Sears, D. W. G. (1999c) Editorial - Fiery origins and museum grit and gravel. *Meteoritics & Planetary Science*, vol. 34, pp.312-313

Fiery origins and museum grit and gravel

It is usually the fusion crust of a meteorite in the museum display case that first catches our eye. That black glassy skin, with all its fine diverse textures, that bears testimony to the rock's fiery passage through the atmosphere (Fig. 1). Lavoisier attributed the fusion crust to the rock being struck by lightning and he had good cause. A roof tile once hit him while walking through the streets of Paris in a thunderstorm (Lavoisier, 1777). When Edward Charles Howard and Jacques Louis Compte de Bournon wrote their pioneering paper laying out the scientific arguments for the extraterrestrial nature of meteorites—a paper more influential than Chladni's in establishing the scientific study of meteorites—they were also intrigued by the fusion crust (Howard, 1802). Howard records that he was able to reproduce the crust by passing "the electric charge of 34 square feet of glass" over the rock and he concluded that atmospheric electricity was involved in forming the crust and the fireball. He thus made the first simulation experiment in meteorite studies, and the first mistaken interpretation. The rock was observed to glow for 15 minutes, making Howard also the first to observe meteorite luminescence. It was not until the laws of thermodynamics were developed that the formation of the fusion crust could be fully explained in the middle of the nineteenth century.

There were many early descriptions of the fusion crusts, like those of Tscherkmak, who made the first observation of everything in meteorite petrology, and those of Borgstrom. In the twentieth century, the great Russian meteorite expert E. L. Krinov pointed out the variety of surface textures produced by different orientations (Krinov, 1966). He also described the major zones of alteration that occurred in the meteorite during fusion crust production: the outer glassy zone, a central partially melted zone, and an inner zone where metal and sulfide had flowed back into unaltered meteorite. The master of reflected light microscopy, Paul Ramdohr, refined this into no less than eight zones (Randohr, 1967). As a beginning graduate student, I wrote my first paper combining the dimensions of fusion crust zones for the Barwell meteorite, with the heat conduction equations of Carslaw and Jaeger to calculate temperature gradients and ablation rates for each face during flight (Sears and Mills, 1973). The work stood me in good stead a few years later when I wanted to avoid heat-altered material for thermoluminescence studies. One of my most memorable events as a graduate student was a letter I received from Harvey Nininger arguing that electron microprobe analysis of the fusion crust could replace bulk analysis. He argued that Nature had given us the natural equivalent of a "fused bead".

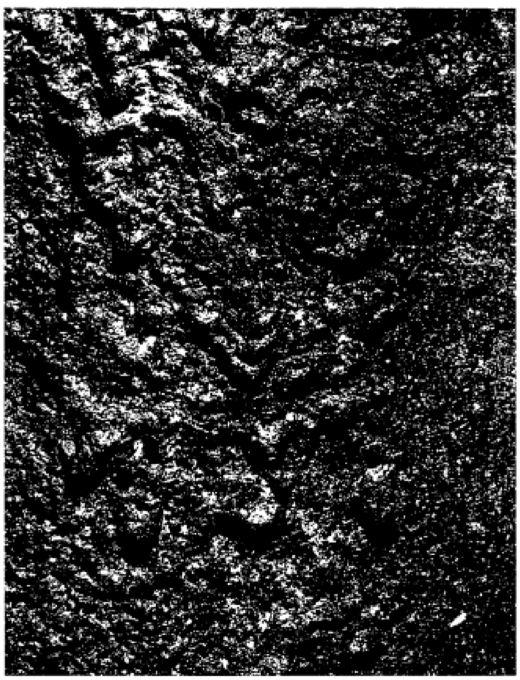

FIG. 1. Detailed image of flow structures in the fusion crust of the Barwell meteorite. This is a lateral face, so the crust has intermediate thickness to that of the front where it is very thin and that of the back where it is very thick, and has textures that indicate rearward (top to bottom) flow. The image field is 2.5 cm wide. (Photograph courtesy of Allan A. Mills, Leicester University.)

In fact, I did no probe work and we have had to wait another twenty-five years for a major survey paper of the composition of phases in the fusion crust. In this issue of *Meteoritics & Planetary Science*, Genge and Grady report their petrographic observations and electron microprobe analyses of the fusion crusts of 73 stony meteorites. They were motivated by the relationship between the fusion crusts and the meteorite ablation spherules found in searches for interplanetary dust particles. Common to fusion crusts and ablation spherules are glass, magnetite, and Ni-rich sulfide and metal. Genge and Grady also performed defocussed electron microprobe analysis of the fusion crusts, as Nininger had advocated. Fusion crust compositions are reasonably similar to that of the bulk meteorite, although loss of volatiles and immiscible Fe-rich liquids and a certain amount of transport and mixing of melted phases had caused a lowering of S, Fe, and Ni. The bottom line is that Genge and Grady expect ablation spherules produced low in the atmosphere, at altitudes similar to those that produced the presently observed fusion crust, to have compositions similar to the bulk meteorite from which they came. However, because of their smaller size and greater alteration, the deviations from host compositions might be more marked in the spherules. So the grit and gravel in the museum specimen trays, much of which is fusion crust rejected in the normal course of study, has important information for us after all.

Derek Sears
Editor

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