CHARACTERISTICS AND SUPERPOSITION RELATIONSHIPS OF SECONDARY CRATERS FROM FRESH RAYED CRATERS IN ELYSIUM PLANTIA, MARS.

C. B. Hundal[1], M. P. Golombek[2], I. J. Daubar[2]. [1]Dept. Astronomy, Whitin Observatory, Wellesley College, Wellesley, MA 02481 (chundal@wellesley.edu). [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Introduction: Secondary craters are formed from the impact of material ejected from a larger primary impact. Zunil crater, which has been the subject of several studies [e.g., 1,2], is estimated to have created $7x10^7$ secondary craters >15 m in diameter that extend thousands of kilometers from the primary [2]. Thermal rays, which can be observed emanating from fresh craters in Thermal Emission Imaging System (THEMIS) nighttime IR images [3], contain high densities of these secondary craters [4]. A large concentration of rayed craters, and their secondaries, overlap in Elysium Planitia in and near the planned landing site for the InSight mission [5]. We have found that populations of secondary craters from a particular primary tend to exhibit a common set of morphological attributes, particularly in the same type of target material and at similar distances from the primary. Because secondary craters form in an impact that occurs essentially instantaneously in geologic time, and extend over long distances, they can be used effectively to determine relative ages via superposition relationships. Identifying different secondary populations superposed on one another at an intersection of rays, on another crater or its ejecta blanket, or on top of a dated unit can thus be used to determine the relative ages of the source craters.

In this abstract, we discuss the secondary superposition relations used in [6] to constrain the ages of seven fresh rayed craters in Elysium Planitia between 1.5 and 13.9 km in diameter. A context image

