KINEMATICS of NORTH ANATOLIAN FAULT UNDER the CONSTRAIN of NEW GNSS VELOCITY FIELD

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I. INTRODUCTION

- North Anatolian Fault (NAF) is one of the most important faults in World. NAF produced an important earthquake sequence Mw ≥ 7 in the 20th century, that migrates westward between 1939 and 1999. The earthquake sequence has broke the great part of the NAF which is approximately 1000 km (Fig.1).
- Due to this seismic activity of NAF, it is important to keep strain accumulation up to date and use recent data.
- Many precious work have been studied to clarify the kinematics of NAF using the data that collected with geodetic methods (terrestrial and space geodetic).
- In this study, we compiled published GNSS data and analyzed it to understand the present strain accumulation of NAF, with TDEFNODE block modelling code using a simple block geometry.

II. STUDY AREA

- The study area extends between Sapanca Lake at the west (Sakarya) to Yedisu at the east (Bingöl) and it stretches out in the north-south direction from the north coast of Blacksea to 130 kilometers south.

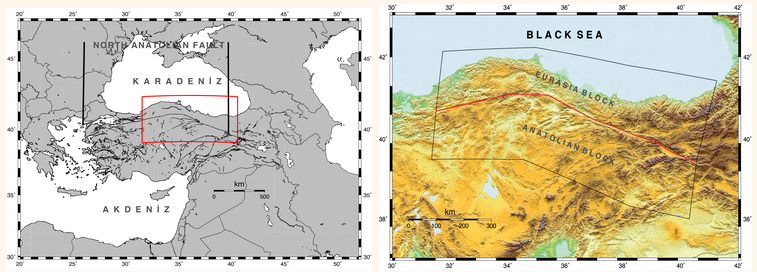

Figure 1. (a) Study area. (b) Fault and blocks of the study area

III. DATA

- In order to predict fault parameters more reliably, the literature have been examined and many studies have been used to create a dense dataset.
- The 90% of GNSS velocity field have RMS values less than 2 mm and the accuracy of estimated slip rates is increased. Additionally, with the dense station distributions in the near field, spatial resolution improved, dramatically.

Reference System

Velocity Field	Reference System	Time Span
Kurt et al. 2022	ITRF-2014	2008-2021
Reilinger et al. 2006	ITRF-2000	1988-2005
Aktug et al. 2013	ITRF-2000	1992-2003
McClusky et al. 2000	ITRF-1996	1988-1997
Ozdemir et al. 2019	ITRF-2008	2008-2018
Ozener et al. 2010	ITRF-2005	2003-2008
Ozener et al. 2013	ITRF-2005	2005-2011
Tatar et al. 2012	ITRF-2000	2006-2008
Yavasoglu et al. 2011	ITRF-2000	2001-2005
Ergintav et al. 2022	ITRF-2014	1988-2021

Velocity Field	Number of Point	RMS < 1 mm
Kurt et al. 2022	236	98%
Reilinger et al. 2006	24	76%
Aktug et al. 2013	39	97%
McClusky et al. 2000	15	1%
Ozdemir et al. 2019	52	96%
Ozener et al. 2010	16	36%
Ozener et al. 2013	5	100%
Tatar et al. 2012	36	94%
Yavasoglu et al. 2011	16	1%
Ergintav et al. 2022	140	82%

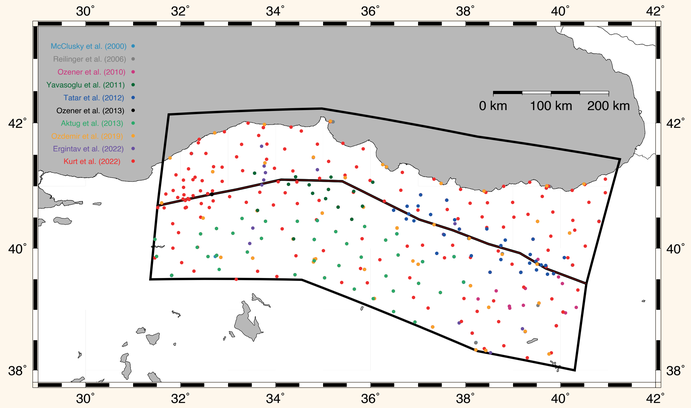

Figure 2. Location of the GNSS sites on the study area

- Most of the GNSS velocity fields are in different reference systems. Therefore it is not possible to be used together for modelling. For this reason, we brought the GNSS velocity fields to the same reference system by using GAMIT/GLOBK velrot module.

