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Lithospheric Flexural Modeling of Iapetus' Equatorial Ridge

W. Zheng (1), W.-H. Ip (2,3), and L.S. Teng (1)

(1) Department of Geosciences, National Taiwan University, Taipei, Taiwan (r99224106@ntu.edu.tw), (2) Institute of Astronomy, National Central University, Taoyuan, Taiwan, (3) Institute of Space Science, Macau University of Science and Technology, Macau

Iapetus, which is one of Saturn's ball-shaped satellites, has some unique features in the Solar System. This satellite has a mean radius of 735 km, and there is an approximately 20-kilometer-high mountain lying precisely on its equator. The mountain is known as an "equatorial ridge" since it makes Iapetus appear walnut shaped. The origin of the equatorial ridge is attributed to several hypotheses, including different endogenesis and exogenesis processes.

In this work, we attempted to construct a flexural model of the equatorial ridge using elastic lithosphere theory. The equatorial ridge is treated as a linear load which exerts uniform force on Iapetus' hard shell (i.e. elastic lithosphere of Iapetus). To calculate the deflection of surface, we use the Digital Terrain Model (DTM) data of Iapetus' leading side published by Giese et al. (2008). Giese et al. also pointed out that the elastic lithospheric thickness of Iapetus must exceed 100 km to support the ridge without deflecting. However, we found possible evidence in the DTM data that implied deflection. There are two sites of surface depression on the northern side of the equatorial ridge. The few-kilometer deflection implies a thinner lithosphere than previous suggested. Assume that the thickness of elastic lithosphere is only 5% below of the radius of Iapetus, so the flat-Earth and one-plate condition could adapt to the flexure model of Iapetus. Based on analysis of the distance between a bulge and the ridge, the calculated lithospheric thickness is 6-10 km.

The new result seems controversial, but the modeled surface profile is highly consistent with numerical ridge DTM profile extracted from Giese et al. (2008). Thinner lithosphere also supports the contraction model proposed by Sandwell and Schubert (2010) since the bucking harmonic degree increases. In the other hand, the transformation layer between hard shell and plastic inner core may need constraint on thermal history or crystal form of ice. In conclusion, The flexural model of Iapetus' equatorial ridge reveals the possibility of thinner hard shell, fits the surface profile, and supplies more clues to the origin of Iapetus, the interesting satellite in the Solar System.