433EROS INTERIOR STRUCTURE AND FORMATION HISTORY: AN ANALYSIS OF GLOBAL LINEAMENT MAPPING. D.L. Buczkowski, O.S. Barnouin-Jha and L.M. Prockter, Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, Debra.Buczkowski@jhuapl.edu.

Introduction: Multiple lineament sets have been mapped on the surface of Eros. Several of these sets are clearly related to visible impact craters while others infer internal structure, at least on a local level. Some of the lineament sets suggest that different parts of the asteroid may have undergone different stress histories; these lineations may derive from Eros' parent body. We will present different evolutionary scenarios based on interpretations of surface lineament formation.

Background: As part of the Near-Earth Asteroid Rendezvous mission, the 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 imaged asteroid in the solar system.

Early mapping of lineaments on Eros has supported the suggestion of planes throughout the asteroid [1,2]. The observed presence of grooves on Eros can be interpreted as being due to faulting resulting from the transmission of impact shock waves [1]. However, two large-scale lineations on Eros - the Rahe Dorsum ridge and the shallow troughs of Calisto Fossae - were found by [2] to be coplanar with a large flat region (the southern "facet") on one end of the asteroid (Fig. 1). They interpreted these observations as indicative of a pre-existing structure throughout most of the asteroid, consistent with a fabric inherited from a parent body.

A global database of all Eros lineaments was recently constructed [3] to better understand the global distribution of these features and thus understand more about the interior structure of the asteroid. Lineaments were mapped on MSI images that were directly correlated to the Eros shape model using the program POINTS, developed by Jonathan Joseph at Cornell University. Image resolutions ranged from approximately 5 to 11 meters per pixel, allowing the best possible identification of linear features. Two thousand one hundred forty-one lineations, ranging up to tens of kilometers in length, were mapped on 180 high resolution images of Eros, creating a global lineation map of the asteroid [3].

Lineation Sets: The mapped lineations have been grouped into sets according to location and orientation and many different sets of lineaments were identified [3]. Some of the lineations are clearly related to specific impact craters; there are lineations radial to 13 of the craters on Eros [3]. Given their proximity and orientation relative to the craters it seems most likely that these lineaments were formed as a direct result of the impact event.

The most distinct set of lineations on Eros (set 1) is found aligned roughly with the prime meridian of the asteroid [3]. Several of these lineations are extremely long, up to 10's of kilometers. The orientation of these lineaments is consistent with the pattern expected from fragmentation due to impact on the long side of an ellipsoid target [4]. We infer that these lineations were formed as a result of the Pysche and/or Himeros impacts, with the Shoemaker impact possibly playing a role in their formation.

Another set of lineations (set 2) is found encircling the "tail" of Eros, from ~170° to 240° longitude [3]. The preferred orientation of these lineaments does not obviously follow any predictions of models of lineation formation by impact. We therefore suspect that these lineations represent a pre-existing internal structure.

Implications for Eros interior: The bulk density of Eros (~2.7 g/cm^3) is lower than the measured density of comparable ordinary chondrite meteorites (~3.3 g/cm^3), indicating that the asteroid has a high porosity [5]. This porosity is not consistent with a 'coherent but fractured' asteroid [6]. However, the presence of long structural features on the surface, including the thousands of lineations mapped by [3], are indicative of a significant internal strength, inconsistent with a 'rubble pile'. Thus Eros is generally placed in the intermediate classification, a 'heavily fractured' asteroid [6].

However, interpretation of the global lineation map introduces the possibility that Eros is a contact binary. The set 2 lineations, although present in both the northern and southern hemispheres, are only found in a restricted longitude range. This observation is particularly interesting in regard to the work of [2], which concluded that a planar structure extends at least 22 km along the length of Eros, from the middle of Rahe Dorsum to the western end of Calisto Fossae. The set 2 lineations of [3] are not in the same plane as the planar structure suggested by [2]. Perhaps more important, the set 2 lineation occur "tailward" of Calisto Fossae; they are not in the section of Eros where [2] observed planar structure. If the [2] planar fabric is indeed a remnant of structure within a parent body, then the presence of a completely different planar fabric in the Eros tail could imply that the tail has a different parent body from the rest of Eros, or that it is a

piece of a larger Eros that has been "relocated" to the end of the asteroid.

Implications for Eros formation history: The possibility raised in the last section yields two possible scenarios for the formation history of Eros. Unfortunately, neither scenario fully explains the observed lineations sets.

