GLOBAL PLATE TECTONICS AND THE SECULAR MOTION OF THE POLE

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Analysis of astronomical observations recorded during the last 75 years by international services (ILS-IPMS, BIH) in charge of providing the coordinates of the instantaneous pole conclusively proves a persistent drift of the "mean pole" (≡barycenter of the wobble). A study was undertaken with the specific objective of investigating the possibility of a true secular motion of the barycenter, that is, an actual displacement of the Earth's pole of figure. Geophysical hypotheses available to explain the astronomically-observed drift of the "mean pole" suggest changes in the Earth's second-order inertia tensor as a plausible cause.

Rapid accumulation of geophysical and geologic evidence during the past decade strongly indicates that the Earth's surface is mobile. Large tectonic plates constituting the outer 50-100 km of the Earth's crust appear to be moving at average rates ranging from 1 cm/yr to as much as 15 cm/yr. This general structural scheme is termed "global plate tectonics."

On this basis a differential method was developed to determine the contributions to the Earth's inertia tensor produced by infinitesimal plate motions. The approach assumes the Earth modeled as a mosaic of $1° \times 1°$ crustal blocks, each one moving independently in accordance with recently published absolute plate velocity models.

The following modeling constraints provide the framework of the investigation and should always count in any final interpretation:

(1) Crustal blocks are assumed 50 km deep but not homogeneous, with varying densities conforming with the theory of isostatic compensation.

(2) The boundaries of each plate and its absolute velocity with respect to the underlying mantle follow the models established by Solomon *et al*. (1975).

E. P. Fedorov, M. L. Smith and P. L. Bender (eds.), Nutation and the Earth's Rotation, 243–244.

The major conclusion of this quantitative analysis may be summarized as follows: No evidence of a true secular motion of the Earth's axis of figure can be found from changes in inertia due to tectonic plate movements during the period covered by astronomical observations.

In view of the above, the effect that station drifting, resulting from the theoretical geophysical models for absolute plate velocities, may have on an apparent displacement of the "mean pole" was studied. It was found that the apparent fluctuations of the pole caused by the motion of the observatories due to tectonic plate rotation may account for only 10% to 20% of the total observed displacement, depending on the absolute velocity model used and the number of stations involved.

After values for the crustal tensor of inertia (assuming an ellipsoidal Earth) and the orientation of its axis of figure were obtained, the overall interpretation of results leans to the explanation of the secular motion of the pole as an apparent displacement consisting of the composition of two movements:

(i) Apparent motion of the mean pole originated by crustal slippage. (The pole of figure of the crust is moving toward the total Earth's pole of figure.)

(ii) Apparent motion of the barycenter of the wobble due to the drifting of the stations.

It is general practice today to apply what is known as polar motion corrections to reduce observations to a common CIO system. Unfortunately, in view of the above, what may occur is that, depending on the epoch of the reduction, different fictitious reference axes are obtained. Hence every polar motion reduction today may create a new reference system as a consequence of the possible movement of the crust and its attached CIO point. This is the disadvantage of a crust-fixed reference system.

For more details, see Soler (1977).

References

Soler, T.: 1977, Global Plate Tectonics and the Secular Motion of the Pole, The Ohio State University, Department of Geodetic Science Report No. 252, Columbus.

Solomon, S. C., Sleep, N. H. and Richardson, R. M.: 1975, Forces driving plate tectonics: Inferences from absolute plate velocities and interplate stress, Geophys. J. R. astr. Soc. 42, 769-801.