Constant Scale Natural Boundary Mapping as Tool for Characterizing Asteroids. P.E. Clark[1] and C. Clark[2], [1]L3 Communications GSI, 3750 Centerview Drive, Chantilly, VA 20151 (pamela.clark@gsfc.nasa.gov), [2]1100 Alta Avenue, Atlanta, GA 30307 (rightbasicbuilding@yahoo.com).

Purpose: We are exploring the Constant Scale Natural Boundary (CSNB) approach to mapping and modeling asteroids in terms of morphological insight that can be gained in the context of traditional flat (2D) map projections and regular plate (3D) models [1,2].

Constant Scale Natural Boundary Mapping: The Constant Scale Natural Boundary (CSNB) mapping method produces maps that are markedly different from those produced by more traditional methods. Whereas traditional maps can be expressed as outward-expanding formulae [3] with well-defined central features and relatively poorly defined edges, CSNB maps begin with well-defined boundaries. A continuous surface on a three-dimensional body could be segmented, its distinctive terranes enclosed by using selected morphologically identifiable positive or negative relief features (e.g., continental divides, plate boundaries, major terrane interfaces). In this way, a surface that is relatively smooth on a global scale, could be portrayed as a single, two-dimensional 'facet' with its boundary a hemispheric-scale dichotomy. In an analogous manner, an irregular, faceted object, such as an asteroid, would be logically segmented along these facets. Such facets are imagined with hinges at occasional points along boundaries, resulting in a foldable 'shape model' in three dimensions. Thus, bounded facet(s) grow organically out of the most interesting features on a natural surface, so that obvious boundaries dominate, and are not dismembered as in conventional, flat map projections. 3D models could grow organically out of the most obvious facet 'edges' on an object, instead of being captive to a triangular 'plate' model imposing regularly shaped facets on an irregular surface [4].

CSNB Implications for Planetary Mapping: CSNB maps have some of the following distinctive features (See Figure 1).

a) The map's edge is a deformable 'wavefront,' with resolution dependent on boundary complexity.

b) Models, folded along edges, are condensations of the actual object, and, for irregular solids, such as asteroids, can be true representations of the object.

c) Resolution is highest at the most recognizable, pivotal, and defined feature, forming the boundary, where local proportions are preserved.

d) The CSNB approach, unlike traditional mapping approaches, preserves antipodal geometry (maps are conformal for antipodal areas).

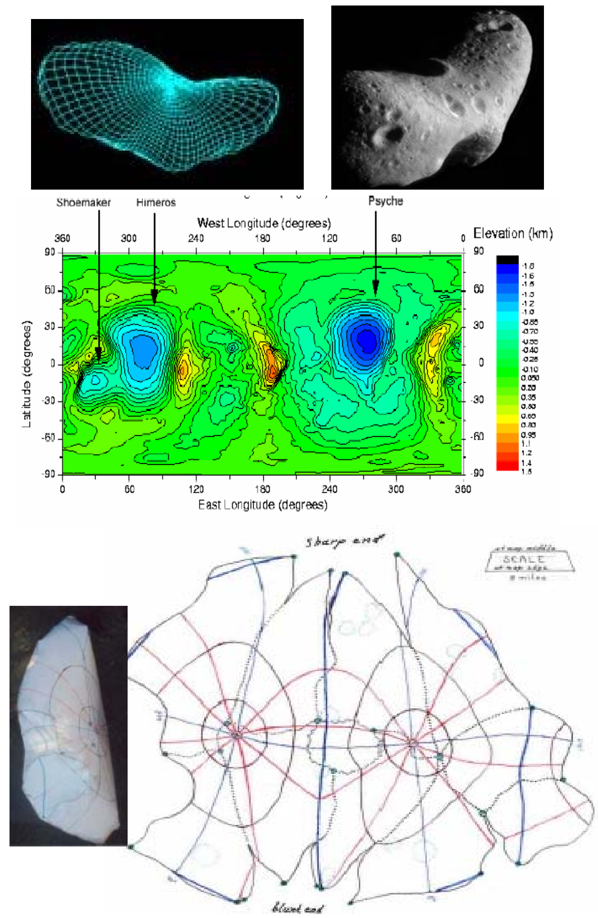

Figure 1: Eros image and plate model (top) [5], simple cylindrical topography map [6], and CSNB Map and 3D model without subsequent distortion minimization step (bottom) showing relationship of morphological features.

e) Local proportions in the interior are preserved on the maps. The amount of distortion can be minimized by equalizing ratios of hinge (boundary pivot) points connector lengths to true distances between hinge points.

f) As resolution increases and/or more natural boundaries are discovered, additional edges subdivide and refine the original shape model.

