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# A time scale of true polar wander on a quasi-fluid planet: Effect of a low-viscosity layer inside a mantle

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In this study, model calculation on long-term polar motion accompanied by viscoelastic deformation are performed in order to investigate the effect of a low-viscosity layer inside a mantle of a solid planetary body on a time scale of true polar wander. Here a planetary body is supposed to be similar to the Earth or Mars, but with the low-viscosity zone. The most important key is dependence of the viscoelastic response on this low-viscosity layer. On the other hand, note that deformation process in here is regarded to be incompressible for solving normal modes of viscoelastic Love numbers. For the sake of the calculation based on this assumption, the interior structure is still simplified to some extent except for the presence of the low-viscosity zone. However, this simplification does not affect the validity of the subsequent discussion.

In this calculation, the quasi-fluid approximation is applied so that the polar motion equation can be integrated just as a nonlinear one. The reason is that the linear approximation is not generally applicable to large polar motion of a magnitude of several tens of degrees as discussed here. Following the application limit of the quasi-fluid equation, load formation is assumed to be much slower than characteristic time scales of viscoelastic deformation. This approximation scheme has already been constructed by the author as well as some other researchers. The present study also deals with this integration in the same manner.

As a result, the above calculation indicates the fact that the time variation of a spin pole with the effect of the low-viscosity layer is faster compared to that without it. In addition, the result also reveals that, the shallower the low-viscosity zone is, the faster the polar wander speed is. The reason why the low-viscosity layer makes polar wander speed faster is because the behavior of this layer is like that of liquid even with respect to relatively short-term variation of external forcing. This corresponds to, in turn, faster hydrostatic readjustment to centrifugal potential perturbation, which shortens a time scale of variation in the moment of inertia tensor associated with that in the spin axis. Furthermore, variation of an oblate shape with viscous relaxation of this layer negatively depends on the thickness of the upper shell which elastically reduces the above-mentioned fluid-like displacement of the layer. This point assures that the effect of the low-viscosity layer on polar wandering is stronger if the upper shell is thinner, that is, this soft layer is shallower.

The calculation result shown above provides the conclusion that the presence of the low-viscosity layer in a planetary interior largely affects true polar wander even if the layer is relatively thin. The previous studies simplified mantle viscosity structure and ignored the low-viscosity layer inside. Unlike them, the present study demonstrates time evolution of true polar wander with the explicit effect of this specific layer. Although it has been pointed out in the past that such an easily deformable domain plays an important role in viscoelastic deformation induced by tide or load on the Earth, this point is the same in the case of secular rotational motion.

It should be noted, however, that the present calculation is also based on the assumption of incompressibility like the former one. Possible effect of compressibility might be required for more realistic calculation in the future.

Keywords: true polar wander, quasi-fluid approximation, low-viscosity layer, mantle