NWA 5000 – ONE OF A KIND?

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Introduction: The list of lunar meteorites consists of 95 names with the total mass of ~75 kg. The spallation theory [1] and numerical simulations [2-4] allowed to explain the formation of solid high-velocity ejecta and to reconcile the results of numerical models with observations. Presence of a porous regolith layer on the Moon decreases at least tenfold the total mass of solid escape ejecta because of much lower shock pressures required for shock melting [4]. Projectiles smaller than 10-20 m in diameter are able to propel exclusively the regolith (i.e., molten dust with random and unknown inclusions of consolidated breccia or rocks) into space. It means that the contribution of these small cratering events to the flux of lunar meteorites is non-predictable. Larger impact events which are able to excavate underlying megaregolith are statistically unlikely within a short, < 10 kyr, time frame [5]. Thus, one of the biggest (11.5 kg) and the youngest (terrestrial age <10 kyr, [6]) lunar meteorite, NWA 5000 (feldsparic breccia) is a real miracle.

Numerical model and initial conditions: High-velocity impacts on the Moon are modeled using the 3D hydrocode SOVA [7] complemented by the ANEOS equation of state for geological materials. The lunar regolith porosity is described in the frame of ε-alpha model [8]. Tracer particles are used to find dynamics and thermal history of solid inclusions into the regolith. An impact of a 10-m-diameter projectile at a 45° angle to horizon with a velocity of 18 km/s forms a 200-m-diameter impact crater. Potential lunar meteorites (non-porous blocks) are incorporated randomly into the highly porous regolith layer down to a depth of 2 m (an excavation depth of the NWA 500 is 335 ± 20 g/cm^2 [6]). Spatial resolution of the problem is a challenge due to a dramatic difference in size between "meteorites" (10-40 cm) and the projectile diameter.

Results: The presence of random non-porous inclusions does not change the excavation flow, i.e., the pressure-velocity distribution within the target is very similar to the pure regolith case. Materials ejected with velocities between 2.4 and 3.2 km/s are considered as candidates for a fast direct delivery to Earth [9,10]. Most of the regolith ejected at these velocities is shocked above 15-30 GPa and, hence, represents impact melt. Neither the shock compression nor heat exchange with molten/vaporized regolith is able to melt non-porous inclusions. Molten regolithic materials may cover the surface of non-molten ejecta with thin crust, but cannot survive meteorites' entry into the Earth's atmosphere.

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