A COMPARISON OF THE MORPHOMETRY OF DOUBLE LAYERED EJECTA CRATERS IN DIFFERENT VOLCANIC REGIONS ON MARS. R. D. Schwegman*, G. R. Osinski, and L. L. Tornabene. Centre for Planetary Science and Exploration/Department of Earth Sciences, University of Western Ontario, London, ON, N6A 5B7 (*rschwegm@uwo.ca).

Introduction: Double layered ejecta (DLE) craters display two distinct blankets of ejecta that appear to have been "fluidized" during the emplacement process [1, 2]. Volatile content within the target [3], atmosphere [4], or a combination of the two [5], is thought to be largely responsible for this causing ejecta to "flow" across the surface. If indeed layered ejecta formation is mainly dependent on the volatile content and/or properties of the target material [6], then the extent an ejecta blanket travels (i.e., runout distance) is likely to be a function of volatile concentration. This appears to be generally consistent with previous observations on Mars [7].

DLE ejecta runout distances are greater at higher latitudes than at lower latitudes near the equator [8], consistent with increasing ice concentration near-surface as a function of increasing latitude [9]; however, this has not been well constrained. For this study, we tightly constrain the target material variable, aiming to determine whether morphometry of DLEs into volcanic targets vary as a function of latitude. Since target material will be grossly similar on volcanic terrains (e.g., basaltic lavas [10, 11, 12]), any differences in morphometry between regions would likely reflect the volatile content in the target, whether surficial or at depth.

Methods: Craters classified as DLEs in Robbins Crater Database (3413) [13] were reevaluated; we recognize 1660 as having two distinct layers of ejecta (nearly half of what was originally classified). Of these, 95 were selected throughout five different volcanic regions on Mars: 25 in Alba Patera (~30–50° N), 18 in Elysium (~10–35° N), 10 in Syrtis Major (~5–15° N), 26 in southern Tharsis (~5–25° S), and 16 in Hesperia (~20–35° S). These are considered major volcanic regions and are situated at low, mid, and high latitudes, making them ideal for our study. Crater sizes range from ~3 to 25 km in diameter. Java Mission-planning and Analysis for Remote Sensing (JMARS) software [14] was largely used for the analyses of DLE craters, which include the measure of ejecta mobility (EM) and the lobateness of the inner and outer blankets of each crater. A slight modification of the EM ratio was used where the "effective" radius of an ejecta blanket was determined based on the enclosed area of the ejecta layer and using the area of a circle:

$$\mathrm{EM} = \frac{\sqrt{\frac{A}{\pi}} - r}{r}$$

where *A* is the total area inside the ejecta layer (including the crater diameter), and *r* is the radius of the crater. The sinuosity of each layer was determined using the lobateness (Γ) formula [15].

Results:

		Avg. EM	SD	Avg. Γ	SD
Alba Patera	Outer	2.56	0.36	1.44	0.13
	Inner	1.42	0.15	1.35	0.11
Elysium	Outer	2.55	0.60	1.58	0.19
	Inner	1.46	0.22	1.38	0.18
Syrtis Major	Outer	2.23	0.36	1.62	0.11
	Inner	1.39	0.13	1.50	0.09
Southern Tharsis	Outer	2.29	0.38	1.60	0.21
	Inner	1.52	0.23	1.49	0.17
Hesperia	Outer	2.29	0.36	1.57	0.13
	Inner	1.33	0.14	1.43	0.13

Table 1: Average ejecta mobility (EM), lobateness (Γ) and standard deviation (SD) values are listed for DLE outer and inner layers in all five study regions.

The highest latitude DLEs in this study are located in the Alba Patera and Elysium regions. EM values tend to be slightly higher in these regions, compared to the other three regions (i.e. Hesperia, Syrtis Major, and southern Tharsis). There is a general increase in EM values for the outer layers of DLEs poleward in these two regions. This trend is also recognized in the southern hemisphere in the Hesperia region, despite DLEs having lower EM values. The Syrtis Major and southern Tharsis regions (i.e. near-equator regions) have EM values similar to those of the Hesperia region, yet the trend of increasing EM poleward seems to be less pronounced, or non existant. Inner layers of DLEs in all five regions appear to have little, to no trend.

Across our five study regions, elevations range from 6 to -6 km (this elevation range accounts for 98% of Mars' surface area based on MOLA topography) and seem to have little effect on DLE EM and lobateness. Lobateness values for all outer and inner layers are similar regardless of volcanic region. On average, outer layers are slightly more sinuous than inner layers.

Discussion and conclusions: Near-subsurface volatile concentrations on Mars are generally highest near the poles and decrease equatorward [9]. Our results show that EM values slightly increase as DLEs move poleward beginning at ~30° latitude in both hemispheres. The trend is subtle, but it is nonetheless consistent with the hypothesis that volatile content is likely playing a role with respect to ejecta mobility. Dust cover could also play a role, but to what extent is unknown.

Properties of the target material (i.e., volatile content and cohesiveness of the material) can also have an effect on ejecta mobility [6]. More volatiles and/or less cohesive surficial materials will allow ejecta to runout further [6]. It has been suggested that near-surface ice could have migrated to latitudes as low as 30° throughout Mars' history depending on the obliquity of the planet [16]. If ice was indeed present at lower latitudes, obliquity would be low and ice would be restricted to higher elevations [17]. This may, or may not affect our study DLEs since they are situated at lower elevations. During a higher obliquity, ice would migrate back toward the poles [17] where we observe the higher EM values in our study.

