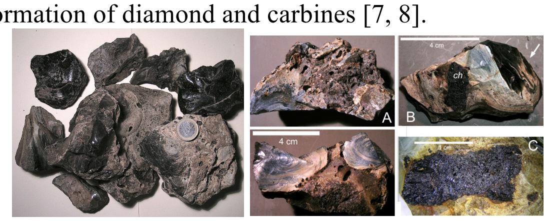
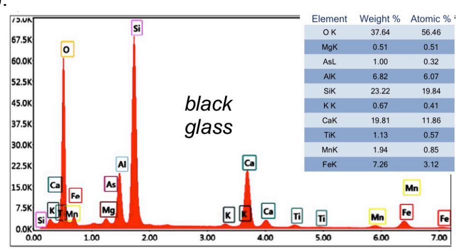


Fig. 2. Larger black-glass melt rocks from the new find locations, a few of which consisting of pure black glass. Coin diameter 22 mm**. Fig. 3**. A: Polymictic vesicular melt breccia (front and rear) with coiled globular bluish glass components. B, C: Polymictic melt rock with brownish-olive glass in sharp contact with bluish glass. ch = a freshly broken chiemite component (see text). Arrow: artifact retouch (see below).



Element	Weight %	Atomic %
O K	37.64	56.46
MgK	0.51	0.51
AsL	1.00	0.32
AlK	6.82	6.07
SiK	23.22	19.84
K K	0.67	0.41
CaK	19.81	11.86
TiK	1.13	0.57
MnK	1.94	0.85
FeK	7.26	3.12

Fig. 3. SEM-EDS element analysis of a black glass. [6].

Properties: The density of the pure black glass is 2.9-3.1 g/cm^3, and the Mohs hardness 6 - >7. All black glasses so far measured show enhanced magnetic susceptibilities of 1-3* 10^{-3} SI.

Looking into the black-glass melt rocks: Preliminary analyses of thin sections for three glass specimens (Fig. 4) show recrystallization in large parts, partly with (iron)metallic microspheres and strongly fractured quartz grains, isolated as single grains and as assemblages of a few grains. Sets of subplanar open fractures indicate shock spallation. In the recrystallization microstructure, a close resemblance to a microcrystalline chert structure appears (Fig. 5), with confusion ruled out by the bubble-rich matrix, fractured quartz, and metallic inclusions.

A frequently occurring distinct mineral structure with complete extinction under the polarizing microscope is ascribed to cubic spinel (Figs. 5, 6). Because of its high melting point of 2,135 °C the spinel is assumed to have survived the temperatures of the glass formation more or less as the only mineral. The formation of multiple sets of PDF (Fig. 6) with width and spacing down to 1-2 µm has, so far known, not before mentioned in the literature as a shock feature.

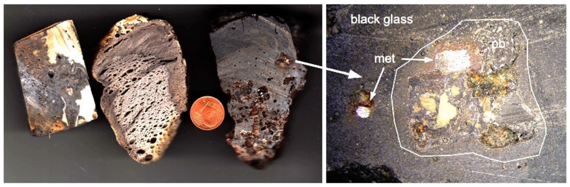


Fig. 4. Black-glass melt rocks for thin-section preparation. The sample on the right shows the contact between a strongly bubbly and a rather dense glass with finest bubbles. Both the small polymictic breccia fragment (pb) and the black glass contain tiny (iron)metallic particles (met).

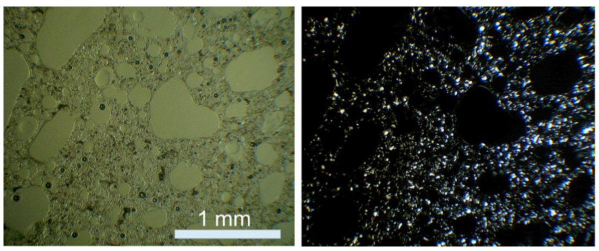


Fig. 5. Recrystallization microstructure of the middle sample in Fig. 4., photomicrograph, PPL and XX polarizers.

