Updated geologic database for 433 Eros. J.H. Roberts[1], D.L. Buczkowski[1], C.M. Ernst[1], O.S. Barnouin[1], R.W. Gaskell[2], A.E. Duck[3], D.T. Blewett[1], L.M. Jozwiak[1], T. Tagle[3], and the SBMT Team. [1]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA (James.Roberts@jhuapl.edu), [2]Planetary Science Institute, Tucson, AZ, USA; [3]University of Maryland, College Park, MD, USA.

Introduction: The topography of 433 Eros has been determined using the NEAR Laser Rangefinder (NLR), and from imaging data using classical stereo [1], and stereophotoclinometry (SPC) [2]. This last technique combines stereo effects and photoclinometry to simultaneously solve for slopes and albedo variations. Shape models based on all these techniques are available in the NASA Planetary Data System (PDS). The SPC shape model has the highest spatial resolution, but is based on only a fraction of the available NEAR images. Because of small errors in spacecraft trajectory and pointing, the locations of images not used in the creation of the shape model may be slightly shifted, making it difficult to correctly map structures contained therein.

As an example, of the 334 ponds (smooth deposits that sharply embay their bounding depressions [3–5]) identified on Eros, only 55 are located in images which were registered to the high-resolution SPC shape model [6]. The topography of ponds on Eros can be useful for evaluating proposed formation mechanisms, but only if they can be precisely located on the surface with respect to the background gravity and slopes.

Another key dataset which has hitherto been mapped only on the older stereo shape model is the set of lineations [7, 8]. These tie together the surface history and internal structure, and it is thus valuable to project them onto the new shape model.

Now that all of the NEAR MSI images have been registered to the SPC shape model [9], we present an updated database of the locations of all known pond deposits and lineations based on the improved pointing knowledge.

Image Registration: In order to accurately locate the image on the shape model, the spacecraft position and pointing at the time the images were acquired is needed. An initial estimate at these parameters is obtained from the SPICE; the spacecraft position and nominal pointing uncertainties are estimated to be 10 m, and 1 mrad, respectively [2].

Here, we have registered a total of 63,776 calibrated MSI images from the Eros Orbital phase of the NEAR Mission to the SPC shape model (developed from a subset of these images) and to existing maplets by matching obvious landmarks such as conspicuous rocks and craters, shifting the images closer to the correct pointing.

Ponded Deposits: An initial pond database created by Peter Thomas has been the basis for many studies of the ponds [e.g., 1, 4–6, 10, 11]. This database contains for each of the 334 ponds identified on the asteroid: a reference MSI image in which it may be found, a pixel/line location of the pond within said image, and both the body-centric and geographic coordinates of the pond referenced to the stereo shape model [1].

In order to properly map the ponds onto the SPC shape model [2], we updated the coordinates of each pond to reflect the position of the projection of the image pixel/line location of the pond onto the shape model, as had previously been done for the 55 ponds in images already registered to the SPC shape model. An example is shown in Figure 1a. MSI Image 134551532 has been projected onto the SPC shape model using both the stereo-derived pointing and the SPC pointing. The SPC
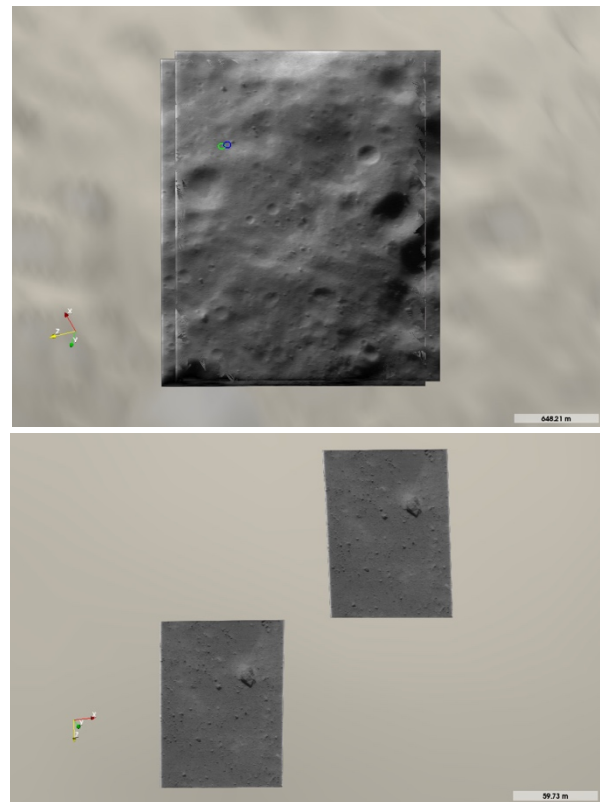

Figure 1: a) MSI Image 134551532 projected on the SPC shape model using both the stereo (left) and SPC (right) pointing. The image projections are offset by ~100 m. The circles indicate the location of Pond 28 from the Thomas database using the original coordinates (green) and the shift onto the SPC shape model (blue). **b)** MSI Image 157415183 projected on the SPC shape model using both the stereo (left) and SPC (right) pointing. Image has pixel scale of 0.2 m/px.

pointing places the image approximately 100 m south of the stereo pointing (a shift to the upper-right in Figure 1a). The green and blue circles indicate the position of the pond using the stereo and SPC pointing, respectively.

