MAPPING RAYS AND SECONDARY CRATERS FROM ZUNIL, MARS. B. Preblich, A. McEwen, and D. Studer, Department of Planetary Sciences, Lunar and Planetary Lab, The University of Arizona, Tucson AZ 85721, (brandonp@lpl.arizona.edu).

Introduction: A 10.1-km diameter crater named Zunil (7.7°N, 166°E) in the Cerberus Plains of Mars is the source for ~10^7 secondary craters ≥10 m in diameter within 800 km of the impact site [1]. The largest Zunil secondary found to date is only 230 m in diameter, whereas typically the largest secondary is 5% of the primary (500 m in this case) [2]. These secondaries are concentrated in asymmetric rays extending west up to 1600 km.

Zunil is thought to be only a few Ma old [1], as it is younger than the Cerberus Plains, one of the youngest areas on Mars, and is a very plausible source crater for some of the basaltic shergottites. Further, its prominent rays and secondaries appear relatively fresh in both the visible and the infrared, and it is only the crater of its size or larger on Mars where rays are still present.

Zunil is unusual since it does not have many large secondaries within 16 crater radii (80 km). It also does not have very many large blocks (>5 m) near its rim or on its ejecta flow lobes. In general, its secondaries lack many of the usual obvious features, such as elongated craters, obvious chains, and herringbone patterns. Most of its secondaries were thrown at high velocities, creating equidimensional craters that would be hard to identify as secondary craters if not for the rays and fresh ejecta.

When dating terrain through crater counting, it is necessary to avoid secondary craters [3]. Yet, as Zunil demonstrates, only a small fraction of the secondaries may be obviously identifiable with the usual distinctive morphologies. This leads to the problem of differentiating small primaries from secondaries, a difficulty which Shoemaker identified [4]. We need to better understand the typical numbers and distribution of distant secondaries, and study of the Zunil secondary field provides constraints on cratering mechanics.

Zunil's relative youth provides a unique opportunity to identify and study secondary craters in two ways. First, its rays highlight locations where secondary craters strongly dominate over any potential primary craters or secondaries from another source. Second, its secondary craters have distinct morphologies in both the infrared and the visible. In the visible, these secondaries have dark, low albedo interiors and bright, high albedo outer ejecta and rays. In the infrared, they have high thermal inertia interiors and low thermal inertia outer ejecta and rays.

Observations and Analysis: Daytime and nighttime (Fig 1) THEMIS IR mosaics of a 1600-km radius area around Zunil were created, each using hundreds of images. Secondary craters from Zunil with bright interiors (high thermal inertia) were found in dark (low thermal inertia) rays visible in nighttime THEMIS IR images (Fig 2).

Zunil's secondaries also have bright ejecta surrounding them in the visible. These bright ejecta craters were mapped out within a 1600-km radius around Zunil using available MOC and THEMIS VIS images (Fig 1). These craters also allow identification of secondaries outside of obvious rays previously identified in the IR. This gives a more complete idea of the distribution of Zunil secondaries. However, it is likely that some secondaries have been subject to eolian erosion of the bright ejecta.

The nighttime IR mosaic illustrates Zunil's asymmetric rays, which indicate an oblique impact from the east-northeast. Previously, the obliquity was not known with certainty because of dust mantling to the east, which provides a low TI background against which the IR rays are difficult to see. However, when bright ejecta craters were mapped out, the rays still showed an asymmetry, albeit somewhat smaller. The utility of these bright ejecta craters is that they are found through their albedo, and so they are not hidden in low thermal inertia regions. Ejecta albedo can also blend in with high albedo background, but this is not strongly correlated with regions where the thermal inertia of the ejecta blends in with that of the background. Initial results show that bright ejecta craters are seen preferentially over regions of moderately high thermal inertia (~375 to 550 J m^{-2} K^{-1} $s^{-1/2}$), which can be seen in Figure 1. It is likely that these bright ejecta craters outline rays that were not seen in the infrared.

The two IR mosaics we have produced facilitate locating VIS and MOC images within 1600 km of Zunil. These images can be used to determine how the size frequency distribution (SFD) of the secondary craters changes with distance and azimuth around Zunil. With the rays mapped in the nighttime

IR mosaic, the SFD can also be found inside vs. outside of the rays. These results will be plotted in contour maps of secondary crater density for given ranges of size, and will be used to refine Artemieva's modeled results of Zunil's secondaries [1,5]. In addition, a more accurate number of secondaries produced from Zunil will be estimated.

Understanding the SFD of Zunil's secondaries will better allow estimation of the crossover diameter (the diameter at which secondaries dominate primaries) for a terrain of a given age. When crater counting, it is important to count only crater sizes at which primaries dominate to get accurate ages.

References: [1] McEwen, A., et al. (2005) Icarus, in press. [2] Melosh, H.J. (1989) *Impact Cratering: A Geologic Process*. Oxford Univ. Press. [3] McEwen, A., et al., this conference. [4] Shoemaker, E. (1965) in Nature of the Lunar Surface, W. Hess et al., Eds., 23-77. [5] Artemieva, N., this conference.

