Enigmatic tubular features in impact glass

Nicola McLoughlin and Eugene G. Grosch
Department of Earth Science, University of Bergen, Bergen N-5072, Norway

The hypothesis that endolithic microbes tunnel into impact glasses is very provocative, but unsupported by the enigmatic tubular features reported by Sapers et al. (2014). We argue that the full range of abiotic processes that can give rise to microtubes in impact glasses has not been excluded by these authors. We also challenge the validity of comparing alteration processes from submarine volcanic systems to those argued to occur in terrestrial impact environments. Lastly, we question the endogenicity of the organics reported by Sapers et al. In short, the biogenicity of the enigmatic tubular features from the Ries impact glasses is far from proven, meaning that any discussion of the potential astrobiological implications is premature.

A range of abiotic mechanisms needs to be more thoroughly considered for the origins of the microtubes in the Ries impact breccias, in particular processes related to shock metamorphism. For example, ballen textures form as the result of impact-triggered transitions of silica phases at high temperatures creating curvilinear boundaries with similarities to some of the Ries microtextures (Ferrière et al., 2009, their figure 2). Incipient ballen textures form around the margins of glass fragments in impact breccias, similar to the distribution of the Ries microtextures, and subsequent thermal annealing could modify these to produce a spectrum of morphologies. Elevated fluid pressures are also conceivable in impact settings, bringing a second abiotic mechanism known as ambient inclusion trail-type processes into consideration. This process is best known in cherts and has been described from vitric tuffs, where elevated fluid pressures during diagenesis and low-grade metamorphism cause crystalline or organic inclusions to migrate creating a hollow tubular trail (Leplot et al., 2011). This process could also occur by the migration of inclusions in viscous impact melts, and can generate spiral-shaped and branched microtubes. In this context, it should be appreciated that the composition and rheological properties of the Ries impact glass is very different from basaltic glass, as it was generated by impact-induced melting of crystalline basement. In summary, several abiotic mechanisms are both highly plausible in impact settings and need to be more fully investigated before they can be rejected as an origin for the Ries microtubes.

We question the geological analogy made by Sapers et al. between processes in sub-seafloor volcanic glasses and in terrestrial impact melts. The origin of the glasses and the hydrogeological settings are very different. On the one hand, high-temperature, high-pressure volcanic glasses that undergo long-term aqueous alteration in a submarine setting are being compared to high-pressure, high-temperature impact glasses that undergo relatively short-lived hydrothermal alteration in a terrestrial setting. In addition, we contest the textural comparison made between the Ries microtubes and microtextures in seafloor basalts. In particular, it appears that many of the Ries microtubes are isolated within clasts, and it is not convincingly shown that they are all uniquely rooted in fractures and/or clast margins. This could support alternative abiotic modes of formation, including those explored above. We also stress that the textural atlas of Fisk and McLoughlin (2013) is intended only as a descriptive guide and not as an indicator of biogenicity; moreover, it has been misapplied by Sapers et al. in taking observations from the sub-seafloor and applying these to impact melts. Lastly, we highlight the ongoing debate concerning the reliability of the microtextural evidence in submarine glasses that Sapers et al. do not acknowledge. There remains the possibility that purely physiochemical processes could account for many of the microtextures found (e.g., Fisk et al., 2013) irrespective of independent isotopic and microbiological evidence.

The endogenicity of the organics reported by Sapers et al. is not demonstrated. The possibility that the FT-IR data records exogenous organics derived from the pre- or post-impact terrestrial ecosystem is not excluded. Howard et al. (2013) showed that impact melts can incorporate pre-impact terrestrial biomarkers, and this scenario needs to be rejected for the Ries impact glasses. Spatially more appropriate techniques other than FT-IR (spot size of ~250 µm in Sapers et al.) need to be applied to the Ries microtunnels. For example, high-resolution FIB-TEM (focused ion beam TEM) and nanoSIMS (nano-scale secondary ion microprobe) are very sensitive techniques for investigating sub-micron organics in volcanic glasses (e.g. McLoughlin et al., 2012). Such methods are needed to verify the apparent EPS biofilms in the Ries impact glasses inferred by Sapers et al. on the basis of SEM morphology alone.

The astrobiological speculations made by Sapers et al. are over-extrapolated from their data as reflected in the strong disconnect between their study title and sweeping conclusions. We do not question the possibility of microbial life in post-impact hydrothermal settings (Cockell, 2006) but rather contest the reliability of tubular features in the Ries impact glasses as biosignatures. We argue that there are more reliable alternative biosignatures; for example, fractionated sulfur isotopes in vein-hosted sulfides (Parnell et al., 2010). More broadly, there are a range of other settings on planetary surfaces where volcanic glasses may have interacted with water, providing the opportunity for microbial activity and a range of putative biosignatures (Grosch et al., 2014). In contrast, microtunnels in impact glasses are currently not a simple or robust biosignature for seeking life on Earth or beyond.

REFERENCES CITED