In the first scenario Eros is a single coherent shard, although heavily fractured. However, there would have to be some explanation of how the two planar fabrics could be so regionally localized. The Eros tail would have to have undergone a different stress history from the rest of the asteroid. Figure 2 shows one possible set of circumstances in which this scenario could work; Eros is in the core of a parent body (Fig. 2a). Impacts striking the surface of the parent body fracture different regions of the core Eros (Fig. 2b). With the destruction of the parent body, the Eros fragment retains the history of parent body fracturing in its structural fabric (Fig. 2c). A new set of fractures form due to the impact of Psyche or Himeros, creating the set 1 lineations (Fig. 2d).

In the second scenario Eros is a contact binary. The tail section of the asteroid is a different fragment of the parent body (Fig. 3a) that accreted on to the main body of Eros after the destruction of the parent body (Fig. 3b-d). However, the set 1 lineations cross both the main body of Eros and the tail. If Eros is a binary asteroid then the set 1 lineations would have had to have formed after the tail and the main body came into contact (Fig. 3e). As discussed, the set 1 lineations could have been formed by the impact of Psyche, Himeros or Shoemaker. However, Psyche, Himeros and Shoemaker are the largest craters on Eros; their impacts must have had significant energy. It seems likely that an impact large enough to create circumferential and radial fractures would have been large enough to push the tail apart from the rest of Eros if Eros were a binary as opposed to a coherent asteroid. Further impact modeling is needed to determine if any of these impacts could strike a contact binary asteroid with enough force to cause fracturing in both components without forcing them apart.

References: [1] Prockter L. et al. (2002) *Icarus, 155,* 75-93 [2] Thomas P.C. et al. (2002) *GRL,* 10.1029/2001GL014599 [3] Buczkowski et al. (in review) *Icarus* [4] Asphaug E. et al. (1996) *Icarus, 120,* 158-184 [5] Yeomans et al. (2000) *Science*, 289, 2085-88 [6] Wilkison et al. (2002) *Icarus, 155*, 94-103

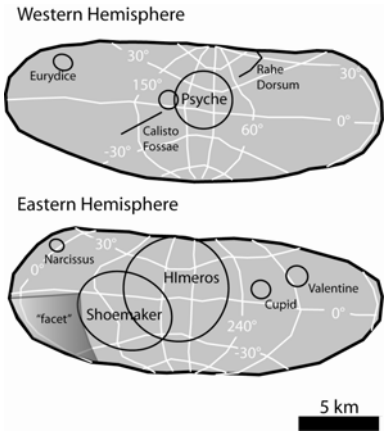

Figure 1. Location map of Eros, showing major features.

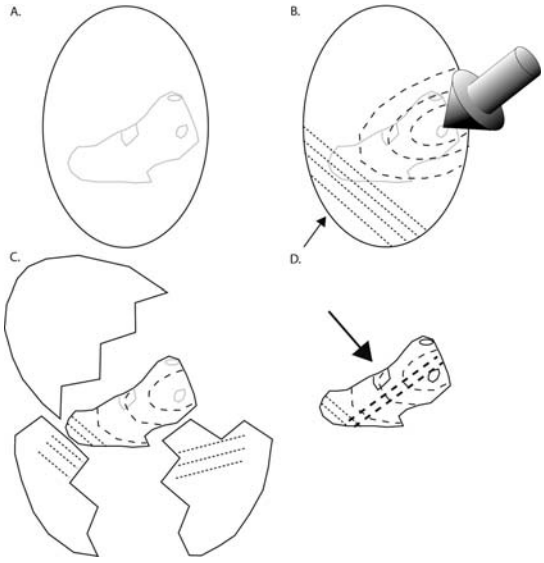

Figure 2. First formation scenario: Eros is heavily fractured, but coherent.

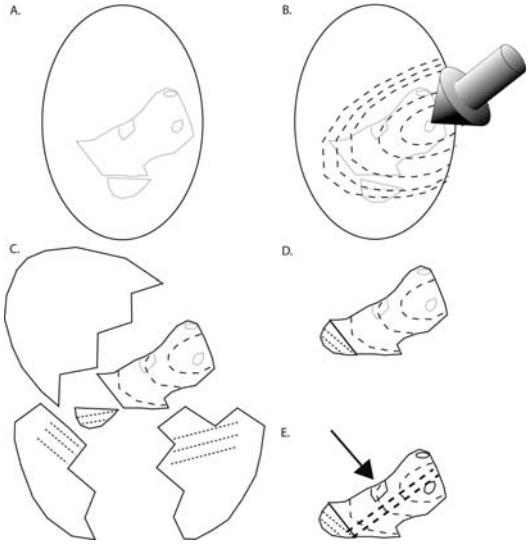

Figure 3. Second formation scenario: Eros is a contact binary.