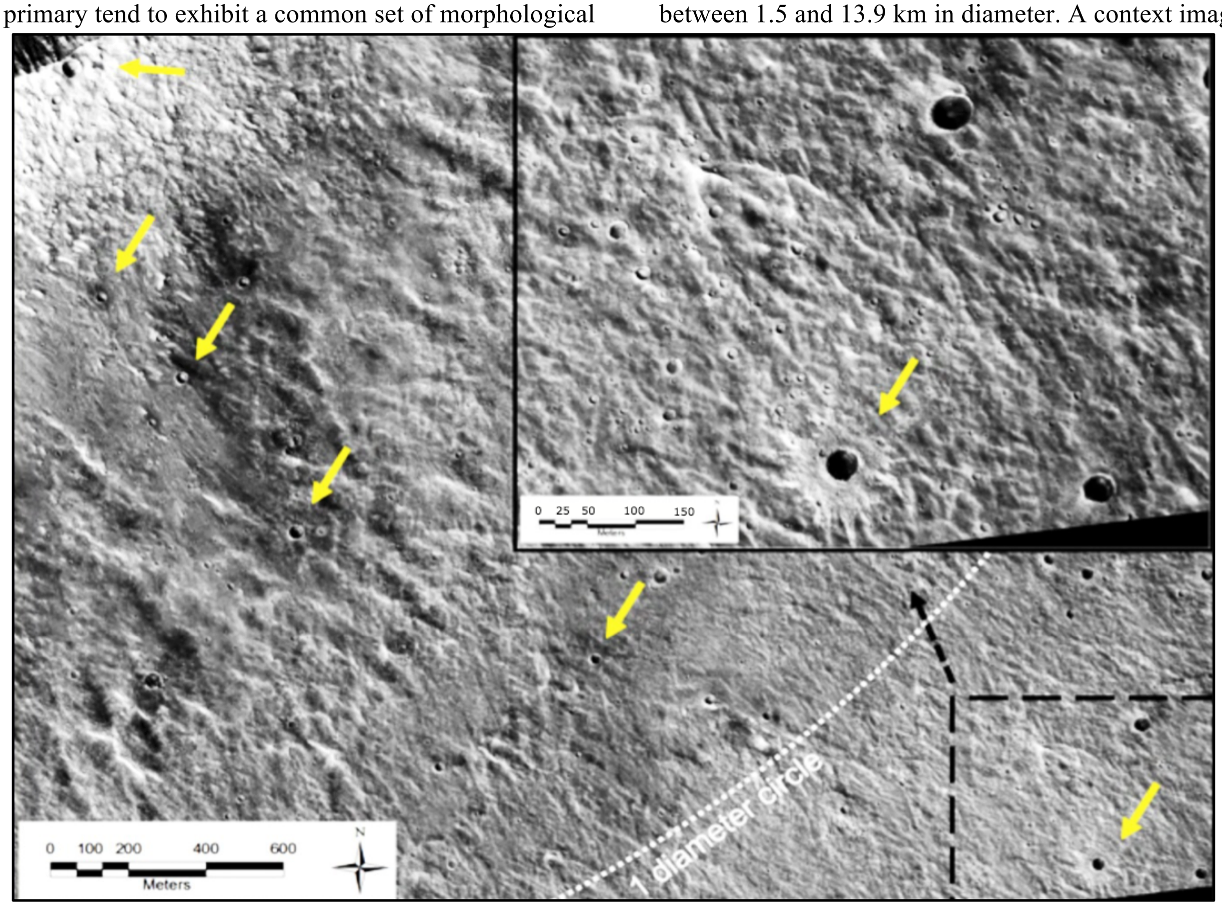

Figure 1. Yellow arrows indicate Zunil secondaries southeast of Dilly crater (HiRISE ESP_030866_1935). Inset: a close-up of a Zunil secondary outside 1 diameter from Dilly's rim (and thus likely outside the continuous ejecta blanket) showing typical stringy, bright ejecta and a dark interior. Although the secondaries on Dilly's ejecta blanket lack both ejecta and dark interiors due to the different target material, their similarity in size and spatial distribution to the typical Zunil secondaries outside the ejecta blanket suggests they are also from Zunil.

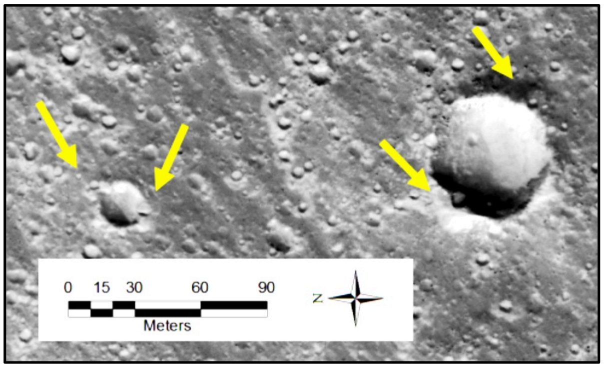

Figure 2. Corinto secondaries (yellow arrows) with typical bright ejecta superposed on the rims of two larger Tomini secondaries, showing Corinto is younger than Tomini (HiRISE ESP_045135_1915).

of these craters along with their mapped thermal rays can be seen in Fig 1 of [6].

Methods: In thermal rays far from intersections with other rays (and thus secondaries from multiple sources), we examined High Resolution Imaging Science Experiment (HiRISE) images of secondaries, noting characteristics for that particular population. These attributes included the presence, shape, and albedo of ejecta, albedo of the interior, typical size, and presence of diffuse, high/low albedo halos surrounding impacts. We then looked at HiRISE images where rays from two primary craters crossed, or where rays were found on ejecta blankets of other primary craters, in order to constrain the age of the source crater. When the target material affected secondary characteristics, we examined clearly attributable secondaries down ray and compared size, distribution, and other characteristics to confirm the source of the secondaries.

Secondary Populations: At distances >600 km northwest of Zunil, Zunil secondaries generally exhibit bright, stringy ejecta (see inset of Fig 1). Secondaries that fall on the ejecta blankets and inside of the craters Thila, Wiltz, and Dilly either no longer have bright ejecta, or the ejecta becomes lobate and less stringy. For example, Zunil secondaries outside 1 diameter from Dilly (and thus likely outside of the continuous ejecta blanket) have stringy, bright ejecta and low interior albedos (see Fig 1). On the ejecta blanket and inside Dilly, however, they lack ejecta and dark interiors, but still exhibit similar density and size distributions to secondaries >1 diameter away from the rim.