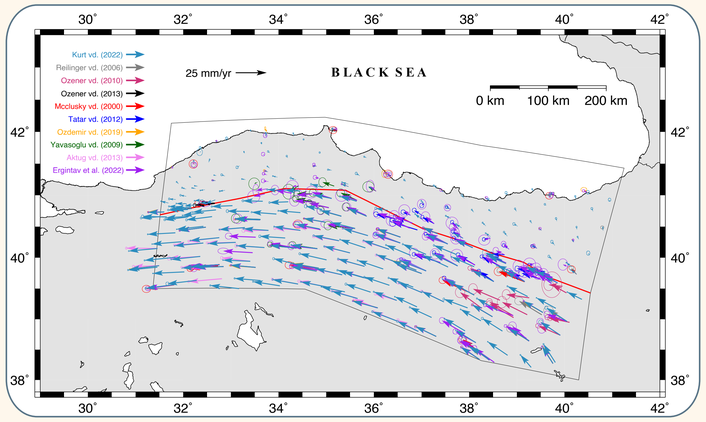

Figure 3. GNSS Velocity field used in the model. Active faults showed with black lines taken from Emre et al. 2013

V. CONCLUSION

- In this study, we estimated fault parameters with the dense and up-to-date dataset at approximately 800 km long part of the NAF.
- According to the first order results, depth-phi figure shows us the east part of the region is locked at 15 km. Middle and the west part of the region has shallower locking depth.
- We estimated Fault slip rates as 20.5 mm/yr at the east and 21.6 mm/yr at the west.

IV. RESULTS

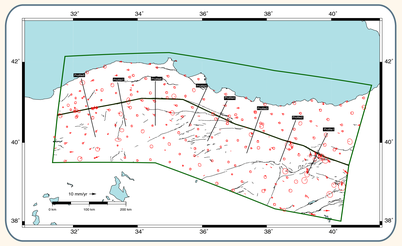

Figure 4. Residual map obtained from model results. Active faults showed with black lines from Emre et al. 2013

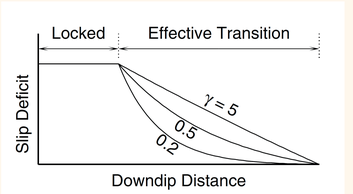

Figure 5. Method that used in block model. Adopted from Wang et al 2003.

- Most of the residuals remain in the limits of error ellipses. Some areas have significant residuals. Some of these areas have secondary faults of North Anatolian Fault Zone .

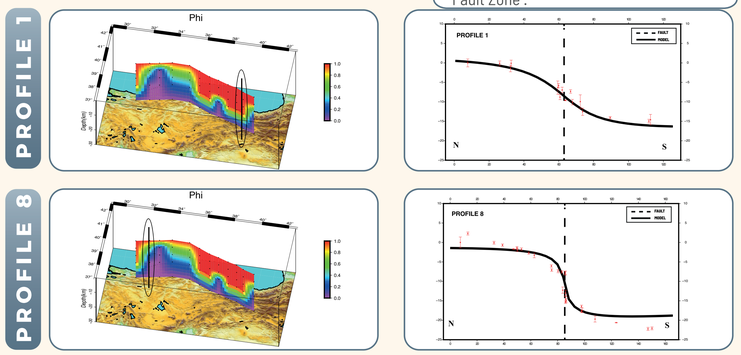

Figure 6. The first and the last profiles from the model

- At the eastern profile (Profile-1), model results show us the region is fully locked. When we look at the profile-1 we can see that model and data are consistent. This profile also shows us this region is fully locked.
- At the western profile (Profile-8), model results shows that the region is not locked up to the surface. This area is well known because of the creep.

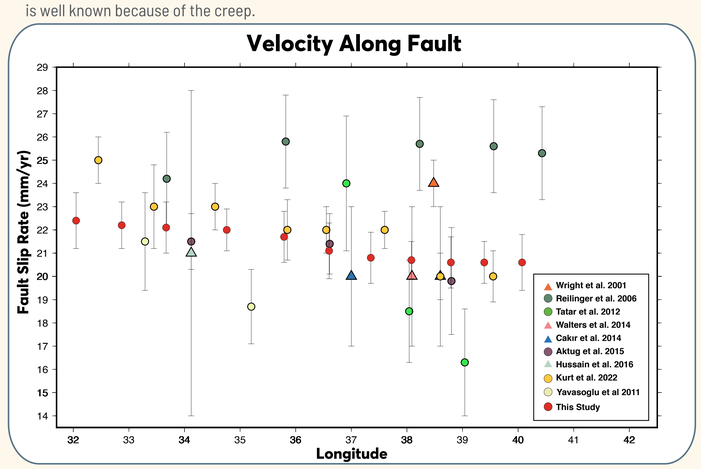

Figure 7. Fault slip rates obtained from different works and fault slip rates estimated in this study. Circle means using only GNSS method, triangle means using only InSAR method. Red circles show fault slip rates estimated in this study.

