THE CURRENT MARTIAN CRATERING RATE. I. J. Daubar[1], A. S. McEwen[1], S. Byrne[1], C. M. Dundas[1], M. Kennedy[2], and B.A. Ivanov[3]. [1]Lunar & Planetary Laboratory, University of Arizona, Tucson, AZ, 85721 (ingrid@pirl.lpl.arizona.edu), [2]Malin Space Science Systems, San Diego, CA, USA., [3]Institute for Dynamics of Geospheres, RAS, 119334, Moscow, Russia.

Introduction: New impact sites are being discovered on Mars at a rapid rate. The increased resolution, temporal and spatial coverage afforded by the Mars Reconnaissance Orbiter (MRO) mission is allowing a detection rate that might approach the actual impact rate over some areas. New impact sites are recognized in Context camera (CTX) data by the disturbance of surrounding dust. The HiRISE camera then follows up to confirm an impact origin and measure the craters [e.g. 1, 2, 3, 4]. The number of candidate sites is currently 121 (Fig. 1), 102 of which have been confirmed as new sites by HiRISE. Two of these sites lack detected craters even via HiRISE (~30 cm/pixel), and so are interpreted as airbursts, marked by areas of disturbed dust with patterns like those that contain craters. Out of the remaining 100 confirmed sites, 60% are clusters of craters created by atmospheric breakup, as opposed to single-crater sites.

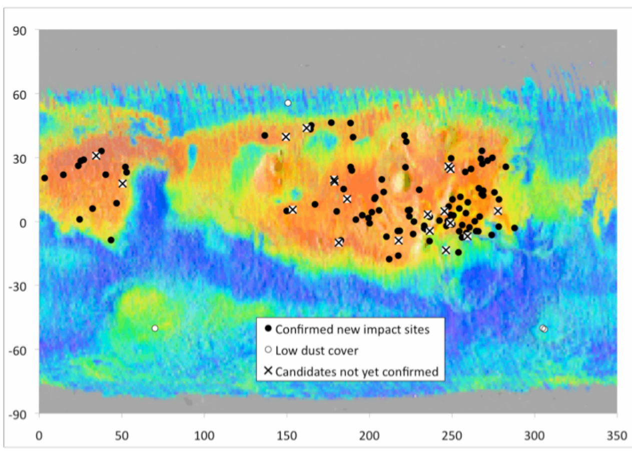

Fig. 1: Locations of 121 new confirmed and candidate impact sites plotted on the TES dust cover index map [5]. All sites except four are in areas of high dust cover.

Using this data set, we aim to better understand current impact processes and test crater chronology models to see whether their predicted cratering rates apply to these small sizes (craters range from <1-80 meters in diameter) and recent time scales (<10 years). Previous work [6] had less complete statistics, especially at small sizes. Nor did those data have the resolution to recognize aeolian bedforms in some craters, which we interpret as evidence that these are more ancient craters that changed in relative brightness due to aeolian processes or atmospheric hazes, rather than new impact events, so they are not included in these studies.

Current flux of impacts: Candidate impact sites are first identified from the characteristic morphologies of the surrounding dark spots; such sites are considered "confirmed" when HiRISE images reveal pristine craters. Confirmed impact sites were "dated" by examining previous coverage for the latest image that lacks a dark spot and the earliest image in which the spot is visible. These bracketing dates are shown in Fig. 2, along with the mean ages, halfway between the dates that constrain their formation. This includes 100 confirmed and dated impact events (not including airburst sites with no detectable craters).

