EJECTA INTERACTIONS FROM MAJOR LUNAR IMPACTS. P. H. Schultz, The Lunar Science Institute, 3303 NASA Road 1, Houston, TX 77058.

Several mechanisms have been proposed to account for the dunelike features (including the herringbone pattern) surrounding large lunar impact craters (1,2,3,4). More recently, the flowlike features within the ejecta blanket have been attributed to downrange secondary crater ejecta interacting with uprange secondary ejecta (5). The following discussion elaborates on a different view offered in (4) in which primary ejecta interact with ejecta from secondary impacts. This mechanism was suggested in order to account for the herringbone pattern wrapped around the uprange side of a single secondary crater as well as the leading member of a secondary crater chain. Specifically it was proposed that material is ejected from a crater as an extended "cloud" of debris containing a few large blocks and that interactions develop between the incoming cloud and material thrown from preceding secondary impacts.

During excavation of the primary crater, ejecta leave at velocities that decrease rapidly with crater growth. At a given time in the transient crater growth, material is ejected from various horizons at depth and travel ballistically to the same range (6). The dynamics of this process is complex, but the result may be viewed as a shell of radius x and thickness dx that leaves at velocity v. This shell will be mapped onto the lunar surface with a mass per unit area, m, at a range r. If it is assumed that all material in the shell at x leaves at velocity v and if the shell is viewed as a hemisphere (a simplification for illustration), then the shell will be mapped as a trail of debris of length 1/2 πx. As a minimum, this trail will have a length equal to the thickness of the ejecta "deposit" (ejecta mass/unit area) at r. Thus as the transient crater increases in size, so does the secondary debris trail. More realistically the debris trail will have a length L = kx. The debris trail represents the thickness of the ejecta curtain (see Fig. 1), and for a given thickness and velocity, the delay between the first- and last-arriving debris is simply calculated as L/v.

Figure 2 shows the estimated time required to form one of the largest secondary craters for different size craters; in addition, different delay times of ejecta arrival are illustrated for different values of k at two crater radii from the crater rim. The maximum delay time is comparable to the maximum time of secondary crater formation. Most secondary impacts will be considerably smaller, thereby increasing the likelihood that ejecta arrival delay will exceed the time for secondary crater formation. Moreover, any dispersion in ejecta velocities or ejection angles will thicken the ejecta curtain and increase the delay time. Consequently, considerable interaction between primary ejecta and ejecta from secondary impacts is possible.

The mass flux of the ejecta skirt can be calculated for the following scale relations: ejection velocities decay as R_{1/2}(R/X)_{3}; crater growth rate scales as R_{1/2}; and ejecta skirt thickness increases as R for ejecta from the same scaled position of ejection. In addition it is assumed that the ejecta are largely composed of particulate debris (<1 m) with a few large secondary blocks. With these assumptions, it can be shown that the flux at a given scaled range will be proportional to R_{1/2}. If the largest secondary crater formed is approximately 5% the diameter of the primary crater, this result means that the ejecta flux from the primary crater will be 4.5 times that of

© Lunar and Planetary Institute • Provided by the NASA Astrophysics Data System
the ejecta flux from the secondary crater at the same relative time in crater growth. This factor will be smaller at earlier stages in secondary crater formation.

Hence it is proposed that the various characteristics of ejecta facies around craters larger than 1 km in diameter (4) could be understood in terms of primary-secondary ejecta interactions. The dunelike appearance of the inner ejecta blanket results from extensive ejecta interactions and partial burial of secondary craters in a manner similar to bowduning as described in (2). Such interactions result in a large ground-hugging flow around the major impact basins that trails the ejecta curtain. At greater distances ejecta interactions are better preserved as well-defined herringbone patterns on the uprange side of secondary craters. At still greater distances, the dispersion of the ejecta results in discrete clouds, which at impact produce septa between simultaneously impacting secondary projectiles as described in (3) as well as downrange interactions described in (4). This model contrasts with (5) in which the ejecta skirt remains thin, and it permits the development of a larger debris surge within one crater radius of the rim (Fig. 3). Although the resulting ejecta deposit remains a mixture of local and foreign material as proposed in (7), the origin of the mixing process is different.

References


EJECTA INTERACTIONS FROM MAJOR LUNAR IMPACTS

Schultz, P. H.

Fig. 1. Shell of length $l$ and thickness $dx$ leaves crater at velocity $v$ and maps as ejecta curtain of thickness $l$.

Fig. 2. Times of formation for secondary crater (diameter = $d$) produced around primary crater (diameter = $D$): solid lines. Time delay between first ejecta and last ejecta arrival for two values of curtain thickness (fraction of transient crater diameter): broken lines.

Fig. 3. Comparison of this model, $a$, and model in (3), $b$, for development of ejecta flow.