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Dynamical environment of Phobos and applications to studies of surface features

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Abstract

In this work, we modeled the dynamical environment of Phobos based on the latest shape model, taking into account the tidal and centrifugal effect. Surface features are being investigated with respect to the local dynamical status.

1. Introduction

Ever since Viking spacecraft accomplished the first close investigation of Phobos, various unusual topographic surface features have been noticed [2]. However, the origin and evolution of these features stay mysterious. The prominent groove structure covering almost the entire surface of Phobos has been interpreted as results of impact ejecta emplacement [4] or chains of secondary craters formed by debris from Mars [3]. With the acquisition of higher resolution images, the unique large blocks known as boulders are drawing more and more attention, most of which are thought to be related to the largest crater Stickney [5].

Being deep in the gravity well of Mars, surface material on Phobos is exposed to a unique dynamical environment [1]. Understanding the dynamical environment is therefore essential for studying the origin and evolution of surface features. With the assumption of homogeneous density, the irregularity of the shape results in a gravitational field varying significantly over the surface. Moreover, due to the extreme proximity to Mars, the tidal force in the sub-Mars and anti-Mars area is of the same magnitude as the gravitational force. Besides, the centrifugal force resulting from the relatively fast rotation cannot be neglected.

In this work, we investigated the dynamical environment of Phobos by modeling it with several parameters. Areas of interests were chosen for comparing with latest high-resolution images from the Mars Express spacecraft in order to find clues for the process of surface modification.

2. Data and Methods

The latest shape model based on Mars Express imaging data [8] is used in our work to develop a gravity model as well as calculate tidal and centrifugal effects. The gravity field of Phobos has been modeled using different methods [7] which all yield consistent results. Considering the convergent requirement on the surface, we chose to model the surface gravity by approximating Phobos using a set of identical cubes, each having a size of 100 x 100 x 100 m. With Mars as a point mass, the averaged tidal effect is taken into account using a semi-major axis of Phobos' orbit as 9377.2 km. The centrifugal effect is calculated taking a synchronous rotation with period of 0.3189 days. The main parameter used to describe the dynamical environment is dynamic height, which represents the total effective potential in the unit of height [6].

3. Results

The global pattern of dynamic height differs significantly from the shape, as shown in figure 1. The sub-Mars and anti-Mars regions (Fig. 1(a) and 1(c)) are dynamically low due to strong tidal effect. Crater Stickney remains dynamically low, which is in agreement with the observational evidence of downslope movement of material on the Western slope of the crater.

Several areas are being investigated where dynamical heights deviate from the geometric topography. For example, figure 2 shows the sub-Mars region with dense distribution of grooves. The pattern of the arrows, indicating the downslope direction, has a certain correlation with the pattern of grooves. However, the grooves extend through the dynamically lowest area.

4. Summary and Outlook

The unusual dynamical environment of Phobos plays an important role in modification of its surface. Based

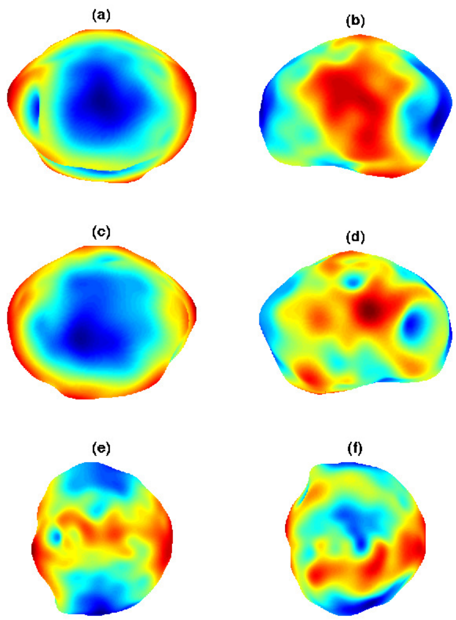

Figure 1: The dynamic height projected on the shape model, (a)-(d): equatorial view with West azimuth angles of 0°, 90°, 180°and 270°in cartography coordinates; (e) and (f): views of north and south pole.

on the latest spacecraft data, we have modeled the dynamical environment using dynamic height. The significant tidal effect caused by proximity to Mars results in dynamic depressions in the sub-Mars and anti-Mars areas.

To find hints for the process of surface evolution in the frame of this dynamical environment, statistics of surface features like grooves and boulders are being analyzed using latest high resolution imaging data.

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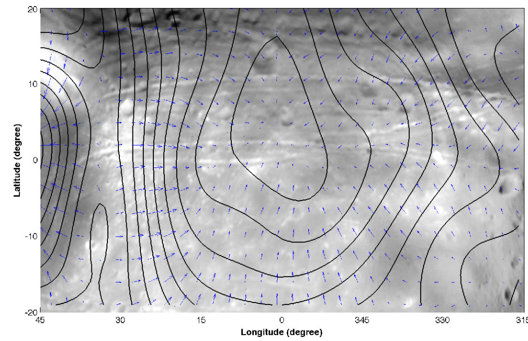

Figure 2: Contours and gradient of dynamic height on top of map at sub-Mars area

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