

## Investigating the Dynamic Behavior of the North Tabriz Fault in the Interseismic Period Using Physical Models of the Earthquake Cycle in a Viscoelastic Half-Space

Milad Salmanian<sup>1</sup>, Asghar Rastbood<sup>2\*</sup>, Masoud Mashhadi Hossainali<sup>3</sup>

1,3 Faculty of Geodesy and Geomatics Engineering, K. N. Toosi University of Technology, Tehran, Iran

2 Department of Geomatics Engineering, Faculty of Civil Engineering, University of Tabriz, Tabriz, Iran

(Received: 09 May 2023, Accepted: 01 September 2023)

### Summary

Significant progress has been made in understanding the mechanisms and locations involved in the accumulation of interseismic strain along faults, which facilitates the identification of fault segments with higher earthquake propensity. Nevertheless, the mechanical response during the transition from deep fault locking to creep behavior remains obscure. Accurate estimation of the slip fraction in such transition zones is a particularly complex challenge. A common assumption in geodetic inversions for surface deformation rates involves treating the depth distribution of interseismic slip rates along the fault as constant over time. The primary model used to calculate fault shape changes is the inverse tangent model introduced in 1973, with subsequent developments leading to the development of models such as the Okada model. The primary limitation of these models comes from the assumption of their constant locking depth, which leads to singularity problems during the solution of the stress theorem and leaves certain equations unanswered. In this study, the assumption of constant locking depth is rejected and the singularity problem is solved by considering variable locking depth. The method used in this research is focused on creep propagation in a perfectly elastic medium. This requires accounting for long-term deformation caused by viscoelastic flow in the upper mantle and lower crust. While fully elastic models typically produce locking depths greater than seismic depths, the inclusion of viscoelastic effects improves the fit to interseismic deformation rates, particularly showing lower locking depths. In this research, the GPS velocity field is recovered using the forward problem and boundary element method and subsequently from a physics-based inversion approach (deep interseismic creep) to infer the values of the parameters full rupture depth (D) and elastic thickness (H), slip rate ( $v^\infty$ ), coseismic displacement (c), relaxation time ( $t_R$ ), recurrence time (T), locking depth (d), uniform creep depth ( $H_{creep}$ ), and propagation velocity ( $v_{up}$ ) in the North Tabriz Fault is used. By overcoming the inherent limitations of traditional models, this study provides valuable insights into the complexities of fault dynamics and interseismic slip behavior. The proposed approach not only enhances the accuracy of slip models but also improves the understanding of fault mechanics in transition zones. The findings suggest that variable locking depths may contribute significantly to the characterization of fault behavior, offering a refined perspective on the seismic risk assessment of fault systems. This work thereby underscores the necessity of integrating viscoelastic considerations in future geophysical models to better predict fault response under varying stress regimes.

**Keywords:** Interseismic creep, Boundary element method, Markov Chain Monte Carlo, GPS velocity field, Earthquake cycle, North Tabriz Fault (NTF)

---

\*Corresponding author:

arastbood@tabrizu.ac.ir