METEORITE MATERIAL MODEL FOR STRUCTURAL PROPERTIES

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To assess the threat posed by an asteroid entering Earth's atmosphere, one must predict if, when, and how it fragments during entry. A comprehensive understanding of the asteroid material properties is needed to achieve this objective. At present, the meteorite material found on earth are the only objects from an entering asteroid that can be used as representative material and be tested inside a laboratory setting. Most of the stony meteorites found on earth tend to be very inhomogeneous, chemically complex, with very high level of porosity. It becomes technically very challenging as well as very costly to obtain reliable material properties for a family of meteorites. In order to circumvent this challenge and predict material properties for the entire family of asteroids, meteorite unit models are developed to determine the effective material properties of stony meteorites and in turn deduce the properties of asteroids. The meteorite unit is a representative volume that accounts for diverse minerals, porosity, cracks and matrix composition inside a meteorite.

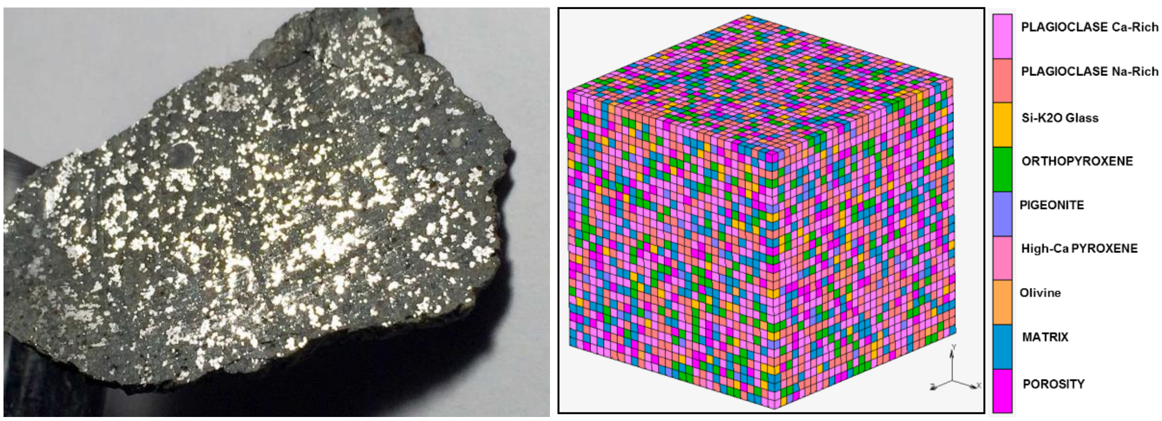

Figure 1: Various phases in Tamdakht meteorite[1], translated into a meteroite unit model representing various phases.

Figure 1 shows a representative meteorite unit model for Tamdakht meteorite that includes, various minerals, porosity and matrix distributed in the form of small cells. The effective mechanical properties such as Young's Modulus and Poisson's Ratio of the meteorite units are calculated by performing several hundreds of Monte-Carlo simulations by randomly distributing the various phases inside these units. Once these values are obtained, cracks are introduced in these meteorite units. The size, orientation and distribution of cracks are derived by extensive CT-scans and visual scans of various meteorites from the same family. Subsequently, simulations are performed to attain strength and effective modulus values in the presence of these cracks. Once several of these simulations are performed, the ranges for mechanical strength and effective modulus values, as well as representative stress-strain curves showing the basic constitutive relationships are developed, for each of the meteorite family. The meteorite unit models are presented for H, L and LL ordinary chondrites, as well as for terrestrial basalt. In the case of the latter, data from the simulations is compared with experimental data to validate the methodology. These material models are subsequently used in fragmentation modeling software like ALE-3D[2] for full scale simulations of an asteroid entry.

References:

[1] Photograph courtesy Tobin J. *Meteorite Times Magazine*, May 2016, Vol 2, No. 2.
[2] Robertson D. K. and Mathias D. L. (2016) *Journal of Geophysical Research*, pp 599-613.