Modeling the formation of Meteor Crater. N. Artemieva[1], E. Pierazzo[2]. [1]Institute for Dynamics of Geospheres, Russian Academy of Science (Moscow, Russia; artemeva@psi.edu); [2]Planetary Science Institute (Tucson, AZ; betty@psi.edu).

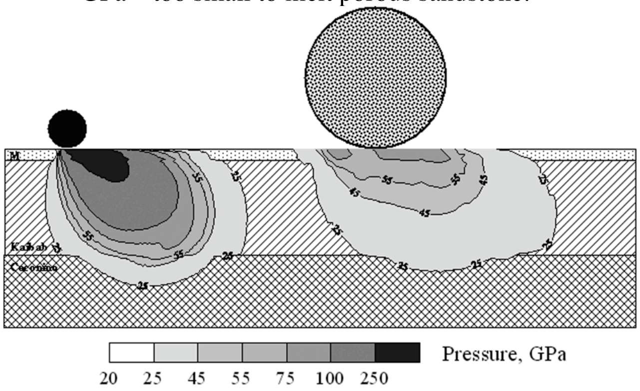
Introduction. About 50 kyr ago the impact of an iron meteoroid excavated Meteor Crater, Arizona [1], the first terrestrial structure widely recognized as a meteorite impact crater. Recent studies of ballistically dispersed impact melts from Meteor Crater [2] indicate a compositionally unusually heterogeneous impact melt with high SiO_2 and exceptionally high (10 to 25%) levels of projectile contamination. These are observations that must be explained by any theoretical modeling of the impact event. A simple atmospheric entry model for an iron meteorite similar to Canyon Diablo suggests that the surface impact speed should have been around 12 km/s [3], not the 15-20 km/s generally assumed in previous impact models [4,5]. This may help explaining the unusual characteristics of the impact melt at Meteor Crater.

Atmospheric Entry Model. To constrain the initial conditions of the impact event that generated Meteor Crater we modeled the atmospheric penetration of a Canyon Diablo type iron asteroid [6]. This work refines the popular result of Melosh and Collins [3] by taking into account projectile fragmentation to estimate more accurately the importance of atmospheric deceleration of an iron projectile. The model produced two types of outcomes: 1) survival of a main "strong" fragment that strikes the surface with significant velocity (~16 km/s), and 2) a more uniform fragmentation ("weak" projectile) where all resulting fragments are rather small and impact velocity does not exceed 14 km/s (similar to the Melosh and Collins result). Observations of Meteor Crater physical characteristics align it with typical bowl shaped lunar craters [7]. Thus the case of one (or a few) strong large fragment only slightly decelerated by the atmosphere followed by a slower cloud of smaller fragments agrees best with field data [6].

Meteor Crater Impact. We carried out a series of 3D simulations of the Canyon Diablo impact event to investigate target melting and projectile fate. The model target layout, based on known pre-impact stratigraphy, consists of 9m of sandstone (Moenkopi), followed by 81m of limestone (Kaibab), and 200m of sandstone (Coconino). The simulations cover various scenarios of atmospheric fragmentation of an iron projectile, representing the cases of a large strong fragment and a disperse cloud of small fragments. Impact energy is 2-20 times smaller than the pre-atmospheric entry energy: strong projectiles lose approximately half of their energy in atmosphere, while weak projectiles lose up to 95% of their initial energy. Melting in the various stratigraphic units varies with impact energy, but in all the simulations the depth of melting is less than 90m. Therefore, the Coconino Formation did not experience shock pressures high enough to cause melting. Figure 2 shows the distribution of maximum shock compression in the Meteor crater target for a large strong fragment (*left*) and a cloud of fragments (*right*).

Results. This study suggests that: 1) Meteor Crater was formed by a main fragment whose impact velocity was significant. 2) The reduction of impact energy during atmospheric passage is not enough to significantly reduce target melting. 3) The lack of melting of Coconino resolve the question posed by Hörz et al. (2002) on the origin of melt at Meteor Crater: melt products with high meteoritic content and SiO_2 originated from the upper Kaibab Formation.

Figure 2: Maximum shock compression in Meteor Crater target for two end-members (same transient cavity): *Left*: intact (□=7800 kg/m^3) 32.4 m diameter asteroid striking at 16.7 km/s; *Right*: disrupted asteroid (low density cloud with □=980 kg/m^3 and D=108 m) after passage through atmosphere, with impact velocity of 11.8 km/s. In Coconino P_{sh} <25 GPa – too small to melt porous sandstone.



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