A study of the thermal characteristics of the ejecta resulting from the impact of a gabbroic anorthosite meteoroid with a (modelled) lunar, gabbroic anorthosite crust (using the calculated flows described in O'Keefe and Ahrens [1,2,3]) demonstrates several new features of ejecta blankets. Although we previously studied the mass distribution of ejecta, the observations of Safronov [4] and Kaula [5] that the thermal diffusivity appropriate for describing the heat loss of a planet accreting via planetesimal impacts is controlled by the turbulent mixing of the surface layer induced by random impacts, has lead us to examine both the ejecta energy deposition in detail and the variation in excavation depth with material strength and planetary gravity field [6]. The areal normalized (to impact kinetic energy) energy density, \(\Omega\), of the ejecta for bombardment of a lunar-sized object with gabbroic anorthosite impactors is given by

\[
\Omega(\text{cm}^{-2}) = 0.0135 \, R^{-1.9}
\]

(1)

where \(R\) is the range from the impact point. In computing \(\Omega\), the kinetic plus internal energy of the ejecta are combined on account of the high efficiency of kinetic to internal energy conversion (70 to 85%) for impacts of gabbroic anorthosite objects onto a gabbroic anorthosite moon (Fig. 1). Since the mass density of ejecta has been shown [2] to decay as \(R^{-2.8}\), it follows from Eq. 1 that the specific energy density increases with increasing radius (Fig. 2). The calculated ejecta energy density versus radius for impact flows (Fig. 2) was calculated for 11.7 and 7.9 \(\mu\)sec after impact of a 5-cm radius impacting gabbroic anorthosite object at 7.5 and 15 km/sec. It follows the following dependence on radius:

\[
E(\text{ergs/g}) = 1.9 \times 10^3 \, R^{0.865}
\]

(2)

The resulting energy density, at a given radius, varies systematically over more than an order of magnitude, as close as \(\sim 10^5\) cm from the impact point. As demonstrated in, for example, Figures 3 & 4 we have found that the ejecta at the base of the "unit", systematically contains a higher internal energy density than that present at the top of the theoretical ejecta unit. Hence, trapping of impact energy by the ejecta is non-uniform.

In order to calculate the sorting at a given range, the ballistic travel time for a spherical moon was calculated for each mass element of ejecta in the impact-induced flow. We observe that at ranges greater than \(\sim 10^5\) and \(\sim 10^7\) cm, for 7.5 and 15 km/sec. impact velocities, the ejecta energy densities become chaotic. One possible interpretation of this result is that the point at which the ejecta energy density becomes chaotic marks the outer boundary of the "continuous" ejecta blanket, and hence the maximum range at which coherent, overturned stratigraphy can be followed (e.g., Roddy et al. [7]). The degree to which this result is sensitive to calculational zone size is not yet known.
Thus, our calculations predict a higher degree of shock metamorphism at the base than the top of the continuous ejecta blanket.

It is also of interest to compare a minimum time-constant for thermal conduction through a 1 m-thick ejecta blanket [8] to the ballistic travel-time. For the energy density differences of Fig. 3, assuming an upper bound to the thermal diffusivity of $6 \times 10^{-3}$ cm$^2$/sec., implies a time-constant of $\approx 2 \times 10^5$ sec. for conduction for ejecta that travels for $\approx 1$ to 10 sec. from the impact point. Carrying out a similar calculation for the Fig. 4 profile yields a characteristic conduction time of $\approx 2 \times 10^3$ sec. for material which traveled $\approx 10^{-10^2}$ sec. after impact.

When scaled to major impact dimensions, the present results demonstrate a phenomenon not previously envisioned, in which burial of impactor energy within the ejecta blanket occurs even more effectively than previous, constant-energy density models [4,5] have predicted.

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Figure 2. Specific ejecta energy density versus range for the moon. Circles and squares indicate ejecta from 7.5 and 15.0 km/sec. impact of gabbroic anorthosite upon gabbroic anorthosite. Filled symbols indicate regions over which ejecta is ordered, with the highest energy density at the bottom of the ejecta blanket.

Figure 3. Ejecta mass versus energy density for 7.5 km/sec. impact at range $R$, of $10^4$ to $10^5$ cm. Ejecta from flow which has evolved for 11.7 usec. only is plotted.

Figure 4. Ejecta mass versus energy density for 15 km/sec. impact at range $R$, of $10^6$ to $10^7$ cm. Ejecta from flow which has evolved for 7.9 sec. only is plotted.