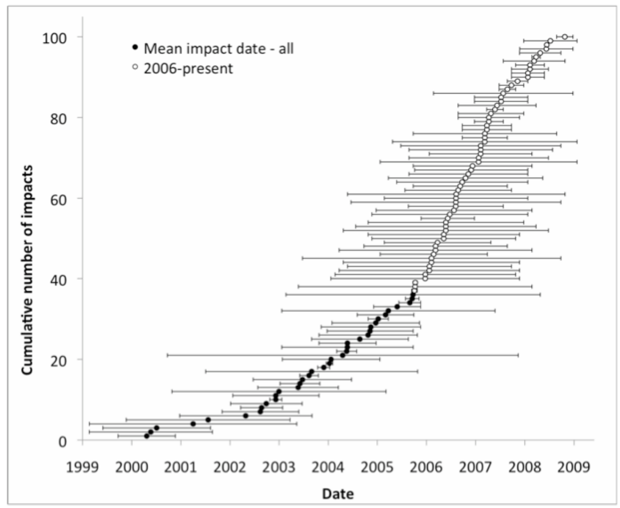

Fig. 2: Dates spanning the formations of 100 confirmed new impact sites, sorted by mean date.

Over the past ten years, these detections have averaged ~12/year. However, when dates are limited to those in the last three years (most of the primary science phase of MRO, for which coverage has been more thorough), detections have averaged ~21/year.

This rate of detections is a lower limit on the actual rate of impacts, since we are limited by the detection method to dusty regions of Mars, and CTX coverage of that area is not yet complete, although other data sets are useful as well. Using the recent rate of detection over dusty areas and scaling up to the entire planet leads us to expect that a minimum of 77 new impact events creating meter-scale or larger craters are occurring on Mars each year: 5.3×10^{-7} impacts/year/km^2, or one impact per year in every 1.8 million km^2 (~1% of Mars). This is similar to the rate previously calculated by other authors [4].

Seasonal variation of detections: If impactors are dominated by main belt asteroids, we expect the impact rate to be highest near aphelion (L_s 70°), when Mars is closest to the main belt [9]. Fig. 3 shows a histogram of possible formation dates compared to the corresponding solar distance at that L_s. The timing of detections is also influenced by other factors, perhaps most importantly the availability of data downlinked to Earth (which has been inversely correlated to solar distance). Despite this, the impact dates seem to roughly follow the expected seasonal trend.

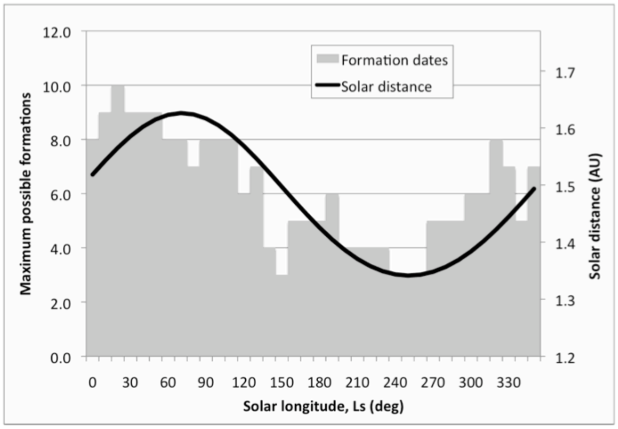

Fig. 3: *Possible formation L_s for 47 confirmed sites whose formation dates are constrained to less than half a Martian year. Each detection increments all Ls bins in the formation interval, so the total shown is the maximum possible number of known impacts that could have happened in that L_s. Also shown is the Mars-Sun distance at the same L_s.*

Size-frequency relations: We measured the rim-to-rim diameters of 280 craters at 69 of the confirmed new impact sites. Approximate effective diameters were calculated for clusters using $D_{eff} = (\Sigma D^3)^{1/3}$ [7]. Airbursts and unresolved craters (<3 HiRISE pixels) were not included. Sites were restricted to dusty areas according to the TES dust index [5] (~27% of the surface of Mars). Diameters were binned and scaled to the area of high dust cover. Chronology [8] and production functions [9] were extended down to these small sizes; more recent [10] isochrons that attempt to account for atmospheric loss at small diameters are not used, since we are trying to evaluate that effect. The plot in Fig. 4a represents a lower limit, since coverage of this area is not complete, and all sites have not yet been included. The average "age" of the 69 sites in this study is 3.9 years; the SFD falls near that model age in the isochrons from [8] at the upper end of the diameter range.

