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# Geophysics of Ganymede as revealed by orbiter missions: application to the JUICE mission

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As indicated by the Voyager and Galileo missions, Ganymede is a very complex world:

(a) Ganymede is highly differentiated. With a dimensionless moment of inertia of 0.3115 [1] it is the most condensed solid-state body of the solar system. The moment-of-inertia value is consistent with interior structure models including an iron-rich core, a silicate layer, high-pressure ice layers, a liquid water layer, and an ice-I layer at the surface. Based on the Galileo gravity field measurements a set of models with different thicknesses of the layers can be constructed (e.g., [2]). The process of differentiation would be accompanied by global extension of the satellite because ice is more compressible than rock.

(b) Ganymede has a magnetic dipole field. Together with the Earth and Mercury, Ganymede is one of only three solid bodies in the solar system that generate a magnetic field in a liquid (outer) iron core [3]. Therefore present temperatures and heat flows of the core and/or compositional gradients must be sufficient to sustain a dynamo.

(c) The magnetic field data is consistent with induced fields generated in an electrically conducting salty global ocean beneath the ice-I layer [4]. This provides strong evidence for a present subsurface ocean on Ganymede. The latter would have strong implications on the tidal response of the satellite.

(d) Ganymede is locked in the three-body Laplace resonance with Io and Europa. Although the forcing of Ganymedes orbital eccentricity of ef = 0.0006 is weaker as compared to Io and Europa, scenarios of formation of the resonance and its implications for tidal heating must be consistent with the satellites orbital evolution (e.g. [5]) and present state.

(e) Ganymedes icy surface consists of two types of terrain exhibiting differences in albedo, surface age (through crater density), and surface morphology (e.g., [6]). Whereas the dark terrain is several Gyrs old the light terrain can be as young as about ˜400 Myrs. The different types of geologic activity may be a consequence of different energy budgets available from the interior during different regimes of thermal evolution.

(f) Ganymedes bright terrain globally shows intense fracturing and tectonic resurfacing. In addition there is local evidence for cryovolcanic activity.

(g) Ganymede displays a great diversity of impact morphologies. Those are related to the thermal state of the icy crust at time of the impact and temperature dependent relaxation processes.

Starting from various scenarios of Ganymedes evolution that have been discussed in the literature to explain the unique features of the satellite we describe measurements by orbiting spacecraft that could constrain these theories. Application to ESAs JUICE mission will be shown. Emphasis is given on the geophysical aspects, i.e. interior structure and tidal deformation. The models are set into perspective by comparison with the neighboring satellites Europa and Callisto. Prospects to investigate the geophysics of Europa and Callisto with flybys are briefly discussed.

References:

[1] Schubert et al. (2004). In Jupiter: the planet, satellites and magnetosphere (Eds. Bagenal F., Dowling T.E., McKinnon W.B.), Cambridge Univ. Press; [2] Sohl et al. (2002), Icarus 157; [3] Kivelson et al. (1996), Nature 384; [4] Kivelson et al. (2003), Icarus 157; [5] Greenberg R. (1982). In Satellites of Jupiter (D. Morrison Ed.), Univ. Arizona Press; [6] Pappalardo et al. (2004) In Jupiter: the planet, satellites and magnetosphere (Eds. Bagenal F., Dowling T.E., McKinnon W.B., Cambridge Univ. Press.