QUANTIFYING THE AMOUNT OF IMPACT EJECTA AT THE MER LANDING SITES AND POTENTIAL PALEOLAKES IN THE SOUTHERN MARTIAN HIGHLANDS. B. A. Cohen, Institute of Meteoritics, University of New Mexico, Albuquerque NM 87131 (bcohen@unm.edu).

Introduction: Martian paleolakes have been offered as landing sites for *in situ* and sample-return missions because of their high probability of containing climatic and hydrologic records and potential biomarkers. Prospective paleolake sites are identified in closed craters primarily based on discrepancies between the craters' expected and measured depths and interpretation of associated fluvial and lacustrine features (e.g. [1]). For instance, the 160-km diameter Gusev crater is shallower than expected and has a clear fluvial system running into it [2], but numerous sediment sources beside fluvial and lacustrine have been suggested as being able to at least partially fill Gusev, including aeolian deposits, ashfall from Appolinaris Patera [3] and basaltic lava flows [4, 5]. This study gives constraints on the maximum thickness of ballistically-emplaced crater ejecta at several sites on Mars to examine its importance relative to the numerous other sedimentation processes operable on Mars.

Calculations: The thickness of ejecta (Th) as a function of distance from an impact crater can be estimated based on terrestrial and lunar craters based on the transient-crater radius [6]. This simple scaling relationship appears to hold for the terrestrial and lunar cases and so should be applicable to many Martian craters, but this type of calculation was developed primarily for ballistically-emplaced ejecta rather than the fluidized ejecta morphologies common on Mars. Nevertheless, distal ejecta deposits from large craters are observed on the Martian surface and this simple calculation gives some insight into the order of magnitude of this type of ejecta.

I used a database of 26,883 craters from The Catalog of Large Martian Impact Craters [7], after excluding craters in the stratigraphically-young northern lowlands, Hellas, Argyre, and other large basins, degraded craters, and craters smaller than 7 km (the simple-complex crater transition diameter on Mars, D_{tc}). For each crater, I calculated the transient crater diameter based on the measured crater diameter using the equation of [8]. This formulation has the advantage of taking target differences into account through a term containing D_{tc}.

I chose 28 sites of interest on the Martian surface, including the MER landing sites, several deep craters used as control sites, and potential paleolakes in the highlands [1, 9]. The thickness at each site was summed over all 26,883 craters, doubled to reflect global symmetry, and is presented in Table 1. Calculations using alternative estimates for thickness [10] or transient-crater diameter [11] yield cumulative thicknesses that are smaller at every site by 25-70%. Thus, these calculations can be considered maximum estimates.

Results: I computed the expected post-modification depth at each of the sites of interest based on their observed diameters [12]; Δd is the difference between the expected and the observed depth. Table 1 also shows the ejecta thickness as a percentage of the Δd for each crater, i.e. how much of the observed sediment can be attributed to crater ejecta. This method assumes that the site of interest contains ejecta from all previously-formed craters. On the other hand, several generations of craters may have been formed and obliterated by subsequent crater formation or sedimentation, so that they are not now contained in the Catalog. Additionally, the contribution from secondary craters, which may be sizable [13, 14], is neglected. Given the uncertainties, Table 1 is merely a guide, but shows that in general, several tens to hundreds of meters of crater ejecta are present at most points on the Martian surface.

Discussion: I used several large craters in the southern highlands that have little to no discrepancy between their measured and calculated depths as control points (Vishniac and sites A and B in Table 1). These craters are relatively young and situated deep in the southern hemisphere; therefore, doubling the calculated thickness may be an overestimation. Nevertheless, it is clear that deep ejecta packages are neither expected nor observed in these craters.

The cumulative thickness of impact ejecta at the Spirit landing site is ~45 m, demonstrating that exogenous crater ejecta contributes only a small percent of the total current fill in Gusev crater. The nearby Thira and Zutphen craters each contribute approximately 5m of ejecta to the site. Zutphen is located outside of Gusev crater and its ejecta may be ancient basaltic crust; Thira ejecta may contain a substantial portion of the Gusev fill sequence, possibly including Gusev-formed melt breccias and shocked basement rocks. The interior of Gusev crater is now capped by basalt flows, but ejecta materials may outcrop in the older Columbia Hills region currently being traversed by the Spirit rover.

