A New Approach to Rift Kinematics During the Formation of the Black Sea Basin

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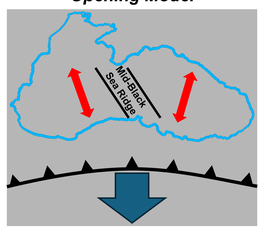
Abstract

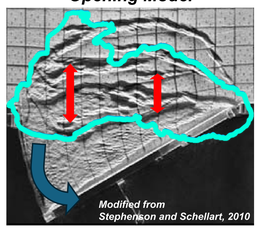
As recent hydrocarbon discoveries rekindle exploration activities in the Black Sea Basin (BSB), efforts to understand the geodynamic processes that led to the formation and evolution of the basin have started to play a significant role in understanding the structural trends formed during rifting. The debate on whether the basin rifted open as one east-west oriented basin, or as two separate basins named the Eastern and Western Black Sea Basins, has been discussed in numerous models. Evidence for the two-basin hypothesis focuses on the basin's semi-parallel ridge and depression architecture, which trends NW-SE in the east and W-E in the west. Conversely, the single-basin model is supported by the correspondence between the regional structure and geodynamic rifting models, specifically those involving an asymmetrical rift pivoting on an eastern hinge caused by slab roll-back of the subducting plate located in the south of the basin.

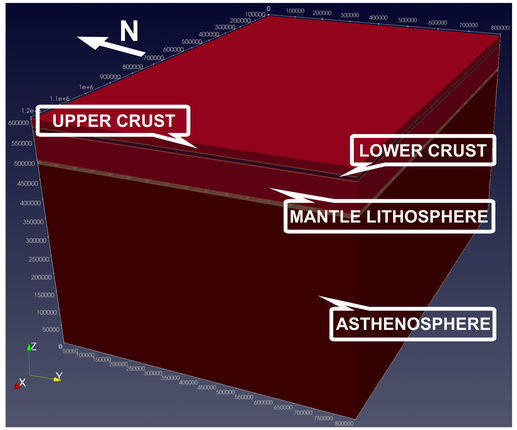
To address existing tectonic uncertainties, we established a new structural framework for the BSB by reinterpreting 24 long-offset 2D seismic lines. These structural constraints enabled the development of two 2D computational models, allowing us to simulate the distinct kinematic evolution of the basin's western and eastern sections. Our 2D sectioned models show that rift velocities vary significantly in the east-west direction. This contradicts previous analog models showing that the formation of the BSB was related to a simple asymmetrical rift with constantly increasing velocities towards the west from a hinge point located at the eastern margin of the basin. The complex velocity changes throughout the rift axis suggest an uneven movement throughout the subduction zone that drives the back-arc rift. Ultimately, proposing a new complex kinematic history during the evolution of the rift and alternating rift velocities throughout the rift axis, provide a better understanding of the timing of all tectonic events and the final ridge depression geometry observed throughout the BSB.

Model Setup

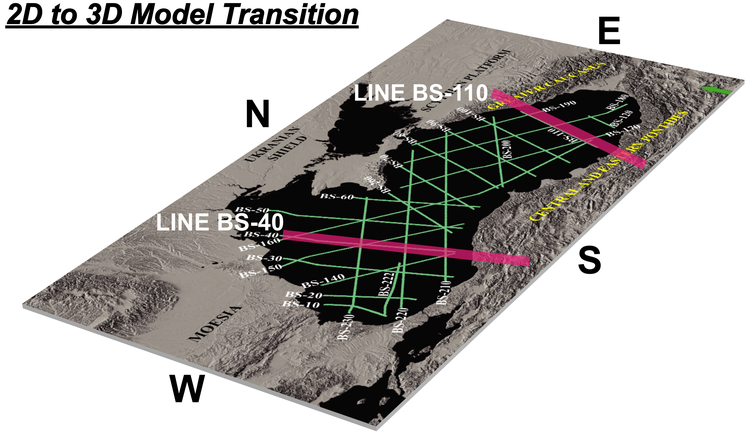
Two-Basin Opening Model VS *Single Basin Opening Model*

