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Long-Term Polar Motion on a Quasi-Fluid Planet with an Elastic Lithosphere: Semi-Analytic Solutions of the Time-Dependent Equation

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Semi-analytic solutions of the time-dependent Liouville equation are calculated for long-term, large-scale polar motion (or so-called true polar wander) on a quasi-fluid, terrestrial planet with an elastic lithosphere memorizing a fossil shape. This re-orientation is considered here to be driven by a huge, surface mass load. Based on these solutions, it is discussed how long a paleo-pole position takes time to settle in a steady state (in other words, a state for a fluid-limit case). In a case without a fossil bulge (the previous results), this stabilizing time scale for a planet with fixed physical properties is governed only by (1) a time scale of load formation and (2) a maximum value of mass excess. In a case with a fossil bulge (the present results), however, the stabilizing time scale is controlled not only by (1) and (2) but also by (3) initial latitude of load emplacement. This is because both (2) and (3) of the load determine how much the load cancels the stabilizing effect of the excess ellipticity. As a conclusion, for reconstruction of a history of true polar wander on a planet with a remnant rotational bulge, it should be noted where the load is emplaced. For example, in the cases of the possible true polar wander induced by Tharsis on Mars and Caloris on Mercury, this effect could not be ignored.