Mapping and Graphic Stress Analysis for Icy Satellites Using Constant-Scale Natural Boundary Methods. C. S. Clark², P. E. Clark³, Chuck Clark architect, 1100 Alta Avenue, Atlanta, GA 30307, rightbasiebuilding@gmail.com, Catholic University of America/StNASA/GSFC, Greenbelt, MD 20771, clarkp@cua.edu

Introduction: Constant-scale natural boundary mapping [CSNB] transforms the surface of any essentially globular object—spherical, triaxial, irregular—to the 2-dimensional plane in a manner which, unlike conventional projections, preserves proportion and adjacency of natural districts composing the object’s surface [1]. This prototopological, i.e., foldable, shape may be usable as an engineering tool to determine stress, after the manner demonstrated by Maxwell [2], using either Eisenlohr projections [3] or CSNB as so-called Maxwell surfaces. Here we apply both methods to icy bodies (See Figure), to test whether CSNB can provide insights into surface morphology and geological activity, such as venting at tiger stripes on Enceladus, distribution of old and young terrain on Ganymede.

Background: Isolines (waterlines) have been used since Victorian times as both cartographic presentation technique [4] and as a geometric method for determining points of inaccessibility (oceanic points most distant from land). Here we use them as surface projections of boundary shape and force.

Geological Context & Boundary Selection for Icy Satellites Ganymede & Enceladus: The surfaces of these two satellites [5] are shaped by a combination of external and internal forces, including impact cratering resulting in mixing of non-icy and icy crust materials, tectonic episodes, and ongoing cryovolcanic processes stimulated to different degrees by tidal forces. See preliminary CSNB maps, with conventional maps for comparison, below.

Jovian satellite Ganymede’s surface [6,7] exhibits two major terrains, ‘light’ and ‘dark,’ their boundaries clearly indicated by distinct albedo boundaries. The darker terrain (brown tones) is more heavily cratered and older. Its dark regolith deposits, postulated to be derived from sublimation of underlying ice-rich crust, are found within craters and on slopes of surrounding radial ridges and concentric arcuate structures or furrows (possibly multi-ring basin remnants). The more abundant light terrain (blue/green tones with tan indicating craters) is less heavily cratered and younger, typically consisting of intricate networks of crosscutting lineaments and smooth patches. It is dominated by extensional faulting, formed by cryovolcanic flooding of dark material with ice, and/or tectonic disruption and exposure of underlying ice at fault scarps. Also identified are ‘relaxed,’ older impact features called palimpsests (greens), and the largest impact basinGilgamesh (orange). CSNB maps include dark-terrain-boundary and light-terrain-boundary maps, based on ‘center lines’ through each. Branches are formed from indications of inflections on the isoline map. Note the increased complexity, in terms of the number of branches and shape of dark-terrain-bounded light terrain CSNB map, from left to right. A rare four-branch intersection occurs in the complex Babylon region, an extensive palimpsest surrounded by distinct craters [8], as well as the occurrence nearby of the largest crater along the light terrain centerline.

Saturnian satellite Enceladus [9] exhibits both east-west and north-south asymmetries in terrain distribution, due at least in part to its tidally locked relationship to Saturn. North and south poles are clearly different: the south is actively erupting and resurfacing, whereas the north is an extension of the oldest, most heavily cratered terrain. At mid to low latitudes, heavily and moderately cratered terrain, facing permanently toward and away from Saturn along an oblate axis, alternates (every 90°) with younger, more deformed terrains including striated, ridged, and curvilinear terrains (see color key) indicating far more complexity, resurfacing, and tensional stresses. We are in the process of creating CSNB maps with southern and northern poles at the center with boundaries representing centerlines of major terrains, as well as using the Eisenlohr projections to predict stresses.

Ganymede
Isolines Compute Complementary Inertial and Disruptive Networks

(1) White tree connects old-terrain centroids
(2) White tree makes CSNB map (above)
(3) Isolines derive complementary tree
(green left, yellow above)
Nodes on complementary tree identify singularities & habitually disruptive locales responsible for old-terrain inertial distribution

Enceladus
Using Geological Boundary Maps as Maxwell Surfaces

CSNB sketch-map edged by cratered terrain, with tiger stripes at map middle (see Poster for finished map)

Legend (from [9])
- wide shallow trough
- wide fracture
- fine fracture
- crater
- central leading hemisphere terrain
- wide shallow trough terrain
- leading-edge curvilinear terrain
- moderately cratered terrain
- heavily cratered terrain
- smooth terrain
- striated plains
- ridged terrain
- southern curvilinear terrain
- curvilinear terrain
- south polar terrain