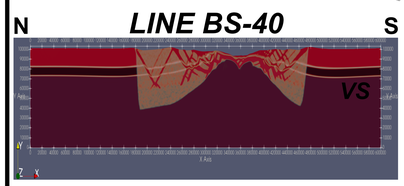


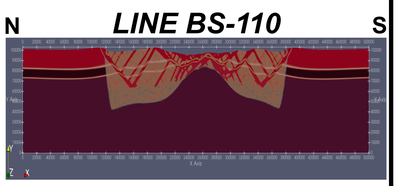


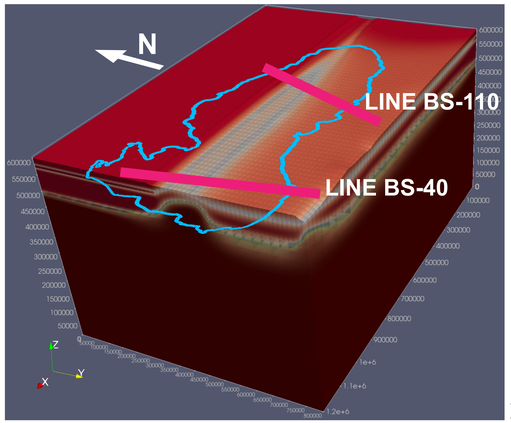


2D to 3D Model Transition



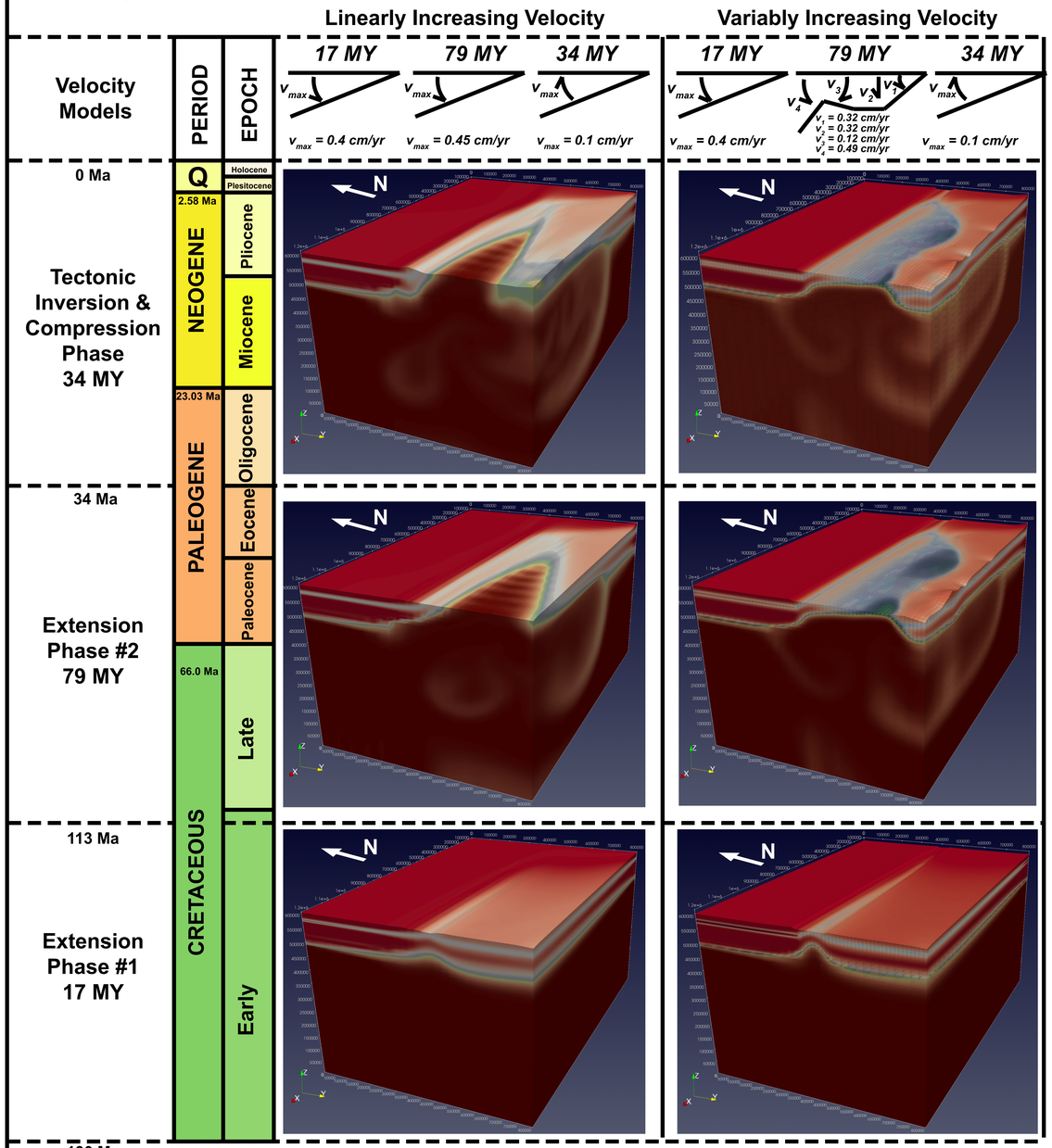






Snapshot taken at 39 Million Years mark

3D Computational Models



References

Nikishin, A. M., Okay, A. I., Tüysüz, O., Demirer, A., Amelin, N., & Petrov, E. (2015a). The Black Sea basins structure and history: New model based on new deep penetration regional seismic data. Part 1: Basins structure and fill. Marine and Petroleum Geology, 59, 638–655. https://doi.org/10.1016/j.marpetgeo.2014.08.017

Nikishin, A. M., Okay, A., Tüysüz, O., Demirer, A., Wannier, M., Amelin, N., & Petrov, E. (2015b). The Black Sea basins structure and history: New model based on new deep penetration regional seismic data. Part 2: Tectonic history and paleogeography. Marine and Petroleum Geology, 59, 656–670. https://doi.org/10.1016/j.marpetgeo.2014.08.018

Okay, A. I., Sunal, G., Sherlock, S., Altiner, D., Tüysüz, O., Kylander-Clark, A. R., & Aygül, M. (2013). Early Cretaceous sedimentation and orogeny on the active margin of Eurasia: Southern Central Pontides, Turkey. Tectonics, 32, 1247–1271. https://doi.org/10.1002/tect.20077

Stephenson, R., & Schellart, W. P. (2010). The Black Sea back-arc basin: Insights to its origin from geodynamic models of modern analogues. Geological Society, London, Special Publications, 340(1), 11–21. https://doi.org/10.1144/SP340.2

Discussions and Future Work

Hinge Model Proposed by Stephenson and Schellart (2010)	*Hinge Model Proposed in This Study*
Single stage rifting with constant velocity increase rate from the hinge to the west.	Two-stage rifting followed by a compressional tectonic phase with different velocity models.
Linear increase in rifting velocity from a single hinge point.	First rifting stage with linear increasing velocity from the hinge. Second rifting stage with a variable velocity model.

Suggested future work is to model three stages of subduction causing the back-arc rifting of the BSB proposed by Okay et. al (2013), and tie the subduction models to two rifting and one compressional tectonic stages. Stephenson and Schellart (2010) proposed a slab rollback with a progressive tear during rifting. In this study we propose the rollback and progressive tear happen during the second stage of rifting and are the main reasons for the variable velocity model we propose.

Sharing is encouraged