NEW IMPACT MODIFICATION OF CORINTO SECONDARY CRATERS. Ingrid J. Daubar[1], M. P. Golombek[1], A. S. McEwen[2], C. Dundas[3], A. W. Britton[4], and L. L. Tornabene[5]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109 (ingrid.daubar@jpl.nasa.gov), [2]LPL, University of Arizona, Tucson AZ 85721. [3]USGS, Flagstaff, AZ 86001. [4]MSSS, San Diego, CA 92191. [5]Centre for Planetary Science & Exploration (CPSX) and Dept. of Earth Sciences, Western University, London, ON, CANADA.

Introduction: Corinto crater is a 13.9 km diameter crater located at 141.72°E, 16.95°N, one of a group of the freshest and best-preserved craters on Mars that have distinctive rays in thermal inertia data [1–3]. Secondary craters from Corinto reach distances of more than 100 crater diameters in length (1400 km) and possibly more than 2240 km [4]. Approximately 18,000 secondary craters were counted within an area of just 4.95 km^2 of one Corinto ray [5]. Some of these rays cross the proposed InSight landing site region [6] (Fig. 1A), also an area where a large number of images have been taken in support of landing site selection [7].

Repeat images by the Context Camera (CTX) are the primary method for finding new, date-constrained impacts [8]. In this case a new impact was discovered within the InSight landing ellipse E9 (Fig. 1). The impact modified pre-existing Corinto secondaries, shedding light on both their nature and the processes involved in impact blast zone formation.

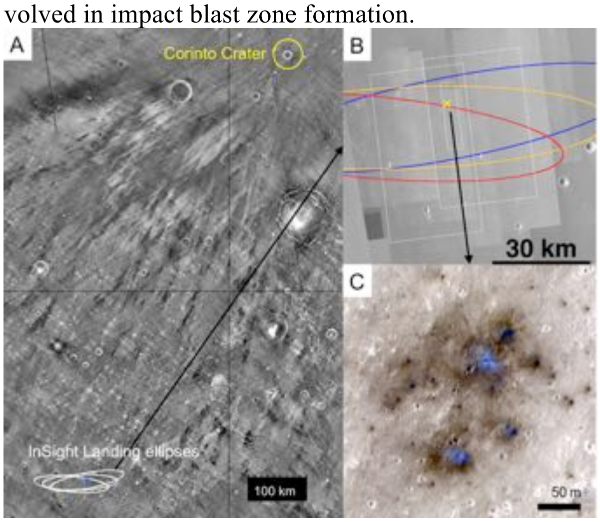

Fig. 1: A: *Context map showing location of Corinto and InSight landing ellipse E9.* ***B:*** *Ellipse area showing CTX discovery image footprints.* ***C:*** *HiRISE image ESP_043605_1845 color RDR showing new impact cluster at 4.5117°N, 135.8191°E.*

Recent new impact: The new impact was found in CTX image F19_043183_1844_XN_04N224W taken on October 13, 2015, and is not present in F18_042827_1842_XN_04N224W taken on September 15, 2015 (footprints shown in Fig. 1B), thus constraining its formation to within one month.

HiRISE image ESP_043605_1845, taken after the impact on November 15, 2015, shows the largest crater in the impact cluster is ~1.5 m diameter, and most of the other craters are too small to be resolved by HiRISE. The new craters are surrounded by "blast zones" (BZs) of darkened areas (Fig. 1C). These BZs formed over several Corinto secondaries.

Modification of Corinto secondaries: Secondary craters from Corinto have been recognized to have distinctive ejecta with relatively high albedos [3,4]. Examples of these can be recognized throughout Fig. 1C. Many have been darkened by the impact, while some appear to be undisturbed. In only one case was the brighter ejecta either completely removed or hidden by the new impact (sample CS1).

Albedo measurements: To quantify the modification of Corinto secondary ejecta by the new impact, we used the relative albedo (A_{rel}) method [9]. Such relative albedos minimize errors resulting from differences between observations in image geometry, lighting conditions, and image calibration. We measured A_{rel} in samples of secondary ejecta before and after the new impact created the dark BZ; these values and the differences between them for each sample are in Table 1.

Results: The bright ejecta was ~10-20% (average 16%) higher A_{rel} than the surroundings before the impact (Table 1). Darkening caused by the new impact reduced their albedos an average of 22%, although this varies significantly with location. In comparison, the blast reduced the relative albedo in bland, non-ejecta areas in the BZ adjacent to the ejecta samples by very similar amounts.

	Corinto secondary bright ejecta			Area adjacent to ejecta
Sample	A_{rel} before	A_{rel} after	Change (%)	Change (%)
CS1	1.17	0.80	-0.37 (31%)	-0.26 (27%)
CS2	1.11	0.82	-0.29 (26%)	-0.24 (24%)
CS3	1.17	0.90	-0.27 (23%)	-0.19 (18%)
CS4	1.16	0.98	-0.19 (16%)	-0.13 (13%)
CS5	1.14	1.01	-0.13 (11%)	-0.12 (13%)
CS6	1.19	1.09	-0.10 (8%)	-0.11 (10%)

Table 1: *Change in relative albedo (A_{rel}) of bright ejecta around Corinto secondaries and surrounding areas when new impact created darkened blast zone.*

Fig. 2 shows the same scene as Fig. 1C, with circles around craters that previously had light-toned ejecta in the image prior to the new impact, (ESP_039913_1845 from January 31, 2015). The

Corinto secondary ejecta that have darkened the least after the new impact are the farthest from the center of the new cluster. Those at intermediate distances have darkened as well, but not as drastically. Only one disappeared completely (CS1), and it is the closest secondary to the largest crater in the new cluster.