The largest Tomini secondaries are generally ~50 m in diameter, lack distinctive ejecta, and lack dark interiors (see Fig 2.) These attributes are largely similar to the north, east, and south of Tomini.

Corinto secondaries (typically 5-15 m in diameter) further than ~500 km from the source crater show distinct bright, lobate ejecta blankets (see Fig 2, 3.)

Results: Through secondary superpositions, we determined that Corinto is older than Zunil (a conclusion also reached by [7]), Tomini and Naryn are older than Corinto (see Fig 2 and 3), and Naryn is older than Tomini. Additionally, Thila, Dilly and Wiltz are older than Zunil.

References: [1] McEwen A. et al. (2005) *Icarus 76*, 351-381. [2] Preblich B. et al. (2007) *JGR, 112*, E05006. [3] Christensen P. R. et al. (2004) *Space Sci. Rev. 110,* 85-130. [4] Tornabene L. et al. (2006) *JGR 111*, E10006. [5] Golombek M. et al. (2013) *LPS XLIV* Abstract #1691. [6] Hundal C. B. et al (2017) *LPS XLVIII, this volume.* [7] Golombek M. et al. (2014) *LPS XLV* Abstract #1470.

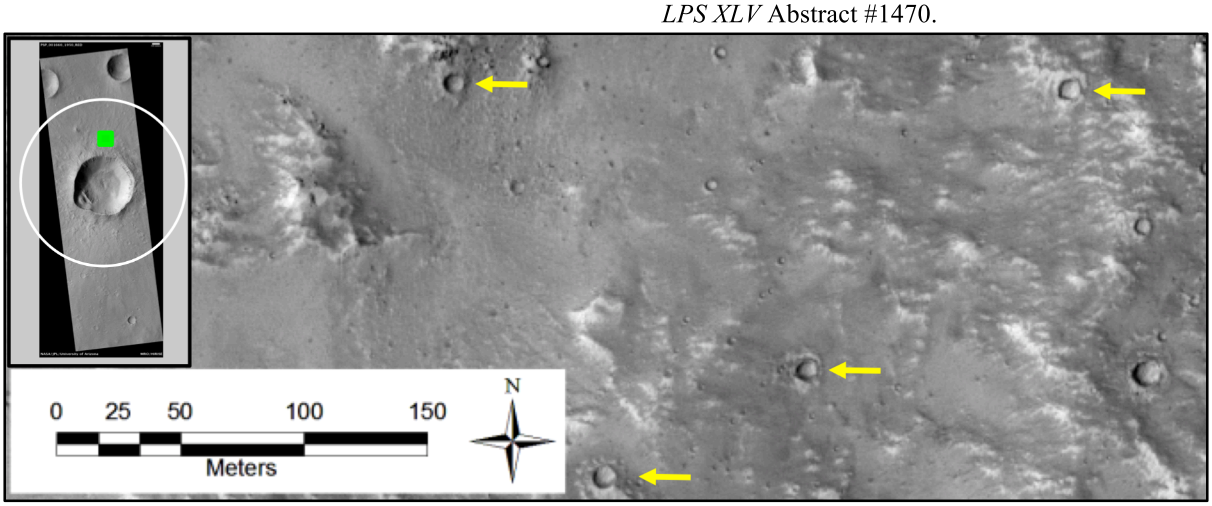

Figure 3. Yellow arrows point out several Corinto secondaries with typical bright ejecta on the ejecta blanket of Naryn (HiRISE PSP_001660_1950). The inset is the full image PSP_001660_1950 showing the location of these secondaries (green square) with respect to Naryn. The white circle marks one diameter from the rim, which is the approximate extent of the continuous ejecta blanket.