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Geodetic studies of Mars in Hokkaido University

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Abstract

During the last decade, several explorers visited Mars, and produced enormous amount of geodetic data, such as gravity field or topography. They have largely become open to public on line by now (visit, e.g. the Planetary Data System Geosciences Node, http://pds-geosciences.wustl.edu/). Here we introduce several geodetic studies of Mars performed in Hokkaido University using such data. First we will compare static part of gravity and topography, and discuss isostatic compensation and thermal history of Mars. We then study true polar wander episodes that may have occurred several times and look for records of crustal deformation possibly caused by them. We finally present a recent topic on the time-variable part of the Martian gravity and topography caused by seasonal growth and decay of polar CO_2 snow caps. We infer seasonal and inter-annual changes of the density of snow, and discuss the seasonal compaction by sintering of CO_2 snow particles and influence of dust storms on the snow density.

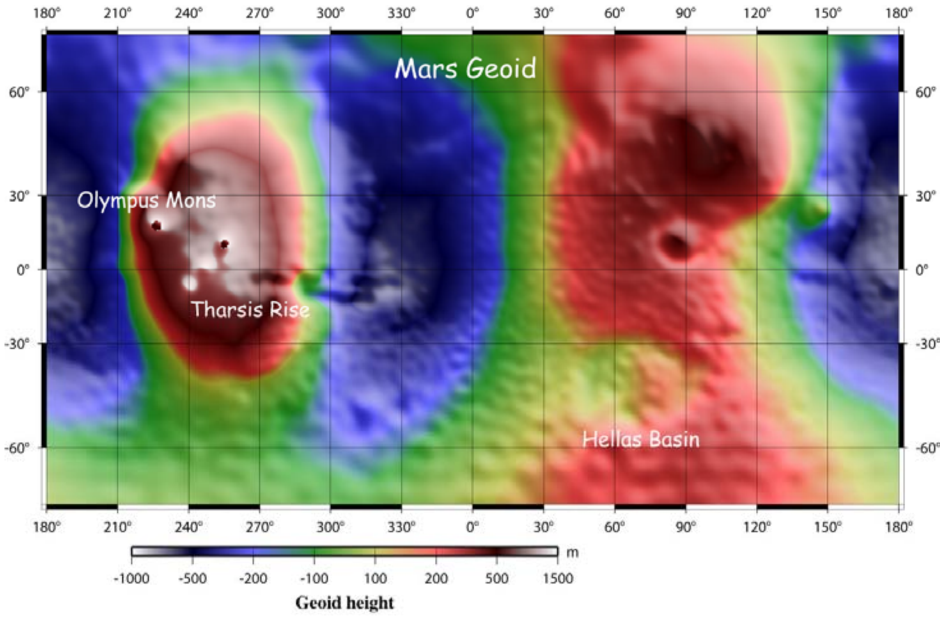

Fig.1 Mars geoid (Areoid) drawn using the ggm1041 gravity model with degree/order complete to 80. Tharsis Rise (large bump in geoid in the equatorial area of the western hemisphere) and the Olympos Mons (a huge volcano NW of the Tharsis Rise) are largely uncompensated. A large impact basin called Hellas (center at ~60E ~45S), however, are almost completely compensated.

Isostasy

Topographic features on Mars show variety of degree of isostatic compensation. For example, the Olympos Mons, one of the largest volcano of the solar system, is 100% uncompensated suggesting that lithosphere was thick enough to mechanically support them when these topography grew. On the other hand, the Hellas Basin, a large impact basin in the southern hemisphere, is almost completely compensated showing that the lithosphere was thin there when the basin was formed. Such diversity is thought to reflect the formation age, i.e. lithospheric thickness monotonously increases with age [1]. It is, however, an open issue whether the lithospheric thickness had significant lateral variation.

True polar wander

Formation of large uncompensated topography gives rise to the true polar wander (TPW). Recently, Taylor-Perron et al. [2] suggested that two large-scale TPW occurred after the formation of Tharsis, and vertical crustal movement associated with TPW (i.e. relocation of the Martian equatorial bulge) accounts for the non-flat coast line found between the northern plain and the southern highland. By using Melosh's [3] model, we calculated crustal stress and strain induced by these TPW, and found that the distribution of wrinkle ridge strikes [4,5] resembles the predicted pattern of fault by the TPW.