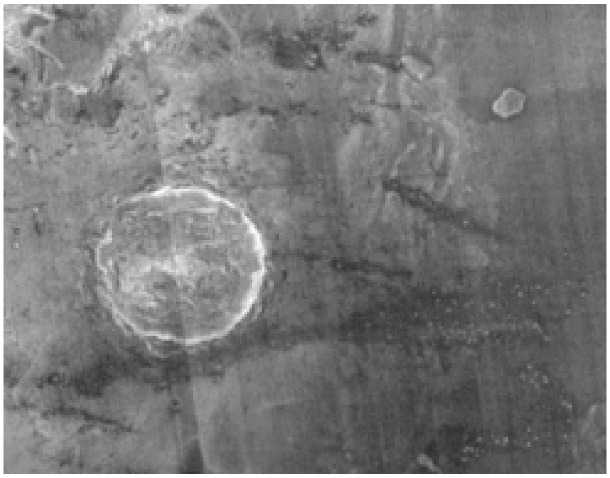

Figure 2: Part of the nighttime THEMIS IR mosaic SE of Athabasca Valles, illustrating the dark rays from Zunil and the bright interiors of secondary craters within the rays. Image is 50 km wide. Resolution is 100 m/pix. North is up and Zunil is east of the image.

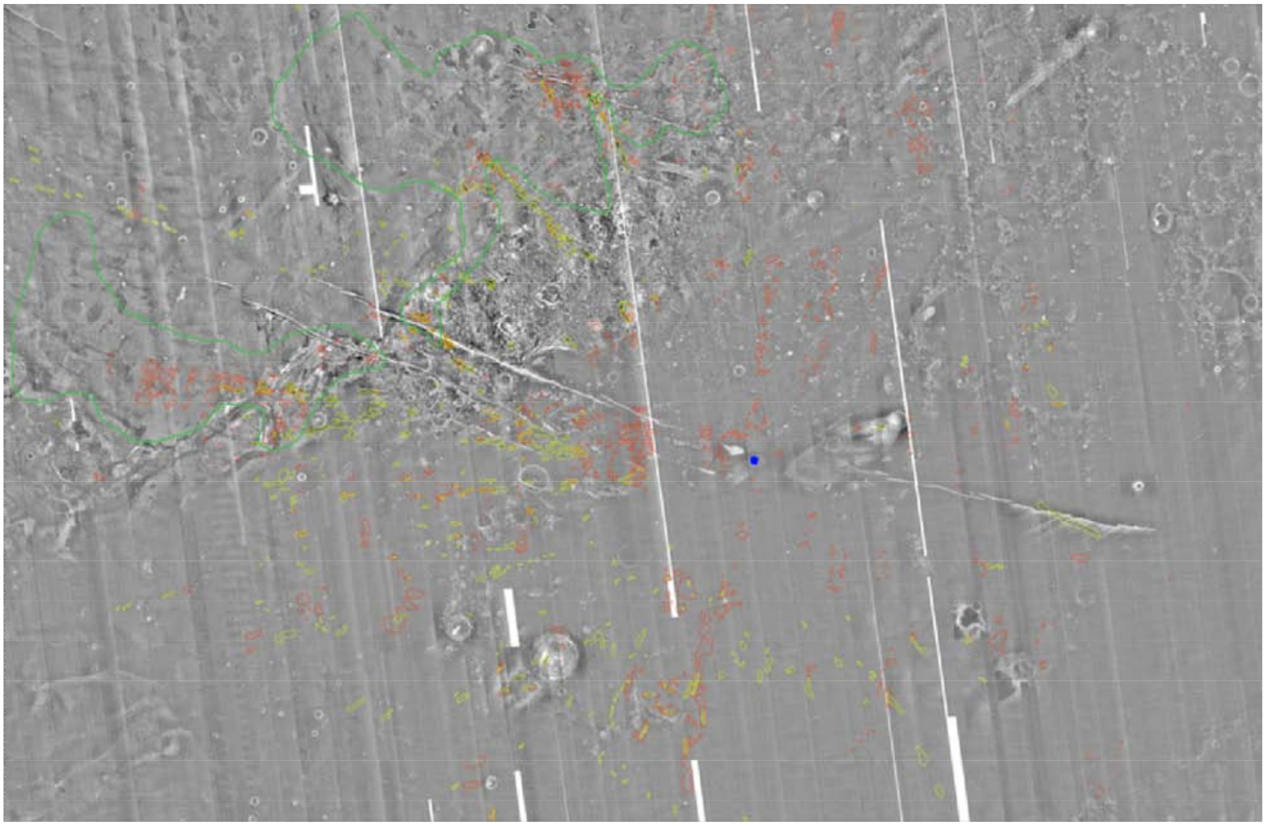

Figure 1: THEMIS IR nighttime mosaic. Zunil is in blue. Rays as seen in the IR are in yellow. Bright ejecta craters as seen in the visible are in red. Moderately high thermal inertia (~375 to 550 J m^{-2} K^{-1} s$^{-1/2}$) is roughly outlined in green. Nighttime IR coverage of the area is nearly 100%, but visible coverage is less than 30%, and so there are most likely many more bright ejecta craters in the region than shown. The above image is ~1600 km wide and is only about 20% of the full mosaic. Resolution is 100 m/pix. North is up.