METEORITE FRACTURES AND SCALING FOR ASTEROID ATMOSPHERIC ENTRY.

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Introduction: We are attempting to understand the behavior of asteroids entering the atmosphere in order to help quantify the impact hazard. The strength of meteorites plays a critical role in determining the outcome of their impact events [1]. Our objective is to scale fracture parameters in meteorites to their parent body.

Experimental: Meteorites in the Natural History Museums of Vienna and London were examined. In Vienna we looked at a few samples from all classes, while in London we looked at all of their H and L chondrites. The fracture patterns in selected fragments were imaged. The density and length of the observed fractures were measured in hand specimens (Fig. 1A), and thin sections (Fig. 1B).

Results: In this study of over a thousand meteorite fragments (mostly hand-sized, some 40 or 50 cm across), we identified six kinds of fracturing behavior. (1) Chondrites usually showed random fractures with no particular sensitivity to meteorite texture. Approx. 80% of these indicated no point of origin, while 20% show an origin. (2) About 10% of the chondrites have a distinct and strong network of fractures making an orthogonal or triple intersection structure. (3) Fine irons with large crystal boundaries fragmented along the crystal boundaries. (4) Coarse irons fractured along kamacite grain boundaries, while (5) fine irons fragmented randomly. Finally, (6) CM chondrites showed that water-rich meteorites fracture around clasts.

Discussion: We assume that fracturing follows the Weibull distribution [3], where fractures are assumed to be randomly distributed through the target and the likelihood of encountering a fracture increases with distance. The images collected of the six fracture behaviors provide a two-dimensional view of the fractures. A relationship exists between the distributions of measured trace length and actual fracture size [4], where the slope of a log-log plot of trace length vs fracture density is proportional to α, the shape parameter. The value for α is unclear [5] and a large range in α has been determined from light curve data [1]. α can be used to scale strengths. Figure 2 plots the fracture lengths and densities measured of both the slab and thin section of Bluff (a). A power law is fitted to the data, and 0.185 was determined for the value of α based off these samples, compared to the commonly used 0.166.

Conclusions: Based on the meteorites examined in our study, six fracture patterns have been observed. The majority of the meteorites displayed no particular sensitivity to meteorite texture. A value of α of 0.185 has been determined for a chondrite with a fracture pattern that shows no sensitivity to meteorite texture and has no point of origin. This study will continue to examine additional meteorites with similar fracture patterns along with the other 5 patterns to see if there is a correlation between fracture pattern and α. This may explain the variations in α determined from fireball data [1,2]. Values of α will be used in models created by the Asteroid Threat Assessment Project to try to determine the behavior of asteroids entering the atmosphere and quantify their impact hazard.

References: [1] Popova O. et al. (2011) *Meteorit. Planet. Sci.* 46, 1525–1550. [2]Sears D.W.G. et al. (2016) *Proceedings of the AIAA SciTech,* AIAA-2016-0997 [3] Weibull W. (1939) *Proceedings of the Royal Swedish Institute for Engineering Research*. No. 153. [4] Piggot A.R. (1997) *JGR,* 102, 18,121-18,125. [5] Asphaug E. et al. (2002) *Asteroids III.* 463-484.

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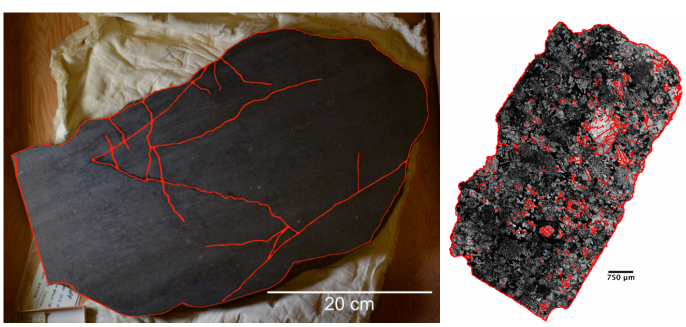

Figure 1. *A. Fractures (red tracings) in this slab of Bluff (a) are insensitive to meteorite texture and have no point of origin. B. Fractures (red tracings) in thin section of Bluff (a). Fracture density and length are used to determine the Weibull coefficient.*

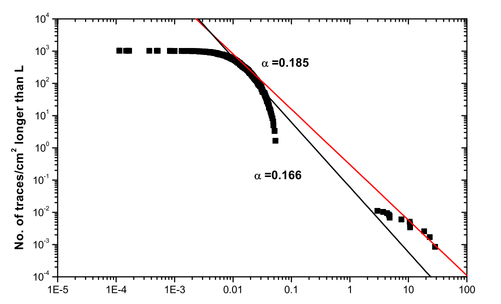

Figure 2. *Distribution of flaw trace length for Bluff (a). The red line is based on the relationship between trace density and length, with a slope providing α. The black line displays the same relationship but with the commonly used value of 0.166 for α.*