The turnover in the SFD at small sizes could be due to several factors. The relevant limiting resolution is not HiRISE's, but rather that of the lower-resolution data used in the initial discovery of the site, often CTX (6 m/pix) but also THEMIS (18 m/pix VIS; 100 m/pix IR) or MOC NA (1.5-12 m/pix). Identification is of the dark spot, however, not the crater itself, so a given resolution limit leads to a rollover at a much smaller crater diameter. A comparison of detections made using only CTX data (Fig. 4b) shows the rollover diameter is similar (~4m D_{eff}, corresponding to ~40m dark spots, or ~7 CTX pixels). Another factor in the rollover might be atmospheric ablation at small sizes. This would affect clusters more strongly: individual fragments would be expected to experience more relative ablation per volume than an unbroken impactor, since ablation is proportional to cross-section. This would cause the lower end of the SFD to be deficient for clusters especially. In addition, these small craters differ in morphology from larger craters [3], which might indicate different strength properties of the target material. Isochrons based on larger craters that penetrate bedrock are probably not directly applicable to these craters [e.g. 12], most of the depth of which comprises weaker, loosely consolidated regolith.

We have established that older sites are not as well represented, so the most recent data were also plotted separately (2006-present). Although they fall below the one-year isochron, their slope is similar to it. This supports the idea that the current cratering rate is representative of that over geologic time. As our data set becomes more complete, there is hope that recent planetary chronologies can be calibrated to these sizes.

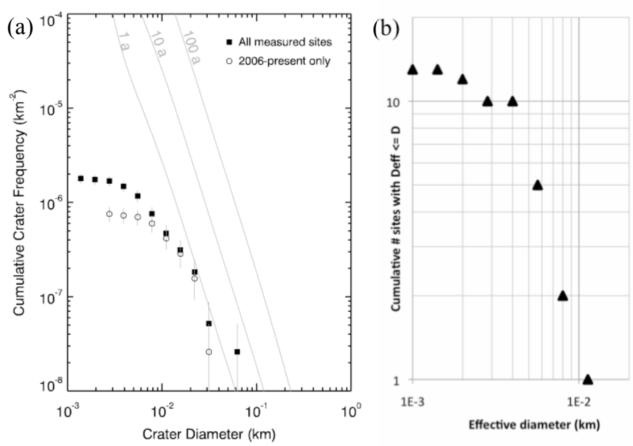

Fig. 4 (a) *Effective crater diameters of 69 of the new impact sites, compared to model ages [8, 9]. Plotted separately are the 29 of those sites that have mean ages within the last three years. Plot made using craterstats program [11].* ***(b)*** *13 detections made using only CTX data, for comparison of rollover diameters.*

References: [1] McEwen A.S. *et al.* (2007) *LPS XXXVII*, Abs. 2009. [2] Ivanov B.A. *et al.* (2008) *LPS XXXIX*, Abs. 1402. [3] Daubar I.J. & McEwen A.S. (2009) *LPS XL*, Abs. 2419. [4] Kennedy M.R. & Malin M.C. (2009) *AGU Fall Meeting,* Abs. ID P43D-1455. [5] Ruff S.W. & Christensen P.R. (2002) *JGR*, *107*, 5127. [6] Malin M.C. *et al.* (2006) *Science, 314*, 1573-1577. [7] Ivanov B.A. *et al.* (2009) *LPS XL*, Abs. 1410. [8] Hartmann W.K. & Neukum G. (2001) *Space Sci. Rev., 96*, 165-194. [9] Ivanov, B.A. (2001) *Space Sci. Rev., 96*, 87-104. [10] Hartmann, W.K. (2005) *Icarus, 174*, 294-320. [11] http://hrscview.fu-berlin.de/craterstats.html [12] Chapman C.R. *et al.* (1970) *JGR, 75*, 1445-1466.