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Global Pattern of Crustal Deformation Associated with the True Polar Wander of Mars

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A large-scale ocean, covering one third of the planetary surface, is suggested to have existed on the northern plain of Mars. Analyses of satellite images suggested two sets of possible paleo-shorelines running thousands of kilometers along the boundary between the northern and southern hemispheres. However, laser altimeter data indicated long-wavelength undulations of altitudes with amplitudes of up to several kilometers along the shorelines, which does not comply with the paleo-shoreline hypothesis (i.e. shoreline should be flat in definition). Recently, Taylor-Perron (2007) showed that global scale crustal deformation associated with true polar wander (TPW) episodes (which occurred after the shoreline formation) may account for the apparent height change along the shoreline.

On Mars are extensively distributed wrinkle ridges, which are formed secondarily when normal or thrust faulting occurred. Mars probe Viking images exhibited the presence of wrinkle ridges on low and mid-latitude regions (Chicarro et al., 2007). Cameras on board the Mars Global Surveyor confirmed them on high-latitude region as well (Mont¥'esi et al., 2003). The distribution of the strikes of these ridges was very systematic, suggesting the presence of global stress fields on Mars.

In this study, we focus on crustal deformation on Mars and calculate the global deformation pattern due to the TPW episodes using the method of Melosh (1980). This method assumes that the entire Mars is fluid (shear stress is assumed to be relaxed after a long time) covered by an elastic membrane (i.e. thin lithosphere on asthenosphere), and calculates stress change in the lithosphere by the movement of the equatorial bulge. According to the numerical result, vertical crustal movement as large as ˜10 km and horizontal movement of several kilometers should have occurred near the paleo-pole. The amount of the deformation reaches the order of milli-strain in terms of areal strain. Then characteristic topographies such as large-scale grabens and dip-slip faults are expected to have developed by the change in the global stress field.

Because such a large strain should accompany lithospheric ruptures, we investigated the correlation between the global stress pattern suggested by the preferred orientations of wrinkle ridge on the present Mars, and those anticipated to occur as a result of TPW. In the middle and low-latitude regions, north-south strike normal faults are predicted to be dominant around the longitude of paleo-pole, and this seems to be the case with the preferred orientation of wrinkle ridges (Chicarro et al., 1985). In contrast, strike-slip faults are predicted to form in low-latitude regions with longitudes 90 degrees apart from the paleopole, and the distribution of wrinkle ridge strikes does not seem to have clear pattern there. This is consistent with the fact that strike-slip faults do not form wrinkle ridges. At high-latitude regions, reverse faults are expected to occur in direction connecting the paleo-pole and the present pole, which is consistent with the observed distribution of wrinkle ridges there. In the future, we plan to evaluate quantitatively the overall consistency between the predicted stress patterns and the wrinkle ridge orientations, by calculating the directions of principal axis of horizontal stress tensors. We will also try to find the paleo-pole position that best explains the observed global wrinkle ridge orientation patters, and to compare such position with those by Taylor-Perron et al. (2007) .