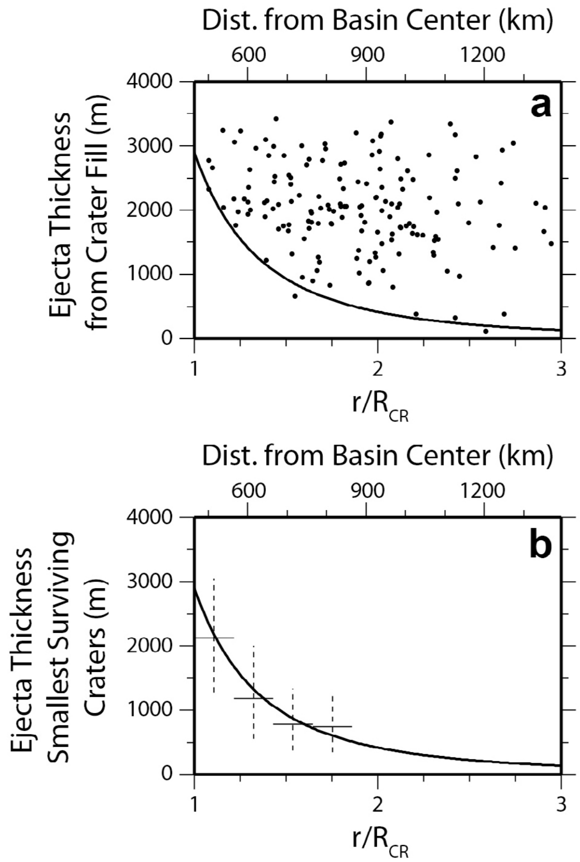

Figure 2. (a) Distribution of fill material within craters near Orientale based on their reduced relief when compared to fresh craters of the same size. Since this reduction in relief reflects the sum of pre-Orientale infill and Orientale ejecta, it is generally an overestimate of ejecta thickness. For this reason, the lower envelope on the data is relied upon for fitting. (b) Estimates for the thickness of ejecta required to erase the small crater population below the size of the smallest surviving craters at various ranges. The dashed thickness line reflects uncertainty in our assumptions about the degradation state of the fresh craters that were erased and the size below which all craters were erased (see Text S1 of the auxiliary material); the thin solid line in range is the 100 km range over which we binned our measurements. In Figures 2a and 2b the primary x-axis is normalized to the Cordillera radius (R_{CR} = 465 km), and the black line is the ejecta-thickness model, $T = 2900(r/R_{CR})^{-2.8}$.

the ejecta volume outside the Cordillera ring and extrapolate this function inward to assess the volumes of ejecta implied as a function of the location of the transient cavity rim crest.

4.1. Comparisons of Past Estimates of Ejecta Thickness and Decay

[12] A wide range of estimates have been made for the thickness of ejecta at the rim crest of the transient cavity, and for the ejecta-thickness decay function. *McGetchin et al.* [1973] suggested a function for the thickness of ejecta at the transient cavity rim crest $T_{TR} = 0.14\, R_{TR}^{0.74}$, with R_{TR} and T_{TR} in meters, on the basis of nuclear craters, Meteor Crater, and observations of lunar craters. The McGetchin et al. function, assuming the Cordillera ring as the location of the transient crater rim crest, implies ejecta thicknesses at this location of 2190 m, a value smaller than our measured ejecta thicknesses. This function implies even smaller thickness estimates if the transient cavity is significantly smaller than the Cordillera Ring, as seems likely. *Pike* [1974] suggested a wide range of models for T_{TR}; his equation (11), $T_{TR} = 0.033R_{TR}$, would imply a thickness of ejecta at the Cordillera ring of ~15 km (assuming that the Cordillera ring was the transient cavity rim crest), at least factor of 5 larger than our measurements. If, however, the transient crater was well within the Cordillera ring, as discussed below, the thickness at the rim of the transient cavity implied by this equation is potentially consistent with our results. *Petro and Pieters* [2006] applied the *Housen et al.* [1983] scaling [see also *Haskin et al.*, 2003] to suggest $T_{TR} = 0.0078R_{TR}$, which would imply a thickness of 3600 m if the Cordillera rim is the appropriate radius for the transient crater.

[13] Our ejecta-thickness measurements also allow derivation of a new power law for the decay of ejecta, with an exponent of B = 2.8 (±0.5); this is shallower than that estimated by *McGetchin et al.* [1973] (B = 3) and steeper than that determined by *Petro and Pieters* [2006] (B = 2.61), who applied the model of *Housen et al.* [1983], although it is formally consistent with both. Our measurements and inferred decay law differ significantly from the monotonic linear decay suggested by *Short and Forman* [1972] and the concave down profile of *Cordell* [1978]. Both of these profiles have thicknesses of ejecta of >2 km at r/R_{CR} ~ 1.5, which is inconsistent with our observations and the preservation of several 7 to 10 km pre-Orientale craters at this range. When fresh, such craters would be expected to have relief of only 1.5 to 2 km, which would have been destroyed by deposition of >2 km of ejecta.

4.2. Ejecta Volumes and Comparisons to Estimated Transient Rim Crest Positions

[14] Using our power law description of the radial decay of ejecta, we can now integrate this function to calculate the volume of ejecta deposited in various regions, and evaluate the results in light of proposed locations of the transient cavity's rim crest for Orientale. Some ejecta was undoubtedly deposited at larger radial ranges than we measure [e.g., *Spudis*, 1993; *Ghent et al.*, 2008], but it is likely to be a small percentage of the total ejecta volume because it commonly occurs in radial chains and is discontinuous.

[15] The Orientale basin consists of the Cordillera ring, which defines the topographic basin rim, the Outer Rook, a ring of continuous inward facing massifs, the Inner Rook, a ring of peaks, and an inner depression that contains Mare Orientale (Figure 1a). A variety of these rings have been suggested to approximate the location of the transient cavity's rim crest (see discussion in the work of *Spudis* [1993]), and our new thickness, volume, and decay law estimates permit us to assess the plausibility of these assignments (Table 1). From the Cordillera ring to one basin diameter from this topographic rim crest (r/R_{CR} = 3), we calculate an ejecta volume of 2.9×10^6 km^3 (+1.2, −0.8).

[16] Assuming a paraboloidal shape for the excavation cavity, its volume is $V_{Ex} = 0.5\pi d(R_{TR})^2$ for radius of the transient and excavation cavity, R_{TR}, and for depth of excavation d, which we assume to be 50 km. This assumed depth is supported by spectroscopic observations that suggest that the ejecta and ring massifs of Orientale are predominantly