Unravelling the Kinematics of Marius Regio, Ganymede.

Richard Ghail[1] and Constantine Thomas[2]
[1]T.H. Huxley School, Imperial College, London, SW7 2BP, UK. *R.Ghail@ic.ac.uk*
[2]Environmental Science Department, Lancaster University, Lancaster, LA1 4YQ, UK. *Constantine.Thomas@lancaster.ac.uk*

Context: Marius Regio is located at 40°N, 200°W, in the mid-latitudes near the antijovian point. It was imaged at 940 m pixel^{-1} during orbit G8 of the Galileo mission (Fig. 1). The dark region in the south-west of the image is northern Marius Regio; the complex region of bright terrain in the north-east is Ur Sulcus. Dividing the two terrains is Nippur Sulcus. The region of ridged bright terrain in the NW corner of the imaged part of Marius Regio is the easternmost extent of Philus Sulcus, and to the east is the southernmost extent of Elam Sulci. Akitu Sulcus is the east-west feature crossing the centre of Marius Regio, and orthogonal of it to the west is Byblus Sulcus.

Mapping Method: Galileo image c0394517800 was rectified to a Ganymede spheroid and Mercator projection (preserving angular relationships), photometrically corrected and interpolated to 500 m pixel-1 (from 940 m pixel^{-1}). Three low-phase, high-resolution (86 m pixel^{-1}) Galileo G2 images were similarly projected and merged in a 3:1 ratio with the G8 scene, effecting topographic shading on the G2 images. These three images were also processed at 100 m pixel^{-1} resolution for detailed mapping. Global context for the G8 scene was provided by the Galileo/Voyager global 2 km pixel^{-1} global mosaics.

Mapping proceeded by dividing the scene into several morphological units (*e.g.*, dark cratered terrain) that provide a context for the structural geology. In structurally simple areas, the youngest features were mapped first, followed by progressively older structures until the stratigraphic sequence was complete. More complex areas were first broken down into smaller regions in which the stratigraphic sequence is preserved before that process was applied.

Interpretation: Though apparently complex, the structural history of Marius Regio and adjacent sulci consists of a sequence of block rotations of semi-rigid plates 100 to 500 km across, resulting in shear and accomodation structures. Planks and smooth bright terrain are inferred to result from transtensional extension, while ridged bright terrain correspond to transpressional shortening. The superposition of multiple scales and phases of deformation results in the observed complexity. Though deformation is concentrated at plate margins, considerable internal deformation is apparent within plates. In-plate shortening is accomodated by widely spaced parallel ridges; sub-parallel fracturing results from stretching within the plate; and *en-echelon* fractures indicate internal shearing. Elliptical craters provide useful in-plate strain markers [1] within blocks of dark terrain.

Various forms of plate tectonics have been proposed [2, 3] to explain the distribution of light and dark terrain on Ganymede. We find no evidence of the large rigid plates bounded by spreading ridges, subduction zones and transform faults that characterise terrestrial plate tectonics. Zones of extension and compression on the surface are a passive response to the openings and closures generated by block rotations, rather than an active process driving the tectonic movements. Plate tectonics on Ganymede is characterised by a number of usually small semi-rigid plates suffering both internal and plate-margin deformation. This is perhaps not surprising, given the positive bouyancy and low yield strength of ice. The small plate size indicates a thin convecting layer (~500 km thick), perhaps a convecting mantle of ice or water above a rocky interior, and a thin lithosphere (~50 km). This probably vary considerably across Ganymede, since large regions of dark terrain (e.g., Galileo Regio) are evidently stable. Variable plate size is consistent with the observed multiple scales of deformation; larger plates generate larger openings or closures at their margins as they rotate.

Speculation: Marius Regio has a long tectonic history of relatively simple block rotations with transtensional and transpressional adjustments.

One possibility is that prior to entry into its current orbital resonance, Ganymede closely resembled Callisto. During an extended laplacian resonance entry period [4, 5], tidal stirring and heating caused Ganymede's convecting ice mantle or water ocean to drive the breakup of its lithosphere, perhaps by eddy currents on sublithospheric topography. This activity probably ceased in the recent past (<1 Ga, [6]) when the resonance established itself and the forced orbital eccentricity decayed.

