The fracture of meteoroids with different composition and structure

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Knowledge of extraterrestrial material properties and internal structure is important for the asteroid and comet collision risk evaluation and mitigation. Physical and mechanical properties of meteoroids' material influence not only the way how they fracture during space collisions or high-velocity atmospheric entry, but they also influence the formation of craters on the surface of planets and minor bodies of the Solar System.

Chelyabinsk LL5 meteorite structure contains several lithologies influenced by different degrees of impact metamorphism in its space history. All fragments can be divided into three groups: white, grey and black. There are numerous thin shock-melt veins in the white pieces and fragmentation occurred along these veins. Porosity of white fragments is more than 10% and this value is overestimated because of material crumbling out. Bright and unusual character of fracture and fragmentation of Chelyabinsk meteoritic body is determined by its structure in macro-, meso- and microscales and a very low mechanical strength.

Meteoritic microstructure varies considerably even within one type of meteorites. Structure determines character of fracture in the case of dynamic loading. There are very limited data about mechanical properties and behavior of meteorites under loading. Mechanical test results of meteorites which have different compositions and structures are summarized in this report. Both dynamic and static loading tests have been performed. The fracture surface analyses have been compared. The values of impact strength and ratio of energy of crack propagation and crack initiation have been acquired during this study for Chinga IVB-an, Dronino Iron-ung, Sikhote-Alin IIB iron meteorites and ice. The highest values of impact-strength ratio were obtained for Chinga and Dronino, which had submicroscopical (kamasite+martensite2+taenite) and duplex (kamasite+martensite) structures, respectively. Decreasing of the test temperature to 77 K led to decrease of impact strength values down for Dronino and Chinga meteorites. Monocrystalline Sikhote-Alin meteorite samples demonstrated brittle trans-crystalline fracture mechanism. In this case fracture energy was less than that for Tsarev L5 chondrite. This study implies that the fracture process for meteoritic materials strongly depends on mineralogical chemical composition, type of microstructure and test temperature. It may be influenced by different values of impact strength, impact testing parameters (ratio of crack initiation, propagation and total fracture energy) along with fracture mechanism transfer from ductile to brittle trans-crystalline mode.

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