MAPPING LINEAMENTS ON 433EROS: PROCESS, RESULTS, IMPLICATIONS.

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Introduction: The Near-Earth Asteroid Rendezvous NEAR-Shoemaker spacecraft orbited the asteroid 433Eros for a year from 2000-2001. The NEAR Multi-Spectral Imager (MSI) collected tens of thousands of high resolution images and as a result Eros is the most comprehensively studied asteroid in the solar system. Previous mapping of lineaments on Eros has supported the suggestion of planes throughout the asteroid [1,2]. We are creating a global database of all Eros lineaments to better understand the global distribution of these features.

Lineament types include shallow and flat-floored troughs, grooves, ridges and pit chains. We identify types of lineaments across the surface using a combination of NEAR Laser Rangefinder (NLR) topographic data and MSI images, and classify them according to region, including areas suggestive of thicker regolith. We compare lineament orientation to impact craters to determine if there is a causal relationship between cratering events and lineament formation. Further lineament/crater interactions are also examined, to determine the effect that lineaments have on crater shape.

Mapping Process: It is particularly challenging to map lineament orientations on a non-spherical body (Eros is the shape of a peanut, measuring 34 km on the long axis). To address this issue we are mapping the lineaments directly on the Eros shapefile using POINTS, developed by Jonathan Joseph at Cornell University. POINTS accesses a database of over 140,000 MSI images. Lines can be drawn on each of these images and, since the lines are saved to the shapefile, the lines will appear in the same locations on all other images opened in POINTS. We mapped lines on images with resolutions ranging from approximately 5 to 11 meters per pixel. Mapping on these high resolution images allows the best possible identification of linear features, but their footprints are not large enough to observe regional lineation patterns. When images with lower resolutions (~35 m/p) were opened in POINTS the previously mapped lineations were in their mapped positions and regional patterns emerged.

Observations: We have mapped 2153 lineations on 180 high resolution (5-11 m/p) images of Eros, creating a global lineation map of the asteroid. These lineations have been grouped into lineation sets according to location and orientation (Figs. 1,2,3,4). Many different sets of lineations can be identified. Some lineation sets are clearly related to specific impact craters. Other lineation sets have no obvious relationship to impact events. Some of these are global, and may be related to interior structures (ex. blue and yellow lineation sets, Figs. 1,2,3,4).

Analysis: We compare the pattern of these lineation sets to impact craters and to models of: 1) interior configuration and structure, 2) cratering mechanics, 3) thermal stresses that occured during orbit migration and 4) downslope scouring. We have identified lineations radial to nine of Eros's 37 named craters and two unnamed craters; these lineations were most likely formed as a result of an impact event. The global lineation set mapped in blue (Figs. 1,2,3,4) correlates to those lineations observed by [1, 2] to be indicative of interior structure of the asteroid but could also be consistent with modeled fragmentation due to impact onto the long side of an ellipsoid target [3]. The global lineation set mapped in yellow (Figs. 1,2,3,4) appears consistent with tectonic features resulting from changes in theremal stresses [4]. Some of the lineations mapped in Himeros and Shoemaker Regio (dashed green and yellow lines, Figs. 2, 3) could be a result of downslope scouring.

We also examine possible correlations between lineament sets and lineament type. Preliminary analysis of the NLR data indicates that grooves can be as much as 5 m deep [5]. Several grooves were identified on Eros with the morphology of merged pits [1] and it was suggested that these pitted grooves could be a result of regolith drainage into an open fissure. The pit chains were identified on the global lineation map (orange lines, Figs. 3). When compared to the volume of low-velocity ejecta from Shoemaker crater [6], it is observed that pit chains occur only where the lineation set overlaps a region of thickest regolith [7], as predicted by [1]. Further analyses of pit crater chains on Eros are being performed [8].

Further lineament/crater interactions are examined, to determine the effect that lineaments have on crater shape [5]. Square craters identified by [1] were found to be bordered by lineations that are included in mapped sets.

References: [1] Prockter. et al. (2002) Icarus, 155, 75-93. [2] Thomas P.C. et al. (2002) GRL, 10.1029/2001GL014599 [3] Asphaug E. et al. (1996) Icarus, 120, 158-184. [4] Dombard A.J. and Freed A.M. (2002) GRL, 10.1029/2002GL015181. [5] Heyler A.J. et al. (2005) GSA Annual Meeting, Abs. 96053. [6] Thomas P.C. et al. (2001) Nature, 413, 394-396. [7] Thomas P.C. and Robinson M.S. (2005) Nature, 436, 366-369. [8] Wyrick D.Y. and D.L. Buczkowski (2006) LPSC XXXVII, abs. 1195.

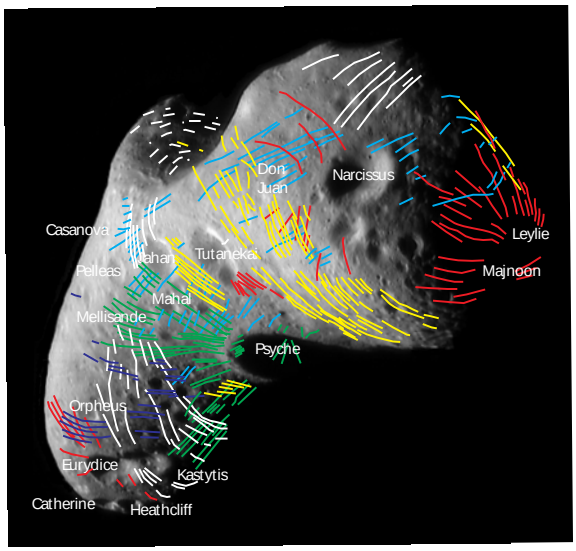

Figure 1. Mosaic of northern hemisphere of Eros, showing mapped lineations and named craters. Different colored lines indicate different sets of lineations.

