

## APPLYING THE CONSTANT-SCALE NATURAL BOUNDARY MAPPING TECHNIQUE

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**Constant Scale Natural Boundary Mapping:** The Constant Scale Natural Boundary (CSNB) mapping method produces maps of 3D objects [e.g., 1,2] that are markedly different from those produced by more traditional practices. Whereas conventional maps can be expressed as outward-expanding formulae with well-defined central features and relatively poorly defined edges [3], CSNB maps begin with well-defined boundaries [4,5,6,7]. A continuous surface on a three-dimensional body can 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 CSNB mapping, researchers choose map edges—natural boundaries—that define or constrain regions of interest and also depend on the nature of the body. For example, is it relatively smooth (planet) or faceted (asteroid) on a global scale? Are the formative processes primarily internally (volcanotectonic) or externally (impact) controlled? Maps resulting from a selected set of natural boundaries represent their subject comprehensively, quasi-conformally (even in highly non-spherical worlds as asteroids), and, notably, without meaningless edge interruptions.

**Application to Global Mapping of Regular Bodies:** A regular planetary body can be portrayed as a single, two-dimensional surface of segment or ‘facet’ with its boundary a selected hemispheric-scale dichotomy, such as a dendritic chain of topographic lows (watersheds or trough(a) or highs (divides or plateaus(b)) on Mars (Figure 1a,b) or Venus (Figure 2a,b) [2,5] or radial/concentric structures related to impact on the Moon [7]. When this technique is applied to Venus (Figure 2) [2], the oldest volcanic highlands form an equatorial band of archipelago-like zones interconnected by younger volcanic highlands on the valley bounded map [8], and a distinct north/south hemispheric dichotomy appear on the ridge-bounded map. When the CSNB techniques was applied to Mars [5], where ridge and trough boundaries are apparently associated with internal activity cells, a clear association between magnetic susceptibility [9] and quasi circular basins [10], associated with troughs, can be seen. We applied the CSNB approach to the Moon (Figure 3) using the putative Gargantuan basin [7] at the center of the map. The antipodal South Pole Aitken Basin appears as arc segments at the edge of the map. Boundaries are defined as ridges and troughs apparently radial and concentric to Gargantuan. The thinner-crust nearside is dominated by more recent flood basalt flows. This projection allows the pattern in the global distribution of Nectarian and Imbrian deposits to be seen more clearly.

**Application to Asteroid Mapping:** An irregular, multifaceted object, such as an asteroid, is logically segmented along facet boundaries (Figure 4). When fully segmented, or ‘unzipped’ in 2-dimensions, scale is constant not only along

boundaries but within facets as well. CSNB maps allow relationships between noses, saddles, and poles, and the origin of features found on them, to be observed without areal distortion. Local maxima and minima in topography, representing bombardment history, are clearly aligned with map boundaries and thus emphasized on the CSNB ‘splat’ maps. Plotted on the CSNB maps of Eros (Figure 4) are depositional ponds and eroded bright patches. What is the relationship between these two sets of features? The mercator projection map with these features [11] gives the impression that most of the significant regolith depositional and erosional features are found in the equatorial region, where area/map element is greatest. The CSNB ‘splat’ map indicates that both features are found at considerable distances from the equator, even approaching the poles. Ponds are found near or on boundaries, particularly fanned out on the ‘lee’ side of ‘noses’ or ends, all near local topographic maxima which apparently act as ‘dust collectors’. Bright patch craters are found at all elevations surrounding the ponds, perhaps providing a source of the dust.

**CSNB Implications for Planetary Modeling:** The CSNB projection has now been used to produce global maps of bodies lying on a continuum between externally and internally driven control of surface morphology. For the Earth and Mars, representing the internally-driven end-member, ridge and trough boundaries are apparently associated with internal activity cells, thus CSNB maps allow greater understanding of, for example, the pattern of gravity and magnetic anomalies [12]. For asteroids, representing the externally-driven end-member, irregular facet edges become boundaries of a ‘splat’ map and allow insight into the bombardment history. The Moon, typically mapped in an Earth-like projection, but more asteroid-like in terms of surface modification, is now ‘splat’ mapped to reveal the continuing influence of old, large impacts. Mapping Mars in the ‘splat’ fashion might also reveal the palimpsest-like influence of its proposed equivalent gargantuan basin [13].

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