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The Effect of Porosity on Meteorite Impact Processes

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Impact induced crater formation and the accompanying mechanical and thermodynamic modification of the surrounding rocks are significantly affected by the petrological, petrophysical, and structural characteristics of the target. The presence of open pore space is usually only taken into account when considering highly porous targets like asteroids or comets, which may have porosities as high as 75-80%. Large-scale crater formation on planetary surfaces is believed to be not substantially affected by porosity because the amount of open pore space is generally much smaller and decreases very rapidly with depth. However, for the formation of smaller craters in sedimentary target rocks, which usually contain porosities of up to 15-20%, the effect might not be negligible. Porous targets are generally known to be poor transmitters of impact shock because their solid and void-space components present extreme acoustic impedance mismatches.

In our study we utilized numerical modelling to investigate the influence of porosity on the impact process with respect to crater formation and shock wave compression. The numerical simulations of impacts into porous material require an appropriate model for how pore space is crushed out during the initial stage of the impact. Most hydrocodes compute the pressure explicitly using an "equation of state" (EOS) for each material, which relates changes in density and internal energy to changes in pressure. The added complication introduced by porosity is that changes in a material's density are due to both the closing of pore space (*compaction*) and *compression* of the solid component. To account for the compaction process we use a newly developed strain-based porosity model [1], implemented in the iSALE hydrocode for impact cratering simulations. The thermodynamic compression is calculated with the Tillotson EOS.

Our modelling results show that the crushing of pore space is an effective mechanism for absorbing shock waves and results in higher post-shock temperatures than observed in nonporous rocks. The loss of energy that is consumed by the closure of pore space results in less-efficient crater excavation and hence smaller crater sizes than for similar impacts of the same impact energy in nonporous targets. This is verified by experimental cratering studies [2]. A further important result from our work is that it is not porosity alone, but the combination of porosity and friction that affects the size of the excavated crater. Porosity and friction (strength) are closely coupled parameters that also influence the ejection angle and velocity, and the thermodynamic processes due to shock wave compression.

[1] Wünnemann, K., Collins, G.S., Melosh, H.J., 2006, A strain-based porosity model for use in hydrocode simulations of impacts and implications for transient crater growth in porous targets. Icarus, (in press) **[2]** Schmidt, R.M., Housen, K.R., 1987, Some recent advances in the scaling of impact and explosion cratering. Int. J. Impact Eng. 5, 543-560.