MICRO-"TUBULES" IN GLASS FROM THE BOLTYSH IMPACT STRUCTURE, UKRAINE. A. E. Pickersgill[1,], M. R. Lee[1], [1]School of Geographical & Earth Sciences, University of Glasgow, Gregory Building, Lilybank Gardens, Glasgow, G12 8QQ, UK, (annemarie.pickersgill@glasgow.ac.uk).

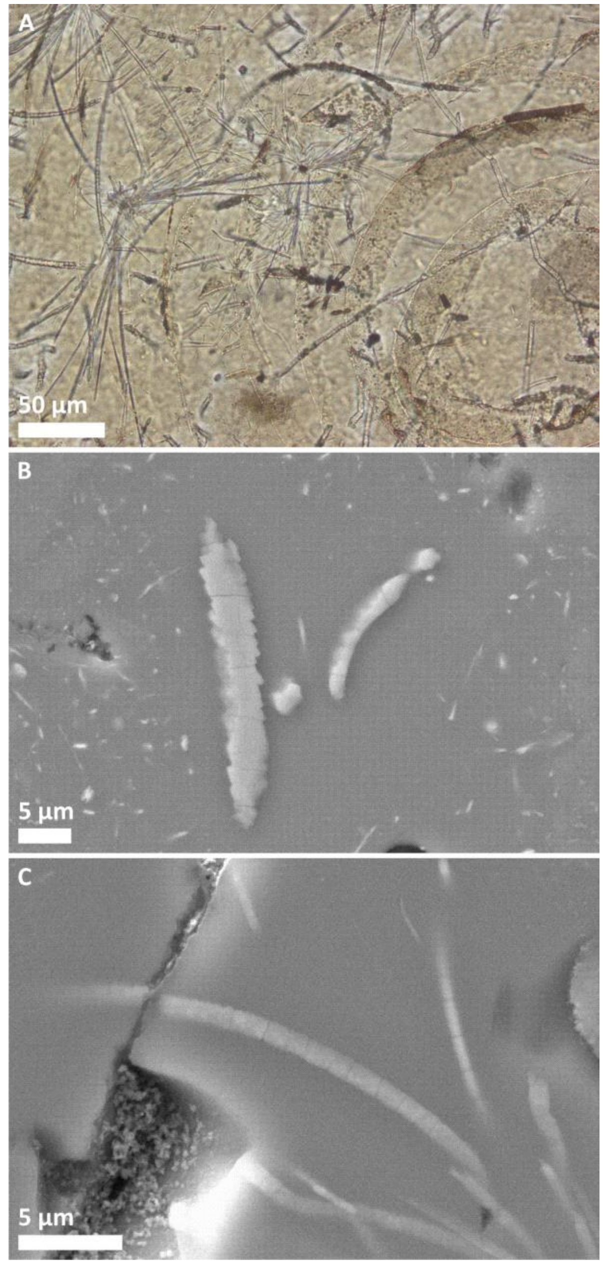
Introduction: Micro- and nanoscale tubular features have been previously reported in impact-generated glasses from the Ries impact structure, where they have been suggested to be biogenic [1, 2] and/or pyroxene trichites/microlites [3, 4, 5]. We report here for the first time morphologically similar features from the Boltysh impact structure. Boltysh, located in central Ukraine (48°45' N, 32°10' E), is ~25 km in diameter and has an $^{40}Ar/^{39}Ar$ age of 65.17 ± 0.64 Ma [6].

The Boltysh target rocks are Precambrian granites and granitic gneisses making up the crystalline basement of the Ukrainian Shield [7]. The impact structure is overlain by >500 m of Cretaceous and younger sedimentary rocks [7]. Owing to minimal post-impact erosion, a near complete section of impact melt rocks (allochtonous breccias and breccia deposits overlying an impact melt sheet) has been preserved [7].

Glass occurs in Boltysh cores B50 and B11475, which were described by [7]. In both of these cores the glass has been near the centre of the melt sheet, with the periphery of the sheet being crystalline. This "inverse" arrangement of crystalline and glassy impact melt rock (one would expect glassy melt rock to occur on the periphery as that should have cooled faster than the interior) is explained by [7] as a result of the extremely high silica content (~69% SiO_2) of the melt rocks. The resulting high viscosity of the impact melt would inhibit migration of chemical species, and therefore inhibit crystallization. This property would allow the melt sheet to have remained glassy during cooling. The microcrystalline periphery would then have formed as a result of advanced devitrification, likely catalysed by hydrothermal fluids [7].