Nonetheless, it is not possible to rule out that several structures within the interior of Marius Regio are relics of earlier sulci and ridges, rather than manifestations of more recent internal deformation. In that case, Ganymede's tectonic history is not monotonic but more complex, with several phases of deformation, or indeed a long period of quasi-uniformitarian tectonic activity.

References: [1] Thomas, C. & Ghail, R.C., 2001 *LPSC XXXII*, this issue. [2] Murchie, S.L., & Head, J.W., 1988, *JGR 93*, 8795-8824. [3] Prockter, L.M., *et* *al.*, 2000, *JGR 105*, 22519-22540. [4] Showman, A., & Malhotra, R., 1997, *Icarus 127*, 93-111. [5] Showman, A. *et al.*, 1997, *Icarus 129*, 367-383. [6] Zahnle, K., & Dones, L., 1998, *Icarus 136*, 202–222.

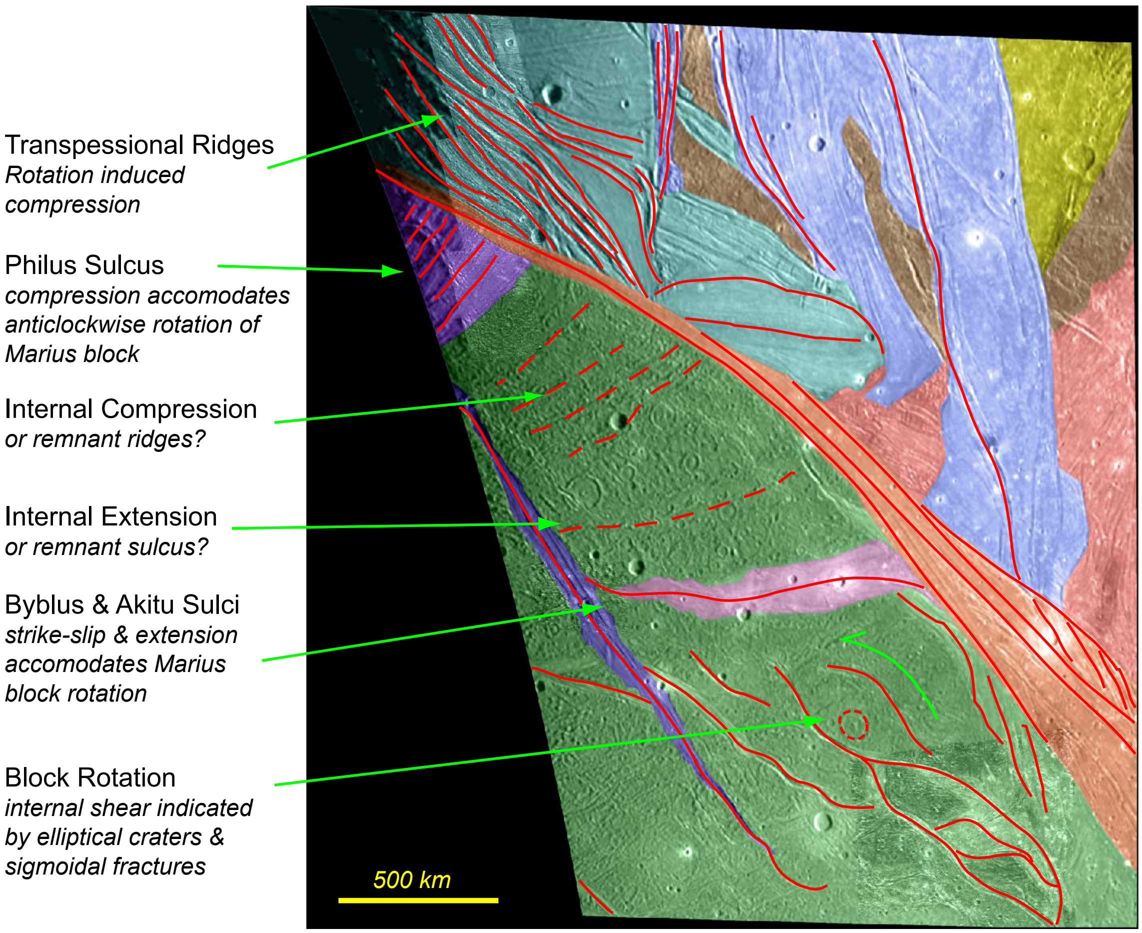

Figure 1. Major Tectonic Features of northern Marius Regio.