Obliquity would also affect dust cover resulting in a cyclic process of accumulation and erosion throughout geologic time on Mars [18] that could affect EM values. Data from the Thermal Emission Spectrometer (TES) shows the highest concentrations of dust largely in the northern hemisphere, including the Alba Patera and Elysium regions [19], and has been suggested accumulations could be up to 2 m thick [18]. The Syrtis Major, southern Tharsis, and Hesperia regions appear to be less dusty. If dust accumulations indeed play a role in EM, the TES dust cover index reflects our EM value results where high concentrations of dust correspond to higher EM values.

References: [1] Barlow N. G. et al. (2000) *JGR, 105,* 26733–26738. [2] Mouginis-Mark P. J. (1987) *Icarus, 71,* 268–286. [3] Carr M. H. et al. (1977) *JGR, 82,* 4055–4065. [4] Schultz P. H. and Gault D. E. (1979) *JGR, 84,* 7669–7687. [5] Barlow N. G. (2005) *LPSC XXXVI,* Abstract #1415. [6] Osinski G. R. (2006) *Meteoritics & Planet. Sci., 41,* Nr 10, 1571–1586. [7] Barlow N. G. (2006) *Meteoritics & Planet. Sci., 41,* Nr 10, 1425–1436. [8] Schwegman R. D. et al. (2014) *LPSC XLV,* Abstract #2385. [9] Clifford S. M. et al. (2010) *JGR, 115,* E07001. [10] Skinner J. A. et al. (2006) *LPSC XXXVII,* Abstract #2331. [11] Scott D. H. and Tanaka K. L. (1986) *USGS I-1802-A,* 1:15M scale. [12] Greeley R. and Guest J. E. (1987) *USGS I-1802-B,* 1:15M scale. [13] Robbins S. J. and Hynek B. M. (2012) *JGR, 117,* E05004. [14] Christensen P. R. et al. (2009) *AGU Fall Mtg 2009,* Abstract #IN22A-06. [15] Barlow N. G. (1994) *JGR, 99,* 10927–10935. [16] Carr M. H. and Head J. W. (2010) *EPSL, 294,* 185–203. [17] Madeleine J. –B. et al. (2009) *Icarus, 203,* 390–405. [18] Christensen P. R. (1986) *JGR, 91,* 3533–3545. [19] Ruff S. W. and Christensen P. R. (2002) *JGR, 107,* E12, 5127.

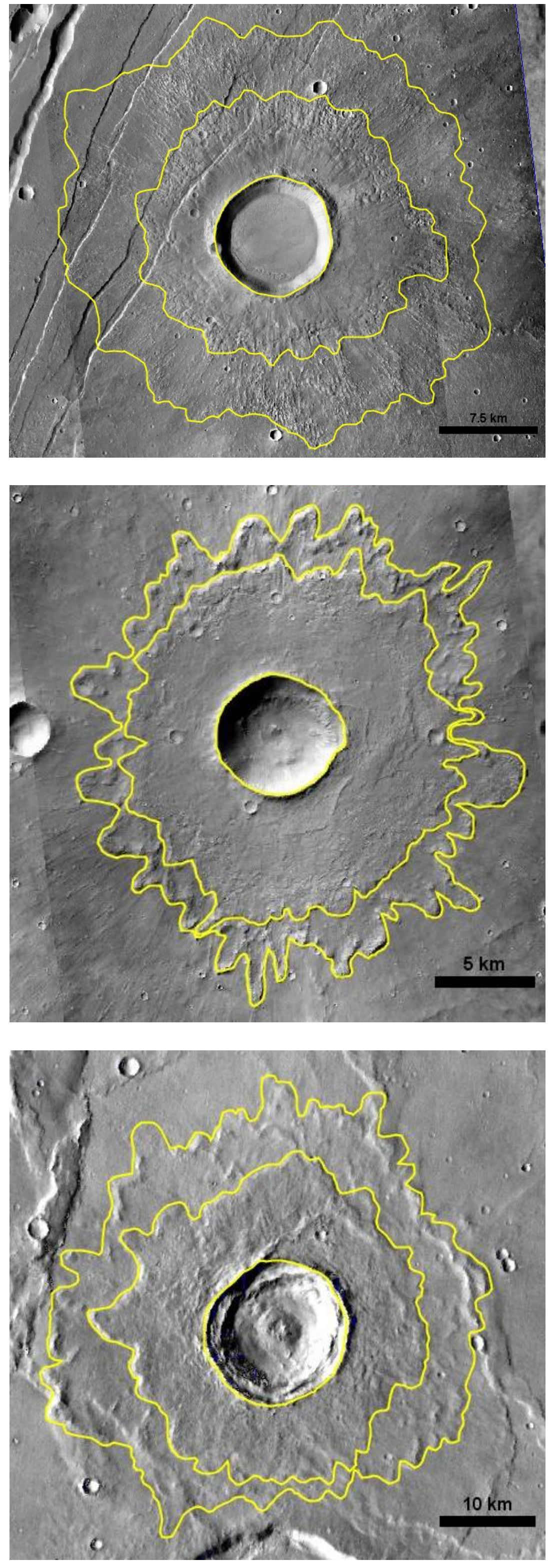

Figure 1: *Top:* Alba Patera DLE (259.46° E, 32.83°). *Mid:* Southern Tharsis DLE (301.04° E, -10.21°). *Bottom:* Hesperia DLE (118.95° E, -29.72°). These 3 craters represent the overall trend recognized in our results, where different ΔEM values are clearly visible.