In situations like this, updating the pond location is fairly straightforward. We make an initial estimate for the pond shift based on the shift in image location. This shift is a small fraction of the total image size, and topographic features can be correlated easily even in cases where the SPC pointing is unavailable. This technique works well for many ponds seen in reasonably large images. The example in Figure 1a has a pixel scale of 4.5 m/px. However, the smallest ponds (< 30 m diameter) are only easily identified in images with much finer pixel scales [11]. The differences in the pointing may result in a shift of best images that exceeds the size of the images themselves, as shown in Figure 1b. In this case, due to the proximity of the spacecraft to the surface (8 km in this example), and the shape of the asteroid, this shift will distort the orientation of the surface captured in the image and makes it more difficult to correlate topographic features. In these cases it is essential to have the updated pointing for all images. In Figure 2 we show one view of the SPC Eros shape model with the updated locations of the ponds mapped on it.

Lineations: A similar technique was used to migrate the locations of lineations to the SPC shape model. However, in contrast to the ponds, these features are extremely elongated in one dimension (Figure 3a). During the migration process we assumed a lineation to be a rigid shape, because the absolute shifts are small (< 100s of meters) (Figure 3b). As a check on this process, we migrated each lineation twice, once using each endpoint of the lineation as the reference point for translation.

Data Products: All data products generated under this effort are maintained at the public APL website, and are incorporated into the Small Body Mapping Tool (SBMT) to facilitate rapid access to the data and future scientific investigations of the topography of Eros. The
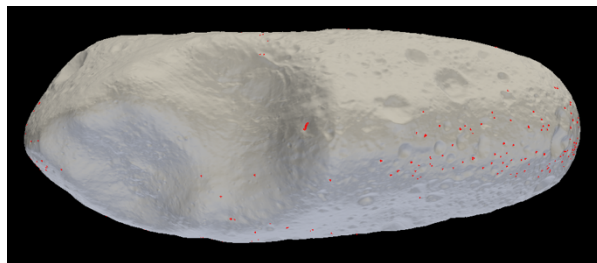
SBMT, including the updated shape and topography models, elevation, slope, and gravity maps, data search and visualization functions, mapping abilities, and a simple user's guide are publicly available (http://sbmt.jhuapl.edu). The shape model and pond and lineation database are also being archived at the Small Bodies node of the Planetary Data System.

References: [1] Thomas, P.C. et al. (2002), Icarus 155, 18–37. [2] Gaskell, R.W. et al. (2008), M&PS 43, 1049–1061. [3] Veverka, J. et al. (2001), Science 292, 484–488. [4] Robinson, M.S. et al. (2001), Nature 413, 396–400. [5] Cheng, A.F. et al. (2002) M&PS 37, 1095–1105. [6] Roberts, J.H. et al. (2014) M&PS 49, 1725–1748. [7] Thomas, P.C. et al. (2002), GRL 29, 1408 [8] Buczkowski, D.L. et al. (2008), Icarus 193, 39–52. [9] Blewett, D.T. et al., (2017) urn:nasa:pds:nearmsi.shape-backplane. NASA PDS. [10] Dombard, A. J. et al. (2010), Icarus 210, 713–721. [11] Roberts, J.H. et al. (2014), Icarus 241, 160–164.
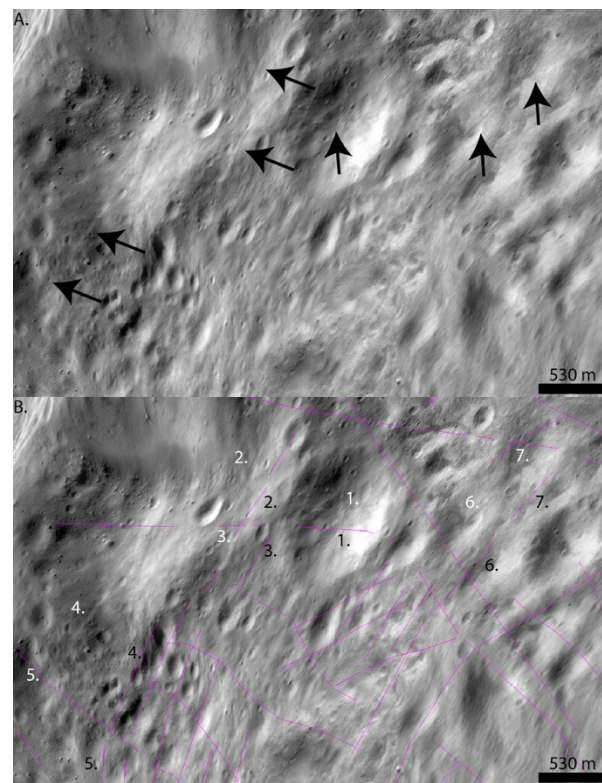

Figure 3: View of the high-resolution SPC Eros shape model, centered at 4.5°N, 214.8°E with image map draped over it. a) Arrows point to visible lineations. B) Lineations mapped on the stereo shape model in magenta indicated by numbers in black. Corresponding number in white indicates the updated location of the lineation visible in panel a).

Figure 2: Shape model of 433 Eros derived from SPC with 3 million plates. Locations of all ponds are marked by red circles.