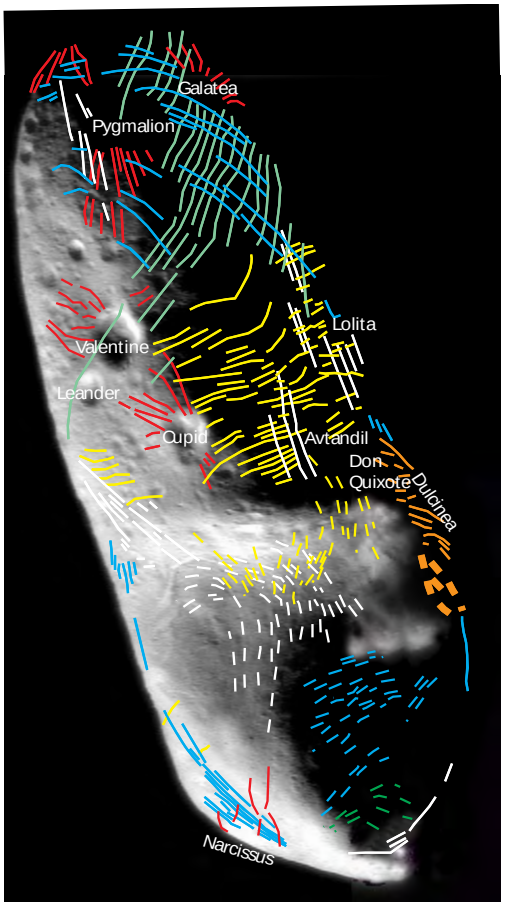

Figure 2. Mosaic of eastern hemisphere of Eros, showing mapped lineations and named craters. Different colored lines indicate different sets of lineations.

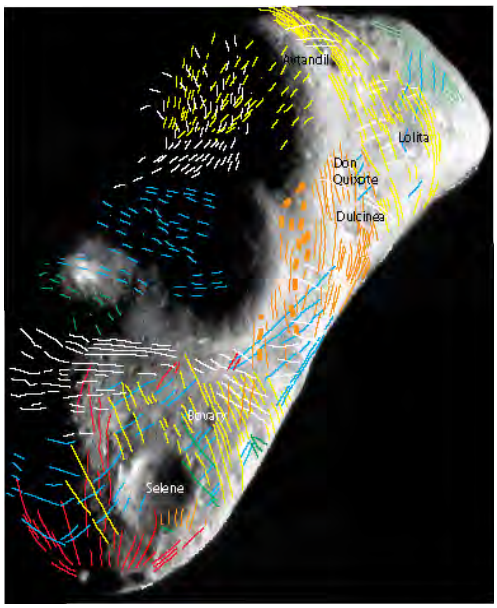

Figure 3. Mosaic of southern hemisphere of Eros, showing mapped lineations and named craters. Different colored lines indicate different sets of lineations.

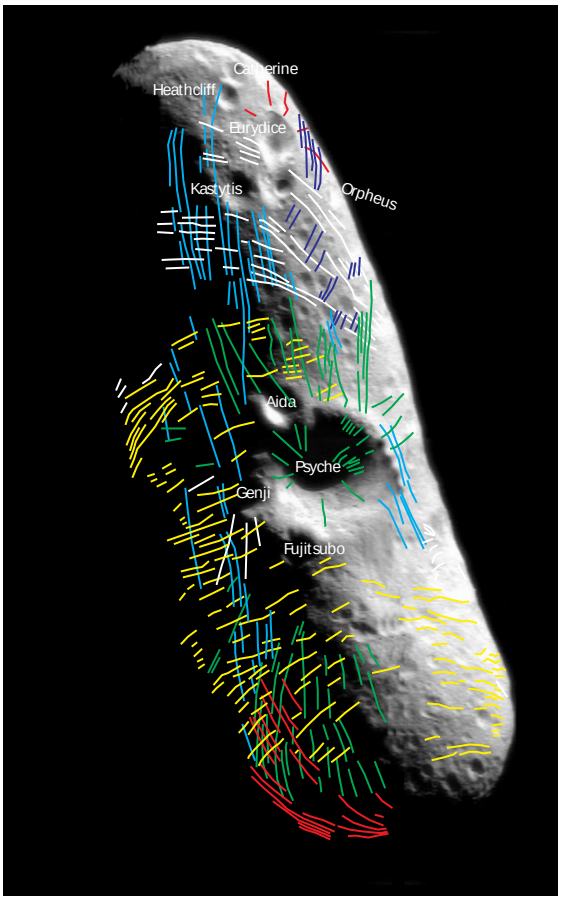

Figure 4. Mosaic of western hemisphere of Eros, showing mapped lineations and named craters. Different colored lines indicate different sets of lineations.