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Reexamination of Mars' Internal Structure

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Zuber et al. (2000) proposed a crustal model of Mars with gravitational and topographic data obtained by the Mars Global Surveyor mission. In their analysis they assume a crustal density of 2.9 g/cm^3, an upper mantle density of 3.5 g/cm^3, and an average crustal thickness of 50 km. But their scientific grounds for those assumptions are not very clear and the effect of the assumption on the final model should be carefully examined.

In this study we examine their assumptions of density values of crust and upper mantle and average crustal thickness. We also study crustal structures for various density values of crust and upper mantle.

It is the mean density and moment of inertia that we can use as geophysical constraints when modeling the internal structure of a planet. Since the crustal structure of a planet occupies a significant fraction of the total moment of inertia, an accurate estimate of the crustal structure is important to infer the internal structure of a planet.

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We estimate density values of the crust from Mars surface chemical compositions measured by APXS onboard the rover of the Mars Pathfinder mission (Rieder et al., 1997) and those of the upper mantle from chemical compositions of both Lherzolitic Shergottites ALHA 77005 (McSween, 1985) and LEW 88516 (Dreibus et al., 1992). To estimate the latter, we also use the information of a Mars mantle model acquired from high pressure and high temperature experiments (Bertka and Fei, 1996). We estimate the crustal thickness model assuming that the thinnest crustal thickness is taken to be 0 km. Results of our analysis show that the crustal density is 2.7 to 3.5 g/cm^3 and the upper mantle density is 3.45 to 3.55 g/cm^3. With these density ranges, we have various crustal thickness models whose maximum crustal thickness extends between 60 and 240 km, whose average crustal thickness extend between 30 and 125 km, and in which the total mass of the crust extends from 2 to 9 wt%. Results also show that we cannot construct the model with an average crustal thickness of 50 km with a crustal density higher than 3.0 g/cm^3 . The range of the crustal thickness of the Mars is compatible with geochemical constraint (Schubert et al., 1992; Spohn, 1991). Thus all our models should be accepted and the Mars crustal model of Zuber et al. (2000) should be accepted as one of numerous models. Further studies need another geophysical investigation such as seismologic measurement.