Commentary
Volume 13:10, 2022

Journal of Physical Mathematics

ISSN: 2090-0902

Open Access

Spherical Geometry Mantle Model with Relics of Subcontinental Sinking Slabs

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Description

One of the most potent techniques available to geophysicists for examining the deep mantle is seismic tomography. The traces of subducted slabs can be seen in maps of laterally varying seismic velocities produced by tomography. When combined with paleogeographic records that construct past subduction history they provide a means of constraining plate motions and slab sinking rates across a variety of mantle depths. However, as imaged slabs descend into the mantle and appear to exhibit morphologies and/or positions that are difficult to reconcile with the interpreted paleogeographic histories, observations in a number of settings suggest a complex subduction history and/or current conceptions of the structure of the mantle. As a result, numerous authors have published in the last 15 years. The mantle may have a radial viscosity profile that includes low-viscosity zones beneath high-viscosity regions or a lower mantle viscosity that is much higher than previously thought. In addition to the idea that the mantle's radial viscosity profile can be restricted by using the current slab positions and other also looked at the role of subduction zone shape, slab dip angle, and slab depth extent at the end of subduction in determining current slab positions. In order to reinterpret tomographic observations, constrain mantle structure, or gain insight into slab properties, the inferred location and history of ancient oceanic plate subduction can be compared with the results of the numerical models [1].

The interpretation of P wave anomalies in the region below India and Siberia's current positions served as the impetus for the present study. Previous research and others, at depths ranging from mid-mantle positions to locations just above the core-mantle boundary, four slab remnants associated with the closing of the Paleo-Tethys and Tethys Oceans are currently visible below Siberia and India, according to inferences. Terrane accretion and continental collisions have been hypothesized to have marked periods of oceanic plate consumption prior to India's collision with the Asian mainland. This tectonic activity is evidenced by a variety of scattered slab remnants that are still visible in the mantle today. Particularly, the subterranean mantle beneath India may contain a subducted seafloor that dates from the Jurassic to the Tertiary and lies beneath the site of the Paleo- and Tethys closures. Additionally, the Mongol-Okhotsk slab, which separated from the surface lithosphere with the closing of the ocean between Siberia and Mongolia in the late Jurassic, has been interpreted as a remnant in the lower mantle west of Lake Baikal [2,3].

The observed depths of the slab remnants provide a timescale for slab sinking rates that can be used to constrain mantle models if these interpretations are correct but they also show that sinking rates are probably heavily influenced by subduction history (such as the subducted slab's age and morphology) in order to reconcile the following. The seismic anomaly that has been identified as the Mongol-Okhotsk slab remnant today reaches the core-mantle boundary at a depth of approximately 1500 km. The approximate date for when the Mongol-Okhotsk slab's shallowest section separated from the surface can be derived from the collision of Mongolia and Siberia 150 Myr ago, when the subduction of the intervening oceanic plate ended. An average sinking rate of approximately 1 cm for a detached slab descending through the upper half of the mantle is suggested by the current location of the slab's top and the age that can be inferred from its detachment. Van der Voo on the other hand identify three additional regions with fast P wave anomalies, all of which are located in the middle of the mantle, and link each one to a slab fragment left over from the end of the Paleo- and Tethys oceans. Curiously, it has been hypothesized that the subduction episodes associated with these similar depth anomalies ended as early as 141 Ma and as late as 52–37 Ma [4].

2-D Cartesian geometry mantle convection model modeled the Tethyan slab remnants' subduction history by simulating three successive closings of the subduction zone with temporal separations that were consistent with the paleogeographic record. They discovered that the current seismic anomaly spatial distribution is consistent with the collision and subduction history of India and the Tethys due to the presence of overriding of the intra-oceanic subduction zone and subsequent indenting of Asia by fast-moving India. However, their study was constrained by the simplicity of the model geometry and plate rheology. The straightforward 2-D model, on the other hand, was unable to replicate the oldest slab fragments' tomographically inferred depths. In the following study, Jarvis and Lowman (2007a) looked at how subduction characteristics (specifically slab depth extent, temperature, dip angle, and width) and the mantle viscosity profile influenced 2-D and 3-D Cartesian geometry models [5].

Conclusion

Our research builds on the work of Jarvis and Lowman (2007) and reexamines the main factors that affect the sinking rate of a slab that has separated from the lithosphere that is above it and is stationary. A temperature-dependent rheology and a three-dimensional spherical geometry, two additional realism-enhancing features in the numerical models, are the focus of our particular investigation. Our method focuses on determining parameters that can vary the sinking rates of detached slabs due to the computational constraints of 3-D modeling. Instead of trying to constrain an absolute radial viscosity for the Earth, we compare models with different slab and mantle properties. As a consequence of this, in order to evaluate the effect on slab sinking rate, our research employs a comparative strategy that varies each model feature individually. The main features of our models are briefly described in the following section. The effects of various physical properties on the dynamics of a detached oceanic plate and its surrounding mantle are the topic of our study's third section. In the final section, we summarize our main findings and discuss the limitations and implications of the findings regarding Earth slab sinking rates.

Acknowledgement

None.

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Received: 01 October 2022, Manuscript No. jpm-22-84306; **Editor assigned:** 03 October 2022, Pre QC No. P-84306; **Reviewed:** 17 October 2022, QC No. Q-84306; **Revised:** 22 October 2022, Manuscript No. R-84306; **Published:** 29 October 2022, DOI: 10.37421/2090-0902.2022.13.394

Conflict of Interest

None.

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How to cite this article: Gastal, Bojan. “Spherical Geometry Mantle Model with Relics of Subcontinental Sinking Slabs.” J Phys Math 13 (2022): 394.