Analyzing effects of impact landers on substrates using advanced surveying techniques

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Abstract. The dual stage impact asteroid sampler[1] designed by the University of Washington can excavate up to 1 kg of source material, while producing an atypical crater morphology and fracture pattern. The sampler is able to impact the surface between 30-120˚ off normal, ejecting the sample to be collected by a separate stage. Typical crater formation involves an invariant radial force distribution from all contact points of the impactor (i.e. A shockwave), creating the well characterized "bowl" morphology of a simple crater. The force of impact oftentimes destroys the impactor, but also creates characteristic fracture zones within the crater. The asteroid sampler (Bore Excavated Asteroid Retrieval System, BEARS) tested in both field and lab experiments, demonstrates consistently narrow, deep craters that indicate a non-uniform impact force distribution. 3D mapping of the craters allowed for extremely accurate depictions of crater volume, morphology, and geometry. Furthermore, mapping of the fracture zones in both ice and granite impact craters indicates minimal radial force progression, with the majority of the impact force propagating deep into the substrate. Thin section analysis of material from each fracture zone will quantify the force reaching each zone. The results from this study will help guide sampling locations, understand possible sample deformation, and be applicable to the design of impact landers for airless bodies[2] and understanding of their particular craters.

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[1] C. Truitt, *Planetary Penetrators for Sample Return Missions,* Thesis (2016).

[2] R. Winglee, T. Robinson, M. Danner, J. Koch, *Acta Astronautica* 144, 136-146 (2018).