IMPACT EJECTA TEMPERATURE PROFILE ON THE MOON – WHAT ARE THE EFFECTS ON THE AR-AR DATING METHOD?
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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 $\tau$ after ejecta deposition depends strongly on its thickness $H$ ($\sim H^2$), which, in turn, increases quickly with a projectile size $D_p$, increase ($H \sim D_p^3$). 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.