HUGONIOT MEASUREMENTS ON HETEROGENEOUS GEOLOGIC MATERIALS, R. G. Kraus[1] , M. G. Newman[1], and S. T. Stewart[1], [1]Harvard University (20 Oxford St. Cambridge, MA 02138, rkraus@fas.harvard.edu)

Introduction: Sedimentary rocks and impact generated regolith are heterogeneous materials. To be able to model impacts into heterogeneous materials, one must have a working model for the material behavior during shock loading and decompression. The behavior of heterogeneous materials at normal stresses of a few hundred MPa to a few 10's of GPa is notoriously difficult to predict. The continuum response, desired for use in impact modeling, is an average over the thermal and mechanical fluctuations inherent within a shocked heterogeneous material [1]. Mesoscale simulations are an exciting prospect for predicting the response of shocked heterogeneous materials [2]; however, there are many numerical and rheological difficulties that remain unsolved. Experiments are necessary to direct the development of continuum and mesoscale models for predicting the behavior of heterogeneous materials and mixtures under shock wave loading conditions

In this abstract, we present the Hugoniots of porous nontronite, and a porous soil composed of 67.2% quartz, 16.4% kaolinite, 7.2% muscovite, 0.2% hematite, and 9% amorphouse phases. The Hugoniot of nontronite will be used to analyze previous shock dehydration experiments on nontronite [3, 4]. Future work will include comparing the Hugoniot of the dry-porous soil with water-saturated soil of the same composition.

Experimental Technique: The 40-mm light gas/powder gun at Harvard University was used to drive planar shock waves through the Nontronite and soil samples. The shock-wave velocity in the nontronite samples was measured either with embedded electromagnetic gauges or via VISAR measurements of the shock-wave breakout on stepped targets. The shock-wave velocity in the soil samples was measured with VISAR or piezoelectric pin measurements of the shock wave breakout on a single soil sample, relative to the time the shock-wave reaches the driver-sample interface. The pressure and particle velocity were determined by impedance matching the shock-wave driver (Al-2024 or SS-304) to the target. Density was determined using the Hugoniot relations.

Nontronite: Nontronite powder (API Clay Mineral Standard #H-33b) of particle size less than 60 microns was pressed to densities of 2.15 g/cc, which is ~8% porous. The Hugoniot data are presented in Figure 1. The scatter in the data limits the best fit to a linear model ($U_s=C_0+S_1u_p$, $C_0=1.58(12)$,$S_1=1.42(9)$).

Soil: A generic soil composed mainly of quartz and kaolinite was pressed to densities of 1.91 g/cc, which is ~25% porous. The Hugoniot of the soil sample is presented in Figure 2. The U_s-u_p data is best fit by a second order model ($U_s=C_0+S_1u_p+S_2up^2$,$C_0=0.20(28)$, $S_1=3.57(96)$, $S_2=-0.85(0.79)$).

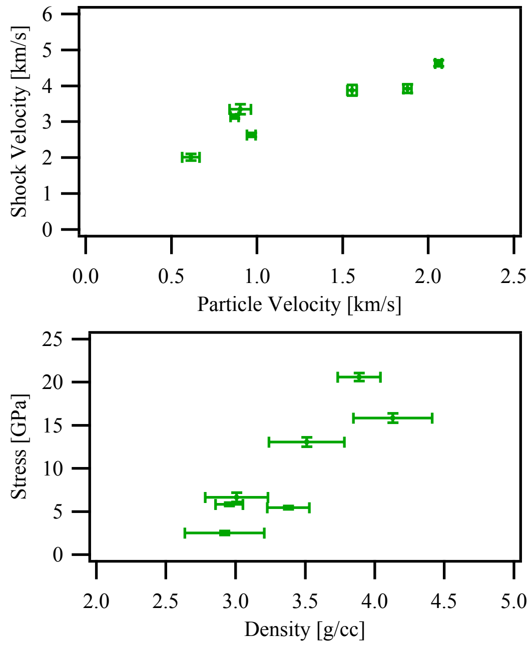

Figure 1: (Top) U_s-u_p data from planar shock experiments on the nontronite sample. (Bottom) Pressure-density data from nontronite experiments.

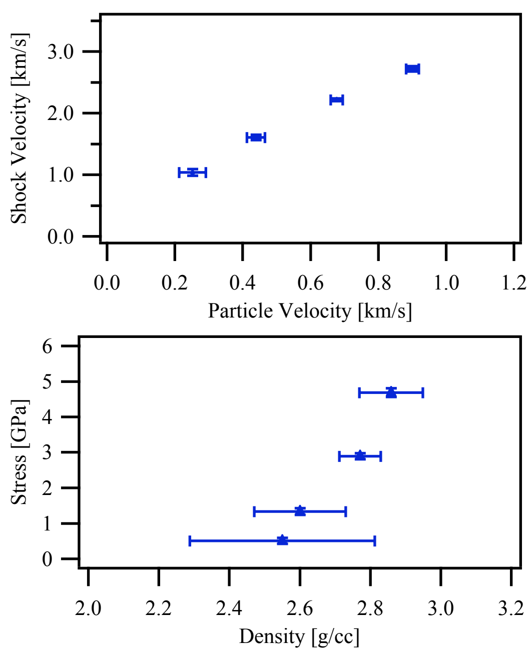

Figure 2: (Top) U_s-u_p data from planar shock experiments on the soil sample. (Bottom) Pressure-density data of soil experiments.

Conclusions: Here we have presented the low-pressure Hugoniots of nontronite, a clay that is thought to be found on the surface of Mars, and a generic soil from Earth. The Hugoniot of the soil suggests that full compaction occurs below 1 GPa, although the uncertainties are significant. Wave profile measurements of the two lowest stress soil experiments do not show clear compaction waves, although further analysis is required.

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