Overall description: Glassy impact melt rocks have a groundmass of light brown glass with local areas of semi-perlitic fracturing. Plagioclase laths make up ~15% of the rock. They are approximately 250-500 µm long and 50-100 µm wide. Some show skeletal texture and/or swallow tail terminations. Pyroxene comprises ~5% of the rock, largely as aggregates of relatively equant crystals of ~100 µm.

The glass shows some variation in colour throughout, and is clearer in some areas than in others. In particular, the glass is clear in haloes around the pyroxene crystals. Approximately 15% of the glass is dark grey in colour, with a 'fuzzy' appearance, when viewed in transmitted light at low magnification. Clear haloes in the glass are also concentrated around these dark grey areas. Higher magnification shows that these grey



A. *Transmitted light image (plane-polarised) of tubular features, showing curvilinear and convoluted shapes, with some segmentation.* ***B.*** *Secondary electron image (SEI) of larger tubules with rough edges and fractures. Smaller tubules (fine white features) are not present in a halo around the larger ones.* ***C.*** *SEI of curved tubular features radiating from a central point (off image to bottom right). Tubules show a smooth curve and fractures forming apparent segmentation.*

areas of glass are concentrations of very thin, curving, and apparently tubular features (Fig A). They are not surficial but permeate the glass. Concentrations of these "tubules" vary significantly between different areas of the glass.

Tubular features: The tubular features are typically curvilinear, helical, or convoluted, and often segmented. They are typically ~1 µm wide and up to 200 µm long. When tubules are extremely dense, they create areas of localised darkness in plane-polarised transmitted light. Tubules are absent from haloes around pyroxene crystals, suggesting a diffusion gradient. The presence of plagioclase crystals does not seem to affect the density of tubules in the surrounding glass. Compared to the host glass, the tubules are enriched in Fe and Mg. Two size fractions of tubules can be recognized, that have widths of < 1 µm and 1-2 µm. Glass surrounding the larger tubules has tubule-free haloes that are similar in appearance to those around the pyroxene crystals (Fig B).

Most tubules appear to be randomly oriented relative to each other. The exception is where they radiate from an iron sulphide nucleus (which opaque in transmitted light, and high atomic number (white) in backscattered electron images), and these tubules appear to be straighter and their walls smoother (Fig. C).

SEM images of the larger of the tubules that intersect the polished surface of the thin section show that they are solid (i.e., they are fibers, not tubular pores). They are commonly segmented by fractures (Fig. C), and they yield electron backscatter diffraction (EBSD) patterns that index as clinopyroxene.

Discussion: This study was motivated by the intriguing possibility that similar features in glasses from the Ries impact structure may be biogenic [1, 2]. However, the preliminary work conducted here is consistent with the tubular features being pyroxene microlites/trichites, similar to those described by [3, 4, 5] at the Ries impact structure and by [e.g., 8] in volcanic glasses. While the morphologies seen here (curvilinear, helical, and convoluted) are not typical growth habits of crystallites, their chemical composition and crystal structure matches pyroxene. The tubule-free haloes around large pyroxene crystals and the larger tubules are suggestive of a chemical gradient whereby the Fe and Mg necessary for pyroxene crystal growth was obtained by depletion of nearby glass. Due to the high silica content of the melt, as described by [7], the mobility of Fe and Mg would have been limited, thus hindering the growth of larger crystals.

Future work: Due to the small size of these features, exact chemical and structural analyses are challenging. Further work is planned using higher resolution techniques including transmission electron microscopy and possibly atom probe tomography. We also plan to expand the study to other impact-generated and volcanic glasses in order to conduct a detailed comparison. If results of subsequent work on the Boltysh tubules reveals chemical/isotopic signatures of biogenicity, it will strengthen the findings of [1, 2], and pave the way for further studies into which types of impactites that are most likely to host signs of former or extant life. Conversely, if our investigations demonstrate that all the tubular features at Boltysh are quench crystallites [5] or products of devitrification [3, 4] then we will have gained valuable new insights into the cooling processes of impact glasses, and into the formation of microlites and trichites more broadly

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