EGU26-6551, updated on 23 Oct 2026
https://doi.org/10.5194/egusphere-egu26-6551
EGU General Assembly 2026
© Author(s) 2026. This work is distributed under
the Creative Commons Attribution 4.0 License.

Elastic Plastic Flexure on Icy Moons: Implications for heat flux

Adrien Broquet
German Aerospace Center (DLR), Department of Planetary Physics, Berlin, Germany (adrien.broquet@dlr.de)

Investigations of ice-shell flexure, as observed from stereo-derived topographic profiles, have been commonly used to provide information on the interior structure and evolution of icy moons (e.g., Nimmo et al., 2002, Peterson et al., 2015). The most commonly used approach is to fit the observed flexure to an elastic plate model to infer the local elastic thickness of the body's ice shell at the time of deformation. The widespread use of this approach lies in its quick analytical expression, allowing to test various parameters at multiple locations (e.g., Turcotte & Schubert, 2002). However, it remains unclear whether elastic plate models can be used to reliably predict the flexure of an elastic-plastic ice shell.

For geologic interpretations, the elastic thickness parameter can be converted to a heat flux using several approaches. First, by setting the bending moment of the elastic plate equal to the bending moment of a more realistic plate with a rheology that considers fracturing and viscous flow (e.g., McNutt, 1984). One critical issue during this approach is related to the selection of the input curvature of the plate, which affects the calculation of the bending moment. Alternative approaches have assumed the base of the elastic lithosphere to be defined by a rheology-dependent isotherm in combination with a specific Deborah number (e.g., Nimmo et al., 2002). However, it remains unclear what Deborah number should be assumed when the plate is elasto-plastic and whether both the equal-bending moment and the Deborah number approaches lead to similar results.

In this work, we follow the framework developed in Mueller & Phillips (1995), to test the applicability of elastic plate models to icy satellites. We show that the maximum curvature of the synthetic elastic flexural profile should be used when relating elastic thickness to heat flux and discuss that purely elastic models predict unrealistic oscillations near and in the flexural bulge region. Finally, we reveal that previous work that used the Deborah number approach substantially overestimated the heat flux of Ganymede (Nimmo et al., 2002) and Ariel (Peterson et al., 2015), with implications for the geologic history of these icy worlds.

McNutt, M. K. (1984). Lithospheric flexure and thermal anomalies. *J. Geophys. Res.: Solid Earth*, 89. doi: 10.1029/jb089ib13p11180.

Mueller, S. and R. J. Phillips (1995). On the reliability of lithospheric constraints derived from models of outer-rise flexure. *Geophys. J. Int.*, 123. doi:10.1111/j.1365- 246x.1995.tb06896.x

Nimmo, F., Pappalardo, R.T., & Giese, B. (2002). Effective elastic thickness and heat flux estimates on Ganymede, *Geophys. Res. Lett.*, 29(7), doi:10.1029/2001GL013976.

Peterson, G., F. Nimmo, and P. M. Schenk (2015). Elastic thickness and heat flux estimates for the Uranian satellite Ariel, *Icarus* 250, doi: 10.1016/j.icarus.2014.11.007.

Turcotte, D. L. and G. Schubert (2002). Geodynamics. *Cambridge University Press*. doi: 10.1017/cbo9780511807442.