Forum Comment

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Widespread glasses generated by cometary fireballs during the late Pleistocene in the Atacama Desert, Chile

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Schultz et al. (2021) interpreted the unusual silicate surface glasses found in the northeastern part of the Atacama Desert as products of a comet airburst that occurred about12 k.y. ago. This interpretation contradicts our conclusions (Roperch et al., 2017). On the basis of abundant field and laboratory evidence, our work suggested that the glasses were formed during intense fires in soils with thick silica-rich plant litter. Here we point out several features that question the interpretation of Schultz et al.; namely, (1) the mode of emplacement of the glasses, (2) the chronology of heating events, (3) the identification of putative bolide composition in glass-hosted mineral inclusions, and (4) the mineralogical evidence for ultrahigh temperatures.

(1) Schultz et al. acknowledge that radiation from a bolide airburst is limited to a few millimeters of surface sediments. They thus assume that melting occurred in the dust cloud generated by the airburst blast effect, and that the melt was projected to the ground and accumulated in thick glass patches. However, Schultz et al. acknowledge that at all localities where they are encountered (mainly Puquio de Nuñez [PN] and Quebrada de Chipana [QC]), the glasses are strictly restricted to paleo-wetlands, which strongly suggests a paleoenvironmental control rather than an external forcing event like an airburst. Paleomagnetic analyses show that surface clasts lying on stable surfaces of nearby hills immediately outside of the glass fields have not been heated. At PN, highly vesicular glasses are also found below the surface, below 10 to 20 cm of sand and soil. These glasses do not show crushing or transport features that would be expected if melted particles entrained in the ionized plume had fallen to the ground. Many glasses contain imprints from the melted silicified stems of wetland plants (Roperch et al., 2017, our figure 4f). Schultz et al. also ignored the several tens of square meters of thick (>20 cm) baked clays that occur at locality QC (Roperch et al., 2017, our figures 3d–3f). The analysis of the thermoremanent magnetization of these clays demonstrates that they were heated above 600 °C. A rain of melted glass cannot bake such thick layers of clays to such temperatures.

(2) Schultz et al. assume that the youngest ^{14}C ages at PN date a single thermal event at all localities despite the oldest ^{14}C ages on carbonized organic matter found in close relation with the glasses at QC. They omit the record of different paleomagnetic directions and paleointensities between localities that demonstrate the impossibility for a single contemporaneous thermal event at PN and QC. During a low-altitude airburst, the ionized plume may generate short term (seconds to minutes after the airburst) local magnetic field variations. But the thickness of the baked clays (>20 cm) and glass patches (up to ~50 cm) implies that cooling from 580 °C (Curie temperature of magnetite) to 200 °C (minimum blocking temperature of the magnetization) took at least hours, especially as cooling started at ~1000 °C. Thus, the baked soils and glasses would record their thermoremanent magnetization well after the initiation of the putative airburst. The different geomagnetic field directions recorded at PN and QC can only be explained by geomagnetic secular variation occurring over centuries. The airburst hypothesis at Pica is thus at odds with the paleomagnetic data and differences in ^{14}C ages.

(3) Numerous small reduced phases (Fe sulfides, Fe phosphides, native iron, 1–100 µm in diameter) are present in Pica glasses. Schultz et al. argue from semiquantitative energy-dispersive spectroscopy (EDS) that the Fe sulfides are extraterrestrial troilite with 0.5–2 wt% Ni. High-precision–inductively coupled–mass spectrometry analyses of our 14 bulk samples (Roperch et al., 2017, our table S1) give Ni concentrations of 9.6–20.1 ppm that are a factor of ten lower than those usually reported in indisputable impact melts (e.g., Tagle et al., 2009). Combined with the available bulk rock S contents, these bulk rock Ni contents correspond to <0.4 wt% Ni in the Fe sulfide phase. If any Ni-troilite is present, it is an exception, not the rule. It is worth recalling that Fe sulfides melt at low temperature and that intense S loss is expected during vaporization associated with an airburst explosion. Thus, original textures of the bolide sulfides like the cubanite overgrowths described by Schultz et al. are unlikely to survive an airburst thermal event. Owing to their preferential nucleation on the walls of gas vesicles in Pica glasses, Fe sulfides represent immiscible sulfide melt droplets rather than input of extraterrestrial sulfides. Their high abundance likely results from reduction of sulfate (for example, the silicified plant stems display up to 5 wt% oxidized S according to our bulk-rock analyses; see our table S1). Schultz et al. also report minerals (melilite and perovskite) interpreted as dismembered calcium-aluminum inclusions (CAIs, typically found in carbonaceous chondrites). CAIs usually enclose highly refractory metal nuggets consisting of refractory platinum-group element (Os, Ir, Ru, Rh, and Pt) alloys. Our search for these alloys that are easily detectable by backscattered electron imaging has been unsuccessful. Finally, the lack of meteoritic contamination is supported by the bulk platinum-group element content of the glass sample richest in Fe sulfides (PN-80; Ir:0.02; Pd:0.36, Pt:0.02 in ppb) that matches the terrestrial continental crust composition (Tagle et al., 2009).

(4) Schultz et al. used the transformed zircon rims as evidence of ultrahigh temperature decomposition. Zircon destabilization features may be equivocal as they can be obtained through several documented ways. Owing to the very long exposure (a scale of several million years) of the Atacama desert surface, a few detrital zircons previously struck by lightning could have been embedded in the glasses (Kenny and Pasek, 2021). Alkali elements from the Atacama salty soils, especially rich in NaCl, may also reduce significantly the decomposition temperature of zircon. Alternative processes should be considered before attributing zircon destabilized rims to ultrahigh temperatures related to a hypothetical airburst origin.

In conclusion, we find no convincing evidence in the Schultz et al. paper indicating formation of the Pica glasses by an airburst. The hypothesis of formation during intense fires, although less spectacular, seems more robust.

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