IMPACT EJECTA TEMPERATURE PROFILE ON THE MOON – WHAT ARE THE EFFECTS ON THE AR-AR DATING METHOD?

N. Artemieva[1,2] and V. A. Fernandes[3]. [1]Planetary Science Institute. artemeva@psi.edu. [2]Institute for Dynamics of Geospheres, Moscow. [3]Museum of Natural History, Berlin.

Introduction: The $^{40}Ar/^{39}Ar$ method is widely used for the acquisition of impact related cooling ages. Several of the Apollo and lunar meteorite samples dated (e.g., [1]) have demonstrated that there is a decoupling between K-Ar reset ages and their shock related petrographic features: partial to total resetting of the K-Ar system occurs even at low shock pressures. This suggests that the Apollo samples, after an impact event, were kept in a warm environment which permitted the partial to total resetting of the K-Ar clock. Here we present preliminary model results for the formation and evolution of shock-heated ejecta blanket produced during a large impact event on early and modern Moon, and its effects on pre-existing cold rock fragments

Numerical model: We model impact cratering on the Moon with the 3D hydrocode SOVA [4] complemented by the ANEOS equation of state for geological materials [5]. We use two thermal profiles within the target: cold modern Moon with a thermal gradient of 2 K/km and hot ancient Moon with a thermal gradient of 15 K/km [6]. To define ejecta distribution on the surface, we use a method of ballistic continuation on a sphere [7]. The evolution of post-depositional temperature profile within the ejecta blanket is estimated via one-dimensional thermal conductivity equation.

Results: At any distance from the crater ejecta are a mixture of materials compressed to various shock pressures (from partial vaporization, P>150 GPa, to weakly compressed fragments) and excavated from various depths. At distal sites, melt and highly compressed materials from the crust prevail; near-crater ejecta consist mainly from unshocked materials. At the current cold Moon, antipodal ejecta have a temperature range of 400-600 K, while proximal ejecta have only slightly elevated T of 250-300 K. If the early Moon was substantially hotter (thermal gradient of 15 K/km during the first 0.2-0.5 Gyr), an average ejecta temperature reaches 600 K at distances > 2400 km from a crater center, and is above 400 K at smaller distances.

Ejecta cooling time τ after ejecta deposition depends strongly on its thickness H ($\tau \sim H^2$), which, in turn, increases quickly with a projectile size D_{pr} increase ($H \sim D_{pr}^{3}$). Thus, gas losses due to an elevated post-deposition temperature is not as important for small impacts (with fast cooling rate), but may lead to a partial or total resetting of the K-Ar system in large, basin-forming impacts.

Considering plagioclase closure temperature is <573K [e.g. 8], a rock fragment kept under this temperature for >20 y within an ejecta blanket [9] will likely have its K-Ar systematics reset and little to no petrographic shock related features.

Future work: (1) high-resolution model of an impact, resulting in a map of ejecta distribution around the crater (thickness H and temperature T as a function of distance and azimuth); (2) cooling time as a function of T and H; (3) Ar diffusion and estimates of gas loss.

References: [1] Fernandes et al. 2008. Workshop Early S. S. Impact Bombardment, Abst. #3028 [4] Shuvalov 1999. *Shock Waves* 9:381-390. [5] Thompson & Lauson 1972. *SC-RR-61 0714.* Sandia Nat. Lab. 119 p. [6] Spohn et al. 2001. *Icarus* 149:54-65. [7] Dobrovolskis 1981. *Icarus* 47:203-219. [8] Cassata et al. 2010. *GCA* 73:6600-6612. [9] Shuster et al. 2010. *EPSL* 290:155-165