PPS04-P04 会場:コンベンションホール 時間:5 月 21 日 18:15-19:30

# 惑星の大きさがプレートテクトニクス・熱史に与える影響：火星への応用
# Large Effect of Small Planet on Plate Tectonics and Thermal Evolution: Application to Mars

松山 健志 [1*]
Takeshi Matsuyama[1*]

[1] 東京工業大学大学院理工学研究科
[1]Graduate School of Science and Engineering, Tokyo Institute of Technology

The likelihood of plate tectonics on other planets has been investigated especially in the last two decades (e.g., Solomatov and Moresi, 1997). In terms of a larger planet than the Earth, a super-Earth is an instance. Geodynamicists have analyzed the probability that plate tectonics operates on its surface, and some results claim that the plate tectonics is conceivable (Valencia et al., 2007). As regards a smaller planet than the Earth, Mars is a representative example. Although several observations of the Martian surface indicate the existence of plate tectonics for the first ~500 Myr, calculated thermal history with plate tectonics (Nimmo and Stevenson, 2000) seems inconsistent with other observations (e.g., Baratoux et al., 2011) and, as a result, the early Martian plate tectonics was concluded to be unlikely (Breuer and Sphon, 2003). To those planets, this study applies the thermal evolution model of the Earth, which has been investigated much more than the other planets, and especially follows a recently proceeded theory about thermal evolution with plate tectonics on Earth (Korenaga, 2006). In addition to the application, focusing on the effect of gravity, in particular small gravity of Mars, this study provides its thermal history, which shows the early Martian plate tectonics conceivable.

Calculation of thermal history mainly follows the theory developed by Korenaga (2006), which includes the effect of plate thickness generated at the mid-ocean ridge by decompression melting. This thermal history model is consistent with geochemical or petrological data of the Earth (Korenaga, 2008; Herzberg et al., 2010). I applied the theory to different-size planets on the assumption that plate tectonics is operating on their surface. I focus on the influence of thickening plate due to the small gravity on a small planet, like Mars, since the effect helps keep the heat of small planet.

First, in order to clarify the effect of plate thickness variation on the Martian early thermal history, I calculate the initial time rate of change of temperature, dT(t=4.5Ga)/dt, with variation of planet size, which shows that a planet smaller than the critical size, ~ 1.1 Earth size, such as the Earth and Mars, first increases the temperature, though a larger planet decreases the temperature as we conventionally expected. Secondly, I calculate the early thermal evolution of Mars with plate tectonics to 4.0 Ga and then employ the stagnant-lid convection (Schubert and Spohn, 1990) from 4.0 Ga to the present, which shows two important results. The first one is that the application of the Earth's thermal history with plate tectonics to Mars enables us to reproduce a conceivable Martian thermal history. Second, if the plate tectonics ceased at 4.0 Ga, the cessation occurred in a hotter condition than the initial one, though the mantle must have convected more vigorously than ever.

Whereas those results depends on some uncertain parameters, such as the initial temperature and the geometry of subducting slab, those uncertainties do not change the essence, that is, Mars with plate tectonics tends to keep the heat in. It means that, if there was plate tectonics in the early stage of Mars, the drastic temperature drop shown in a conventional theory (Nimmo and Stevenson, 2000) is unlikely, which results in a realistic temperature evolution after the cessation of plate tectonics. In addition, plate tectonics cessation with the hot mantle at 4.0 Ga means that other factors than temperature are indispensable to retain plate tectonics, such as liquid water on the surface. As future works, we should consider other observational data, such as Martian morphology, to constrain this thermal model of Mars.

キーワード: 火星, プレートテクトニクス, 熱史
Keywords: Mars, Plate tectonics, Thermal Evolution