Table 1. Parameters of Possible Transient Crater Radii[a]

Mapped Ring	Transient Crater Radius, R_{TR}	Volume of Excavation Crater, V_{Ex}	R_{TC} Ejecta Thickness at Transient Rim	Volume of Ejecta From R_{TR} to R_{CR}	Volume of Ejecta From R_{CR} to 3 R_{CR}
Inner Dep.	160 km	2.0×10^6 km^3	57.5 km (+50.7, −27.2)	6.6×10^6 km^3 (+3.4, −2.2)	2.9×10^6 km^3 (+1.2, −0.8)
Inner Rook	240 km	4.5×10^6 km^3	18.5 km (+9.9, −6.6)	3.4×10^6 km^3 (+1.1, −0.9)	2.9×10^6 km^3 (+1.2, −0.8)
Outer Rook	310 km	7.5×10^6 km^3	9.0 km (+3.2, −2.4)	1.9×10^6 km^3 (+0.4, −0.4)	2.9×10^6 km^3 (+1.2, −0.8)
Cordillera	465 km	17.0×10^6 km^3	2.9 km (±0.3)	0 km^3	2.9×10^6 km^3 (+1.2, −0.8)

[a]This table gives the volume of excavation assuming a paraboloidal cavity with depth of 50 km, the ejecta thickness at the transient crater rim found by extrapolating the derived ejecta-thickness model to that location, the volume of ejecta between the transient crater rim and Cordillera, and the volume measured between the Cordillera rim and one basin diameter away.

feldspathic and lack obvious signatures of lunar mantle material [*Pieters et al.*, 2009; *Yamamoto et al.*, 2010] as well as by geophysical modelling [*Wieczorek and Phillips*, 1999; *Hikida and Wieczorek*, 2007]. If the Cordillera ring radius approximates the radius of the excavation, this would imply an excavation volume of 17.0×10^6 km^3, substantially greater than the ~2.9×10^6 km^3 of ejecta observed within one basin diameter of the Cordillera ring.

[17] Extrapolating the power law description of ejecta inward to the current position of rings inside the Cordillera by varying radius R_{TR}, we can estimate the thickness of ejecta at the transient cavity's rim crest and the additional ejecta volume expected between R_{TR} and R_{CR}. If the transient radius is expressed as a fraction of the Cordillera radius, $\rho = R_{TR}/R_{CR}$, then the thickness expected at the transient crater rim is:

$$T_{TR} = T_{CR}\, \rho^{-B} \qquad (2)$$

[18] If the next innermost ring, the Outer Rook Mountains approximates the size of the transient cavity [*Head*, 1974], then $\rho \approx 2/3$. Thus, given $B = 2.8$, we would expect 3.1 times as thick an ejecta deposit at the Outer Rook (~9000 m) than at the Cordillera ring, and ~1.9×10^6 km^3 of additional ejecta would have been emplaced between the Cordillera ring and Outer Rook ring. This ejecta would have ended up within the final topographic depression of the basin defined by the Cordillera ring, with an average thickness of ejecta of ~5 km in this region, known as the Montes Rook Formation [*Scott et al.*, 1977]. The deposition of this volume of ejecta would have provided a significant load that may have influenced the modification stage of basin formation by facilitating the collapse of the transient cavity's rim [e.g., *Head*, 2010]. If we were to include this inferred volume of ejecta between the Cordillera ring and Outer Rook, a total ejected volume of ~4.8×10^6 km^3 would be implied (Table 1).

[19] The Inner Rook Mountain ring has also been proposed to represent the approximate position of the transient cavity rim crest [*Floran and Dence*, 1976]. This smaller transient cavity would have an ejecta thickness of ~18.5 km at the rim crest, a volume inside the Cordillera ring of ~3.4×10^6 km^3, and a total volume of ~6.3×10^6 km^3. The inner depression could also represent the transient cavity rim crest. Extrapolating our ejecta decay function to this much smaller transient cavity would imply an ejecta thickness at the rim crest of >50 km, a volume inside the Cordillera ring of ~6.6×10^6 km^3, and a total volume of ~9.5×10^6 km^3. The extremely large volume of ejecta for such a small transient cavity rules out this ring as a realistic candidate for the transient cavity's rim crest. Similarly, the extremely small volume of ejecta, relative to the excavation cavity of volume for a Cordillera ring–sized excavation cavity also suggests that it is unlikely to have been the location of the transient crater rim.

[20] These ejecta volumes can also be compared to the volume estimates for the Orientale transient cavity derived on the basis of alternative approaches. On the basis of gravity data, *Wieczorek and Phillips* [1999] determined a volume of $3.1 \pm 0.4 \times 10^6$ km^3 for the transient cavity, with a maximum excavation depth of ~50 km and radius of excavation of R_{TR} ~ 200 km (midway between the Inner Rook ring and the inner depression). More recently, *Hikida and Wieczorek* [2007] derived similar values for the radius of the excavation cavity and slightly smaller depths using different gravity-inversion techniques.

[21] The ejecta volume we infer outside the Orientale topographic basin (outside the Cordillera ring), but within one basin diameter, is ~2.9×10^6 km^3. This rises to ~4.8×10^6 km^3 if the ejecta profile is extrapolated back inside the basin to the Outer Rook ring (R = 310 km). Estimates for the transient cavity volume derived from lunar gravity analyses (~$3.1 \pm 0.4 \times 10^6$ km^3) [*Wieczorek and Phillips*, 1999; *Hikida and Wieczorek*, 2007] are more comparable to the value we observe outside the Cordillera ring (R = 465 km), but the Cordillera ring radius is considerably greater than their estimated R_{TR} of ~200 km. One possibility is that the radius of the transient cavity is simply larger than inferred in these gravity models. For example, if the current Outer Rook approximates the size of the transient cavity, then a 50 km depth of excavation would imply a volume of ~7.5×10^6 km^3, and a 40 km depth of excavation would yield a volume of ~6×10^6 km^3, consistent with predicted ejecta volumes.

[22] Four other factors may contribute to this difference: (1) the excavation cavity volume of a large basin is greater than the total ejecta volume deposited outside the crater [e.g., *Schultz et al.*, 1981]; (2) the shape of the excavation cavity may be more realistically estimated by a nested cavity configuration than by assuming a paraboloidal geometry [*Cintala and Grieve*, 1998; *Head*, 2010; *Baker et al.*, 2011]; (3) the ejecta-thickness model assumes no 'bulking' or net change in density or porosity of the ejecta, and does not include incorporation of local material into the ejecta; and (4) extrapolating the ejecta profile from outside the basin into its interior may not adequately reflect what would be deposited within the rim of the basin as it formed.

[23] In summary, our new ejecta measurements and inferred ejecta decay profile are consistent with a transient cavity radius approximated by the current location of the Outer Rook