CSNB Asteroid Mapping: We have applied the CSNB approach to Eros to create antipodal equal azimuth maps with major ridges as boundaries (Figure 1). The CSNB map shown illustrates the ridge structure relative to Psyche, the largest crater. We are in the process of creating CSNB maps for a series of asteroids with shapes and topographic modalities ranging, respectively, from clearly bimodal to nearly spherical or uniform (Castalia, Ida, Phobos, Deimos as portrayed in Figure 2) to determine systematic relationships between boundary parameters and large and small scale morphological complexity.

CSNB Implications for Asteroid Modeling: Because CSNB projections are conformal for antipodal areas, unlike traditional projections, CSNB maps can be folded, along boundaries, into 3D models. This step is superfluous for bodies which approximate spheres and thus can be best represented by globes. For extremely irregular objects, like asteroids, CSNB maps can in principle be transformed to represent a highly faceted surface with minimum distortion. Flat sheets can be generated as ortho-normal photos, then folded into photoreal models (Figure 1).

Using analogous techniques in reverse, a 3D model could be generated directly from a series of images of a spinning object. Boundaries would be the readily identifiable (by albedo and linearity) ridges and troughs that edge apparent facets on a highly irregular surface. The relative orientation of facets could be determined by observing trends in changes in their appearances (size, shape) during the course of each spin [1,2]. The model complexity would grow, and the number of interconnected boundaries increase, naturally, as the object was approached and the resolution of observations increased. In principle, the CSNB mapping technique would be well-suited to autonomous operation.

References: [1] Clark C. (2002), LPS XXXIII, #1794; [2] Clark C. (2003) ISPRS, 34, XXX; [3] Krantz S. (1999), American Scientist, 84, 436; [4] Thomas P. et al (2002) Icarus, 155, 1, 18-37; [5] http://near.jhuapl.edu; [6] Cheng A. and Barnouin-Jha O. (2002), LPS XXXIIII, #1522; [7] Oner A.T., http://www.solarviews.com/eng/asteroid.htm; [8] Stooke P., http://www.ssc.uwo.ca/geography/ spacemap/contents.htm

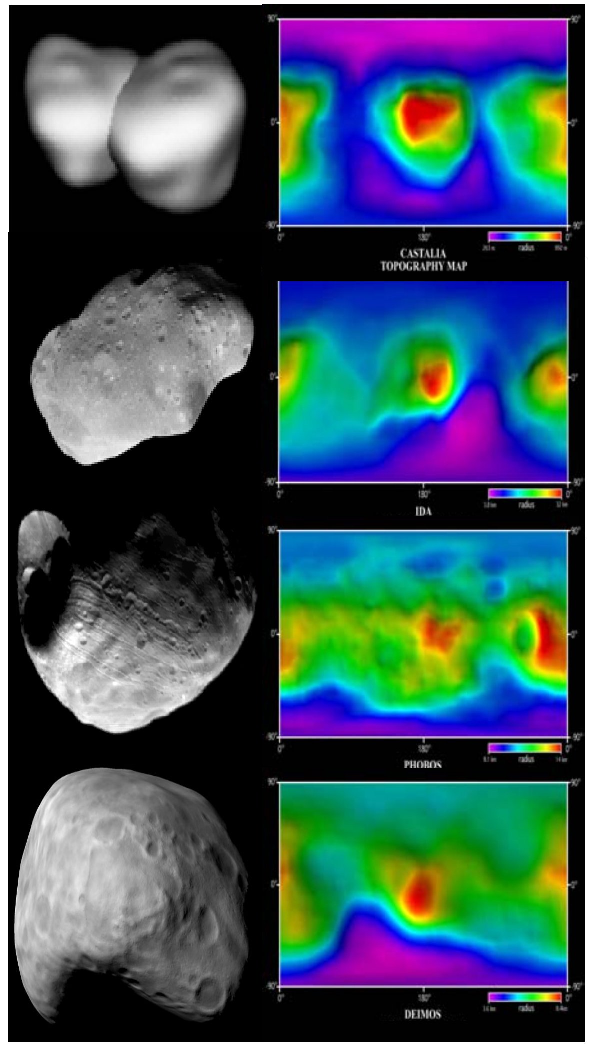

Figure 2: Images [5] and simple cylindrical Topography maps (courtesy of A. Tayfun Oner based on work by P. Stooke) [7,8] of asteroids ranging from clearly bimodal to nearly spherical in shape (from top to bottom, Castalia, ida, phobos, deimos).