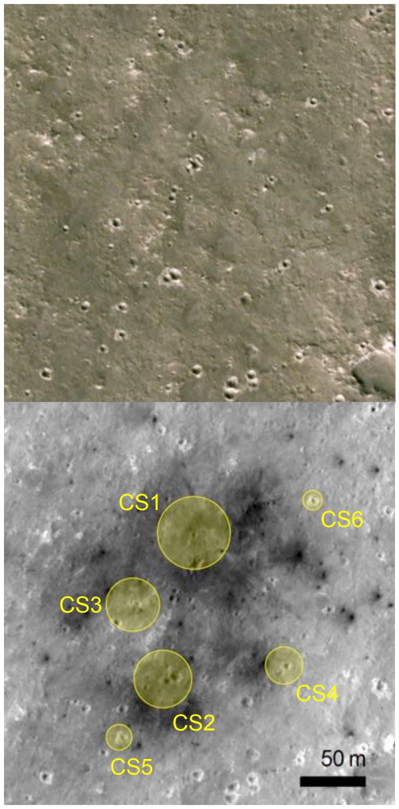

Fig. 2. Top: *HiRISE image ESP_039913_1845 color RDR showing area of Fig. 1C before impact.* ***Bottom:*** *Same area in ESP_043605_1845 RED RDR, after impact. Selected Corinto secondary craters are identified. Width of the circle centered on a secondary ejecta sample is proportional to the change in relative albedo of that ejecta before vs. after new impact.*

Discussion: This occurrence of a new impact on top of Corinto secondaries addresses two outstanding questions about different aspects of small craters:

1) What is the explanation for the unusual light-toned ejecta of Corinto secondaries? The extremely low thermal inertia of Corinto rays [2,4] indicates the presence of extremely fluffy material, with minimal grain-grain contact. Hypotheses for the bright secondary ejecta formation thus include induration of fine material, perhaps dust in the primary ejecta curtain that was sintered at the time of impact [1,7]. Another possibility is that the bright dust isn't completely sintered, but is trapped between small rocks in the ejecta.

The changes caused by this new impact are consistent with these hypotheses: if the material were not indurated at all, the blast of the impact would have removed it entirely around all of the secondaries. The fact that most of the ejecta is still present afterwards indicates that the light-toned ejecta material has some non-trivial cohesive strength. The correlation between amount of change in albedo and distance from the center of the impact indicates that the BZ effects, whether depositional or erosional, are dependent on the strength of the blast, which falls off with distance from the center of the impact. This leads to the next question:

2) What processes create dark blast zones around new impacts? We consider removal of bright dust to be the most likely mechanism creating darkened areas around new impacts, but deposition, redistribution of dust and/or associated changes in roughness could also be contributing to albedo changes [9]. If light-toned dust was removed to create this BZ, then that dust must also have been present on top of Corinto secondary ejecta prior to impact. Such a dust layer must necessarily be quite thin, because it does not completely mask underlying albedo features. Removal of such a thin layer might be expected to darken all areas equally, which is not consistent with the distance dependence of the darkening. Removal could also be in patches, and the patch area could vary with distance. If a portion of the bright ejecta, which also must be quite thin and could possibly be removed in sub-pixel patches, was also being removed in the BZ formation process, the underlying surface may be exposed to cause the darkening. Nearby dust devil tracks show removal of dust creates dark streaks in their paths [11], so in at least some areas nearby, removal seems to be causing similarly darkened areas.

If the impact is instead depositing dark material excavated from the subsurface, then the distance dependence could be explained by a falloff in ejecta thickness with distance, as is seen in larger impacts [10]. Surface disturbances caused by shaking or the atmospheric airblast could also be distance-dependent [12].

Conclusions: The unique bright ejecta around Corinto secondaries is likely composed of a thin layer of sintered dust with enough strength to partially, but not completely, withstand the blast associated with a few-meter-diameter impact. The dark BZs around new craters in general are still considered to be caused by impact removal or disturbance of high albedo dust, revealing an underlying darker surface.

References: [1] McEwen, A. S. *et al.* (2005) *Icarus* **176,** 351–381. [2] Tornabene, L. L. *et al.* (2006) *JGR* **111,** E10006. [3] McEwen, A. S. *et al.* (2010) *Icarus* **205,** 2–37. [4] Bloom, C., *et al.* (2014) *8th Int. Conf. Mars* Abs. 1289. [5] Ong, L., *et al.* (2011) *LPSC* **42** Abs. 1552. [6] Golombek, M., *et al.* (2014) *LPSC* **45** Abs. 1499. [7] Golombek, M. P., *et al.* (2014) *LPSC* **45** *Abs.* 1470. [8] Daubar, I. J., *et al.* (2013) *Icarus* **225,** 506–516. [9] Daubar, I. J. *et al.* (2016) *Icarus* **267,** 86–105. [10] Melosh, H. (1989) Oxford University Press, 253 pp. [11] Reiss, D. & Lorenz, R. D. (2015) *LPSC* **46** Abs. 2070. [12] Burleigh, K. J. *et al.* (2012) *Icarus* **217,** 194–201.