Possible tidal resonance of the Martian paleo-ocean

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It is suggested that there was the paleo-ocean on the northern hemisphere of the early Mars from the topographic features (e.g. Head et al., 1999) and the hydrogen isotopic data (e.g. Kurokawa et al., 2014). The water volume on the early Mars is estimated to be more than 100 m in thickness of the global equivalent water layers (e.g. Villanueva et al., 2017). Considered with the topography, the mean depth of the paleo-ocean is 620 m in depth and 2.4 x 10^7 km^2 in surface area (Head et al. 1999). This is equivalent to a polar paleo-ocean with a circular boundary of ~ 50 degrees in colatitude. Such a wide ocean would be associated with the Solar tides, S2 equilibrium tide of which is ~ 0.02 m on the Mars. Although this tide is not large, it might work for several tenths of billion years, possibly inducing a decrease in the Martian rotation rate. Thus we examine the Solar tides on the paleo-ocean on the early Mars with special reference to the tidal resonance.
We assumed that the paleo-ocean have a polar basin of a constant depth (h) with no bottom friction.The eigen-angular velocity of the ocean (σ) is determined by the basin radius(θ in colatitude), the angular velocity of the Martian rotation (Ω), and the gravity acceleration of the Mars. We calculated the eigen-angular velocity of S1 and S2 tides for the representative values of the parameters, applying the approximation by Goldsbrough (1915). Calculations for h = 400 m and θ = 45 - 60 degrees show that S2 tide has the eigen-angular velocity of $\sigma/2\Omega$ ~ 1 for $\Omega = \Omega_p - 2\Omega_p$ (Ω_p, the present angular velocity of the Martian rotation). This implies that the paleo-ocean might be under the tidal resonance of S2 for a long time if the rotation rate of the early Mars was larger than at the present. For S1 tide, the eigen-angular velocity is much smaller than at the present. Thus S2 tidal resonance may possibly be taken into account for the study on the Martian rotation in the early time, although the tidal torque due to the bottom friction should be examined.

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