Measuring fracture properties of meteorites: 3D scans and disruption experiments

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Many meteorite studies are focused on chemical and isotopic composition, which provide insightful information regarding the age, formation, and evolution of the Solar System. However, their fundamental mechanical properties have received less attention. It is important to determine these properties as they are related to disruption and fragmentation of bolides and asteroids, and activities related to sample return and hazardous asteroid mitigation. Here we present results from an ongoing suite of measurements and experiments focusing on maps of surface texture that connect to the dynamic geological properties of a diverse range of meteorites from the Center for Meteorite Studies (CMS) collection at Arizona State University (ASU). Results will include high-resolution 3D color-shape models and texture maps from which we derive fractal dimensions of fractured surfaces. Fractal dimension is closely related to the internal structural heterogeneity and fragmentation of rock, and to macroscopic optical properties, and to rubble friction and cohesion. Selected meteorites, in particular Tamdakht (H5), Allende (CV3), and Chelyabinsk (LL5), will subsequently be disrupted in catastrophic hypervelocity impact experiments. The fragments obtained from these experiments will be scanned, and the results compared with the fragments obtained in numerical hydrocode simulations, whose initial conditions are set up precisely from 3D scans of the original meteorite. By attaining the best match we will obtain key parameters for models of asteroid and bolide disruption.

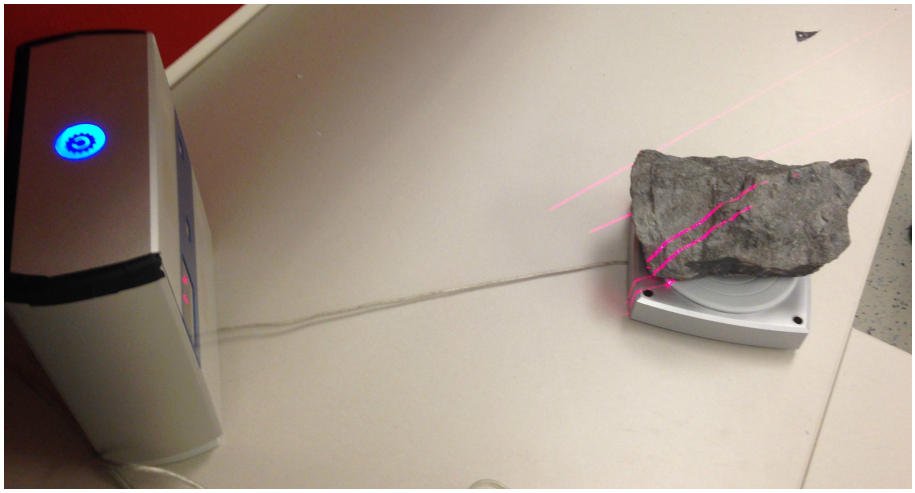

Figure: Obtaining a 3D surface scan of the Tamdakht (H5 chondrite, 5 kg) meteorite using a NEXTENGINE 3D Scanner HD, which can resolve meteorite surfaces with a resolution of 0.2 mm. The meteorite, as well as fragments of Allende (CV3) and Chelyabinsk (LL5) chondrites, will be disrupted in ballistic experiments and subsequent 3D surface scans will be obtained of the resulting fragments.