Comparing methods to estimate the decay rate of fracturing away from impact centers

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Four methods can be used to estimate the fracturing rate away from the impact center: (i) mapping shock induced fracture densities with remote sensing tools, geophysical methods, or by in-situ field measurements (Gurov&Gurova 1983; Pesonen 2011, Henkel 1992); (ii) modeling damage and deformation in the impact structures and surrounding target rocks using numerical codes (Collins et al. 2004); (iii) interpreting gravity anomalies of the impact and fractured target layers in terms of porosities (Henkel et al. 2010); or (iv) studying porosities of impact and target rocks vertically down (deep cores) or horizontally away (sampling of exposed rocks) (Pesonen 2011). All methods have serious flaws and their comparison is difficult. Here we present a study of 18 impact structures on Earth from which we have shocked samples as a function of radial distance. The rocks were split into 5 types in order of decreasing shock: melts, suevites, breccias, fractured and unfractured target rocks. The petrophysical properties measured in a laboratory were: density, porosity, susceptibility, NRM and the Q-value. The data reveal distinct trends: 1. Porosity decreases from suevites to breccias to melts to fractured target rock up to unfractured target. By analogy, the density increases in same order, 2. The case for susceptibility is more complex: the fractured rocks reveal declined suceptibilities which is the main cause for the magnetic "haloes" surrounding many impact structures. 3. The NRM is also very variable: the suevites and melts have the highest NRM´s and Q-values. The main result of this work is that porosities and fracture densities decay away from the center with much faster rate than the fracturing in the numerical models or in gravity data. We discuss the possible causes of these discrepances in terms of defining the radial distance, assessing shock degree to various samples, and how to account for the various ages and erosion levels.