Title: Understanding Tethys' Interior from its Long-Wavelength Topography

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Text:
An increasing number of icy worlds have been determined to have subsurface global oceans. The presence or lack of such an ocean has implications in our understanding of the formation and evolution of a world. We sought to peer into the interior of Tethys in order to ascertain whether or not it too had a subsurface ocean. The interior structure of a planetary body can be inferred from its long-wavelength topography, namely of spherical harmonic degrees 2 and 4. A major component of degree 2 topography of a spinning body is ts rotational bulge. After accounting for this tidal and rotational contribution, the residual topography is determined largely by isostastic effects upon the body's crust, which maintains equal pressure at a constant depth in the body. There are two types of isostasy: Pratt isostasy wherein topographic variations are the result of thermal expansion of a crust with constant column mass, and Airy isostasy wherein the crust has a constant density but thinner crust is compensated for by the underlying material (be it an ocean or mantle). Using Pratt isostasy, basal heat flux highs under Tethy's ice shell (its crust) create topographic highs, but using Airy creates topographic lows. Beuthe (2013) demonstrated that the heat flux distribution at depth in a planetary body can be described as a linear combination of 3 basis functions, themselves composed of spherical harmonic functions. The combined basis function weights is equal to 1. The spherical harmonic coefficients of basal heat flux distribution reduce to a set of multilinear functions of Beuthe's basis function weights. Thus, for an assumed isostasy type, moment of inertia, and other properties, we performed multilinear regressions for the basis function weights. These weights then describe whether heat is flowing from a solid or liquid interior, as well as the depth of this transition. We found the regression fits best for a Tethys that is undergoing Pratt isostasy and obliquity tides, and indicate a solid interior. We also found an ice shell thickness using Fourier's law. Using the moment of inertia and shell thickness, we solved for the average densities of the shell and interior of Tethys. For all methods to agree on shell thickness, we invoked a Tethys with a porous ice outer shell, a solid ice inner shell, and an ice and rock interior.