EPSC Abstracts
Vol. 12, EPSC2018-283-1, 2018
European Planetary Science Congress 2018

Estimates of Non-hydrostatic Stresses in the Martian Interior

Alexey Batov (1,2), Tamara Gudkova (2) and Vladimir Zharkov (2)
(1) V.A. Trapeznikov Institute of Control Sciences RAS, Russia (2) Schmidt Institute of Physics of the Earth RAS, Russia (batov@ipu.ru)

Abstract

We perform the stress field analysis of different zones on the surface and in the lithosphere of Mars in order to reveal the areas of maximum shear and extensional stresses as potential marsquakes' sources. Joint analysis of recent gravity and topography data truncated to degree 90 spherical harmonic in a frame of the static method is applied. The source of gravity anomalies is assumed to be the topographic loading and density anomalies at the crust-mantle boundary. Only non-equilibrium components of gravity and topography fields are considered: an outer surface of the hydrostatic equilibrium form of the planet is taken as a reference surface for topography and gravity field of Mars. Numerical calculations of extension-compression stresses and maximum shear stresses are carried out for an interior structure model of Mars having 150-300 km thick lithosphere, with a 1x1 arc-deg spherical grid and up to 1000 km depth.

1. Introduction

Studying of stress field in the Martian interior is of importance for forecasting seismic activity of the planet (for the seismic exploration of Mars). Discovery Program mission InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) will place a single geophysical lander with a seismometer in Elysium Planitia on Mars to study its deep interior [1], as well as the international project of Russian Space Agency and European Space Agency suggesting seismic sounding of Mars is under preparation [3]. The estimates of global seismicity are reported in [2]. The youngest volcanic and tectonic features near Elysium Planitia are assumed to provide potential seismic sources. The purpose of this paper is to reveal areas of large shear and extension-compression stresses in the lithosphere of Mars as possible marsquakes' sources.

2. Method

Numerical simulation is based on a static approach (the loading factors technique or the Green's functions method) [4], [5], [7]. According to this method a planet is modelled as an elastic, self-gravitational spherical body. It is assumed, that deformations and stresses which obey Hooke's law are caused by the pressure of relief on the surface of the planet and anomalous density $\delta\rho(r, \theta, \varphi)$, distributed by a certain way in the crust and the mantle.

3. Interior structure model

As a benchmark real model for the planetary interior we use a trial model of Mars M_50 from [6] which satisfies currently available geophysical and geochemical data. The mean density of the crust is 2900 kg m^{-3}, the thickness of the crust is 50 km, the density contrast at the crust-mantle boundary is 360 kg m^{-3}.

4. Results

The results of modelling at depth 10 km are presented at figure 1.

The performed analysis shows that of particular importance are the areas beneath the impact ring basins, mascons Hellas Planitia and Argyre Planitia; the areas adjacent to the Tharsis rise Mare Acidalia and Arcadia Planitia; and huge canyon Valles Marineris. Beneath these regions, both the maximum shear stresses and the extensional stresses are quite high.

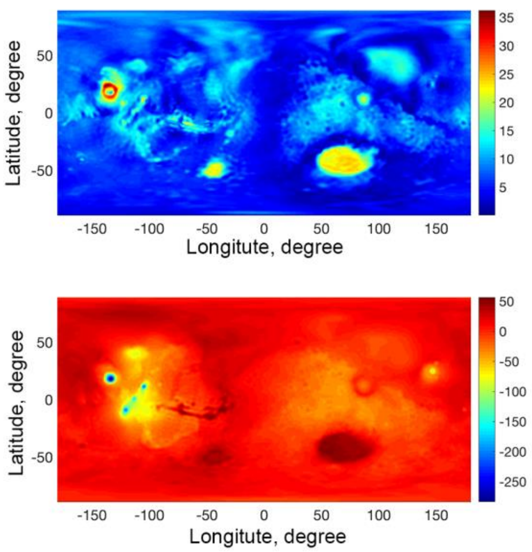

Figure 1: Non-hydrostatic shear stresses (up) and extension-compression stresses (down, extensional stresses are positive) at depth 10 km. Lithosphere 300 km.

5. Summary and Conclusions

High non-hydrostatic stresses may lead to relatively increased seismic activity for the above regions. The results could be of interest for the forthcoming seismic experiment on Mars. Investigation of areas of large stresses would be useful for further seismic events analyses.

Acknowledgements

The work was partly supported by Program 28 of Russian Academy of Sciences, the Russian Foundation for Basic Research, project no. 18-32-00875.

References

[1] Banerdt, W.B., Smrekar, S., Lognonné, P., Spohn, T., Asmar, S.W., Banfield, D., Boschi, L., Christensen, U., Dehant, V., Folkner, W., Giardini,D., Goetze, W., Golombek, M., Grott, M., Hudson, T., Johnson, C., Kargl, G., Kobayashi, N., Maki, J., Mimoun, D., Mocquet, A., Morgan, P., Panning, M., Pike, W.T., Tromp, J., van Zoest, T., Weber, R., Wieczorek, M.A., Garcia, R., Hurst, K. InSight: a discovery mission to explore the interior of Mars. In Proceedings of the 44th Lunar and Planetary Science Conference, p.1915, 2013.

[2] Knapmeyer M., Oberst J., Hauber E., Wählisch M., Deuchier C., Wagner R. Working models for special distribution and level of Mars' seismicity // J. Geophys. Res. E Planets, V. 111(11), P. 1-23, 2006.

[3] Manukin, A. B., Kalinnikov, I. I., Kalyuzhny, A. V., Andreev, O. N. High-sensitivity three-axis seismic accelerometer for measurements at the spacecraft and the planets of the solar system. In Proceedings of Solar System conference 7ms3, IKI RAN, 2016.

[4] Marchenkov, K.I., Lyubimov, V.M., Zharkov, V.N. Calculation of load factors for deeply buried density anomalies. Doklady Earth Science Sections 279, 14-16, 1984.

[5] Marchenkov, K.I., Zharkov, V.N. Stresses in the Venus crust and the topography of the mantle boundary. Sol. Astron. Lett. 16 (1), 77-81, 1989.

[6] Zharkov, V.N., Gudkova, T.V., Batov, A.V. On estimating the dissipative factor of the Martian interior. Sol. Syst. Res. 51, 6, 479-490, 2017.

[7] Zharkov, V.N. Marchenkov, K.I., Lyubimov, V.M. On long-waves shear stresses in the lithosphere and the mantle of Venus. Sol. Syst. Res., 20, 202-211, 1986.