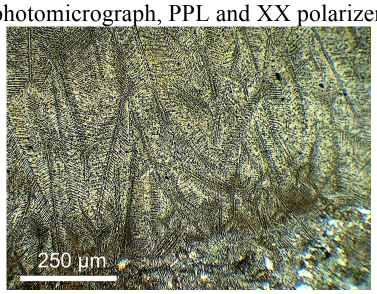


Fig. 6. Spinel grain with planar deformation features and twinning in contact to the glass matrix. Sample to the left in Fig.4, PPL.

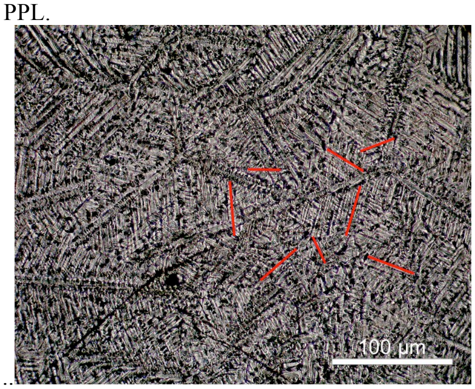


Fig. 7. Multiple sets (eight at least) of PDF in the spinel grain of Fig. 6. PPL.

The archeological aspect: The use of the Saarland glasses as Paleolithic artifacts also sheds light on previously established artifacts made of natural glass, with volcanic obsidian glass probably being the best known, and Libyan desert glass now generally recognized as impact glass. Otherwise common impact glasses usually do not have the size and consistency for fabrication of even smaller tools. Therefore, the large, often very pure black glasses from the Saarland were so predestined already in the Paleolithic. If the chronology for these artifacts is correct, the impact that left the glasses must have occurred as early as the Pleistocene and not, as assumed at the beginning of the Saarland impact research, in the recent Holocene [1]. A side effect of the artifact distribution is that all glassworks arguments of impact critics are untenable.

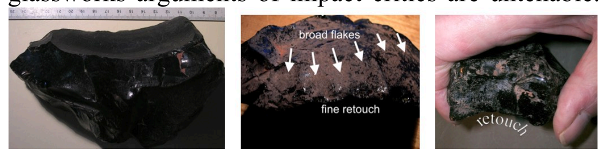


Fig. 8. One of the bigger glass chunks from the Litermont mountain (Fig. 1) weighting 1 kg, which must have been even larger because stone age men reduced the size when producing a side scraper (middle.). Right: Paleolithic hollow scraper, made of black glass.

Discussion: The event of the Saarland impact with the already immensely substantial finds has been considerably enriched by new observations and findings. The black glasses, some of them weighing more than one kilogram, and the accompanying larger polymictic melt rocks with mostly also high glass contents stand out. A similarity with many glasses and melt rocks of the Zhamanshin impact structure (zhamanshinites) is unmistakable. Similarities with the special type of layered Muong Nong tektite glasses should also be pointed out. Interesting to note that the black glasses do not show aerodynamic shape (like e.g. the Irghizites from the Zhamanshin impact structure) but rather intense flow textures of the melt rocks. This could suggest that the glass formation happened *in situ* directly on the ground underlining the possibility of near-ground airbursts [10], which could have heated the target up to temperatures of 5,000 K or more [11].

References: [1] Ernstson, K. et al. (2013) *Meteoritics & Planet. Sci.*, 48, Issue s1, Abstract #5058. [2] Berger, N. (2014) Diploma thesis, University of Trier. [3] Berger, N. et al. (2015) *46th LPSC*, Abstract #1255. [4] Ernstson, K. et al. (2018) *49th LPSC*, Abstract #1876. [5] Ernstson, K. (2020) Modern Problems of Theoretical, Experimental, and Applied Mineralogy (Yushkin Readings - 2020), *Proceedings*, 361-362. [6| Hiltl. M. (2017) pers. comm. [7] Shumilova, T.G. et al. (2018) *Acta Geologica Sinica,* 92, 2179-2200. [8] Ernstson, K. and Shumilova, T.G. (2020) Modern Problems of Theoretical, Experimental, and Applied Mineralogy (Yushkin Readings - 2020), *Proceedings*, 363-365. [9] Molnár, M. et al. (2017) *48th LPSC*, Abstract #1920. [10] Ernstson et al. (2020) *51st LPSC*, Abstract #1231. [11] Boslough M. (2014) Airburst Modeling. In: Allahdadi F., Pelton J. (eds) Handbook of Cosmic Hazards and Planetary Defense. Springer.