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Porosity of impactites - key for understanding cratering process?

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Impact event releases a large amount of energy, which is derived from the kinetic energy of the impacting projectile and it is equal to $^1/_2mv^2$, where m is projectile mass and v its velocity. At the instant of impact, the object's kinetic energy is converted into intense high-pressure shock waves, which radiate rapidly outward from the impact point through the target rock. The extreme physical conditions of pressure, temperature, and strain imposed by shock waves produce unique effects (e.g. mineral deformation, melting, fracturing) in the rocks and mineral grains through which they pass (French 1998). In this work we will concentrate on the shock induced fracturing by observing the porosity of the impact rocks and target rocks.

It is well-known that densities of impact rocks can be up to 30% lower than in unshocked target rocks due to impact-increased porosity and fracturing (Pilkington and Grieve 1992). Shock- and rarefaction waves created by a hypervelocity impact profoundly change the porosity of the target material. In crystalline targets impact cratering generally leads to shock metamorphic rocks with increased porosity, whereas in the case of sedimentary lithologies with high initial porosity, some of the energy delivered in impact causes pore collapse, thus reducing porosity (Kieffer et al 1976). Kieffer and co-workers showed that in the Coconino sandstones at Meteor crater, Arizona, the porosity of the material was reduced from approximately 20% (Kieffer 1975) to less than 5% (Kieffer 1971) following low shock pressures. Thus, in some cases, impact will reduce pore space. The reduction in porosity was caused by the re-orientation of the grains into a more closely packed configuration.

Porosity is fast and easy to measure and it may offer important additional information on cratering process. When the porosity is reported as a function of distance from the centre point of the crater, it gives indirect information about the attenuation of the shock wave. We are compiling a global database of porosities in various types of impact structures, in order to gain a deeper insight into shock attenuation and other processes (e.g. hydrothermal fluid circulation) pertinent to impact cratering. So far this work summarizes the porosity data of 20 impact structures, which comes partly from literature and partly from our unpublished data. The rocks have been divided into two categories: impactites (divided into melts, suevites, and breccias) and target rocks (divided into fractured and unfractured). These units roughly correspond to the increasing distance either downward (drill core data) or radially away (lateral sampling) from the point of impact. However, we are aware that the distances (r_r/r_c) are to be viewed only as rough measures of the original radial distance since the structures are different in their diameter, age, erosional level, and tectonic modification. Nevertheless, we note that generally the porosity decreases when moving away from impactites to fractured and to unfractured target rocks. For example, in the case of the Jänisjärvi impact structure (Salminen 2004) the porosity has a trend to decrease (from approximately 10%) in impactites to the unfractured target rocks (approximately 0.5%), consistent with decreasing shock pressure.

In addition to being an important aspect of the theory of impact cratering, porosity of impactites bears major economic significance, since fractured rocks in impact structures can act as traps for hydrocarbons or groundwater. Also the fundamental questions on the origin of life and life on other planets relate to impactites' porosities, since bacteria and algae are supposed to thrive on craters' fractured rocks nourished by hydrothermal fluids circulating in the newly formed crater.

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