Even though there are several craters near Meridiani Planum, it is difficult to tell which postdate the current surface [15, 16]. In contrast to Gusev, most of the calculated ejecta at the Opportunity landing site comes from large, distant craters. This distal ejecta is emplaced with high velocities and can significantly rework the target rocks. The nature of ejecta material (fractured, shocked, unconsolidated) and the extent of reworking it causes may make Meridiani Planum an easy target for infiltration and alteration by transient or episodic water. The proximity of Schiaparelli crater, in particular, contributes to the idea that Meridiani Planum may itself have been emplaced by an impact surge [17].

None of the craters identified as potential paleolakes in the southern highlands (Craters FH and CG) is likely to be completely filled by exogeneous ejecta. Though ejecta can be contributed by nearby and distant craters, depending on the site of interest, Table 1 shows that crater ejecta contributes no more than ~20% of the thickness needed to explain the depth discrepancy in these craters, and in most cases is much less than that. The relative age of crater ejecta events and paleolake sedimentation are unknown; it seems likely that falling ejecta and other sedimentation events may be intermittent and deposits from these episodes may be interbedded and modified by each other.

Conclusions: Based of these cases, only tens of meters of foreign-derived material may be present at any point on the present Martian surface. In some places, such as stratigraphically old craters with minimal subsequent depth modification, the sediment is probably largely contributed by crater ejecta. These sites may be good locations to collect rocks that represent the upper Martian crust within a several-hundred-mile radius. In other places, the ejecta component is minor compared with other sedimentation processes, such as aeolian or lacustrine activity. In particular, enclosed craters identified as potential Martian paleolakes, even those situated deep in the southern Martian highlands, cannot have their apparent depth discrepancy completely explained by filling from crater ejecta. Impact ejecta deposits, though a small component of most sediment packages, can provide critical lithologic diversity to any particular landing site on Mars.

Table 1. Ejecta thickness calculations.

Site	Lat	Lon	Δd (km)	Th (m)	% fill
Opportunity	-2.0	5.9		44	
Spirit	-14.6	184.7	3.0 ± 0.7	45	2
A	-72.9	204.7	-0.4 ± 0.3	256	-64
B	-72.0	82.3	0.7 ± 0.4	131	19
Vishniac	-76.6	84.1	1.1 ± 0.4	107	10
FH	18.4	282.3	2.0 ± 0.2	24	1
CG26	26.0	31.5	2.4 ± 0.4	8	0
CG27	24.6	32.0	1.6 ± 0.2	14	1
CG28	22.0	7.0	4.2 ± 0.7	129	3
CG33	17.2	32.4	1.3 ± 0.2	13	1
CG38	12.1	21.0	1.5 ± 0.2	237	16
CG40	11.5	20.5	1.4 ± 0.2	257	18
CG41	11.0	337.0	3.5 ± 0.7	91	3
CG42	10.3	16.7	1.7 ± 0.2	68	4
CG43	8.1	45.2	1.7 ± 0.2	22	1
CG44	8.0	29.0	1.5 ± 0.4	83	6
CG45	7.2	321.5	2.3 ± 0.5	311	14
CG46	5.5	27.0	3.0 ± 0.6	23	1
CG47	5.5	22.7	1.8 ± 0.3	38	2
CG49	4.0	16.2	1.3 ± 0.2	57	4
CG50	4.0	16.0	1.2 ± 0.1	29	2
CG53	2.5	16.0	2.6 ± 0.4	27	1
CG55	1.2	39.2	2.5 ± 0.5	33	1
CG56	0.2	331.3	2.0 ± 0.3	193	9
CG58	0.0	255.8	1.6 ± 0.2	20	1
CG59	0.0	331.1	1.6 ± 0.3	178	11
CG60	-0.2	270.4	1.6 ± 0.2	58	4
CG61	-0.8	234.2	0.6 ± 0.1	53	8

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