Time-variable gravity

The Martian atmosphere seasonally exchanges CO_2 with the surface by repeating condensation and sublimation, causing seasonal growth and decay of the polar CO_2 snow caps. These processes leave two kinds of geodetic signatures, i.e. seasonal changes of the Martian gravity field [6,7] and of surface elevation of the snow-covered regions [8]. Here we study gradual increase of the density of the Martian snow due to compaction, by combining these two data sets during 1999-2001 covering three Martian winters. We found that light fresh snow of $\sim 0.1 \times 10^3$ kg/m^3 slowly becomes denser reaching $\sim 1.0 \times 10^3$ kg/m^3 or more immediately before it thaw. The maximum snow density varies slightly from year to year, and between hemispheres. In the second southern winter, the density became as high as $\sim 1.6 \times 10^3$ kg/m^3 possibly reflecting, e.g. enhanced mixing ratio of silicate particles by a dust storm.

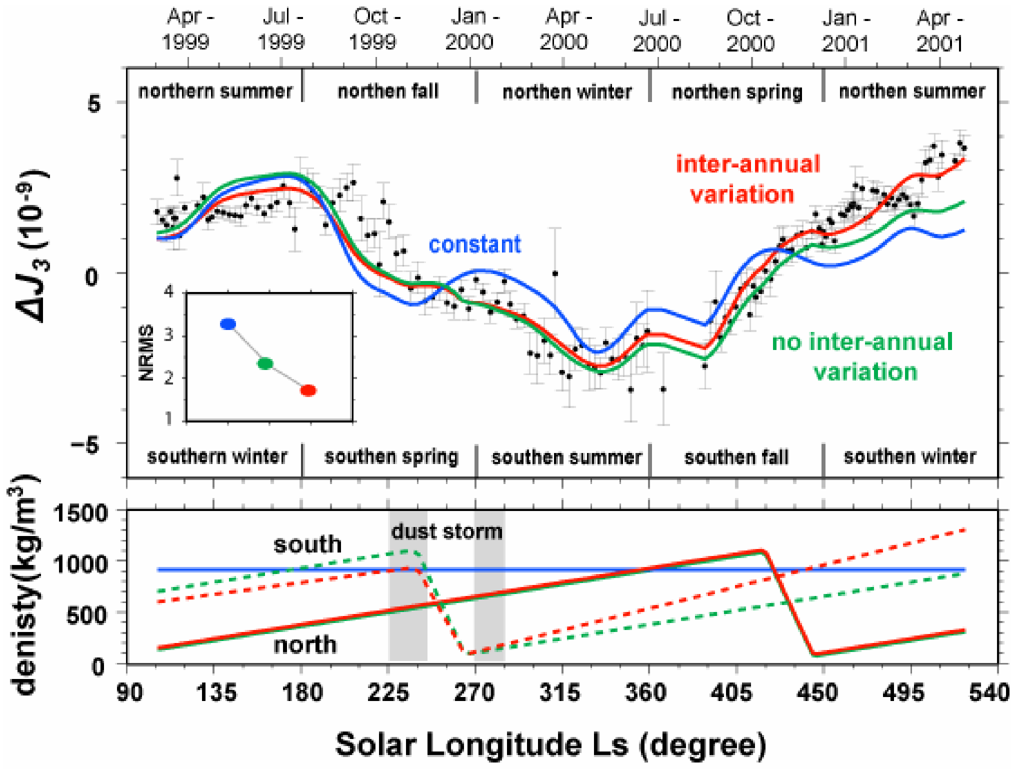

Fig.1. (Upper panel) Time series of changes in gravity coefficient J_3 (ΔJ_3). The black dots with 1-σ error bars show gravimetric ΔJ_3 observed by the Mars Global Surveyor (MGS) [7]. The three curves show altimetric ΔJ_3 calculated from MOLA (Mars Orbiter Laser Altimeter) snow depth data [8], where the average density of snow pack is assumed constant (model 1: blue), time-variable without inter-annual difference (model 2: green), and time-variable with inter-annual difference (model 3: red), respectively. Improvement of normalized root-mean-squares of post-fit residuals is shown in the inset (their colours correspond to those of the curves). (Lower panel) Time series of average snow density in the northern and southern hemispheres. Three colours correspond to those in the upper panel. The two grey squares indicate regional dust storms [9], and the second one that started at *L*s ~270° around the south pole may have increased the snow density in the second southern winter.

References

[1] Zuber, M. et al. (2000) *Science*, *287*,1788-1793.
[2] Taylor Perron, J. et al. (2007) *Nature*, *447*,840-843.
[3] Melosh, H. J. (1980) *Icarus*, *44*, 745-751.
[4] Chicarro, A.F. et al. (1985) *Icarus*, *63*, 153-174.
[5] Head III, J. W. et al. (2002) *JGR*, *107*, E15003, doi:10.1029/2000JE001445.
[6] Yoder, C.F.et al. (2003) *Science*, *300*, 299-303.
[7] Konopliv,A.S. et al., (2006) *Icarus 182*, 23-50.
[8] Smith, D.E et al. (2001) *Science*, *294*, 2141-2146, 2001.
[9] Smith, M.D.(2004) *Icarus*, *167*, 148-165.