REFERENCES

- R. McCaffrey, A. I. Qamar, R. W. King, R. Wells, G. Khazaradze, C. A. Williams, C. W. Stevens, J. J. Vollick, ve P. C. Zwick, "Fault locking, block rotation and crustal deformation in the pacific northwest," Geophysical Journal International, vol. 169, pp. 1315–1340, 3 Jun. 2007.
- Y. Okada, "Surface deformation due to shear and tensile faults in a half-space," Bulletin of the Seismological Society of America, vol. 75, no. 4, pp. 1135–1154, Aug. 1985.
- S. McClusky, S. Balassanian, A. Barka, C. Demir, S. Ergintav, I. Georgiev, O.Gurkan, M. Hamburger, K. Hurst, H. Kahle, K. Kastens, G. Kekelidze, R. King,V. Kotzev, O. Lenk, S. Mahmoud, A. Mishin, M. Nadariya, A. Ouzounis, D.Paradissis, Y. Peter, M. Prilepin, R. Reilinger, I. Sanli, H. Seeger, A. Tealeb, M. N.Toksoz, ve G. Veis, "Global positioning system constraints on plate kinematicsand dynamics in the eastern mediterranean and caucasus," Journal of Geophysical Research, vol. 105, pp. 5695–5719, B3 2000.
- O. Tatar, F. Poyraz, H. Gürsoy, Z. Cakir, S. Ergintav, Z. Akpinar, F. Koçbulut, F.Sezen, T. Türk, K. Ö. Hastaoğlu, A. Polat, B. L. Mesci, Ö. Gürsoy, I. E. Ayazli, R. Çakmak, A. Belgen, ve H. Yavaşoğlu, "Crustal deformation and kinematics of the eastern part of the north anatolian fault zone (turkey) from gps measurements," Tectonophysics, vol. 518–521, pp. 55–62, Jan. 2012.
- T. Wright, B. Parsons, ve E. Fielding, "Measurement of interseismic strain accumulation across the north anatolian fault by satellite radar interferometry," Geophysical Research Letters, vol. 28, no. 10, pp. 2117–2120, 2001.
- R. J. Walters, B. Parsons, ve T. J. Wright, "Constraining crustal velocity fields with insar for eastern turkey: Limits to the block-like behavior of eastern anatolia," Journal of Geophysical Research: Solid Earth, vol. 119, 2014.
- Z. Cakir, S. Ergintav, A. M. Akoglu, R. Çakmak, O. Tatar, ve M. Meghraoui, "Insar velocity field across the north anatolian fault (eastern turkey): Implications for the loading and release of interseismic strain accumulation," Journal of Geophysical Research: Solid Earth, vol. 119, pp. 7934–7943, 10 2014.
- S. Ergintav, M. Floyd, D. Paradissis, H. Karabulut, P. Vernant, Frederic Masson, Ivan Georgiev, A. Ö. Konca, U. Doğan, R. King, R. Reilinger (2022). New geodetic constraints on the role of faults and blocks vs. distribute strain in the Nubia-Arabia-Eurasia zone of active plate interactions, Turkish Journal of Earth Sciences. doi:10.55730/yer-2205-5
- Emre Ö, Duman T, Özalp S, Elmacı H, Olgun Ş, Şaroğlu F (2013) Active fault map of turkey with explanatory text. General Directorate of Mineral Research and Exploration Special Publication Series 30
- R. Reilinger, S. McClusky, P. Vernant, S. Lawrence, S. Ergintav, R. Cakmak,H. Ozener, F. Kadirov, I. Guliev, R. Stepanyan, M. Nadariya, G. Hahubia, S. Mahmoud, K. Sakr, A. ArRajehi, D. Paradissis, A. Al-Aydrus, M. Prilepin, T.Guseva, E. Evren, A. Dmitrotsa, S. V. Filikov, F. Gomez, R. Al-Ghazzi, ve G.Karam, "Gps constraints on continental deformation in the africa-arabia-eurasia continental collision zone and implications for the dynamics of plateinteractions," Journal of Geophysical Research: Solid Earth, vol. 111, 5 May 2006.
- B. Aktug, E. Parmaksiz, M. Kurt, O. Lenk, A. Kiliçoglu, M. A. Gürdal, ve S. Özdemir, "Deformation of central anatolia: Gps implications," Journal of Geodynamics, vol. 67, pp. 78–96, 2013.
- S. Özdemir, ve M. O. Karslioglu, "Soft clustering of gps velocities from a homogeneous permanent network in turkey," Journal of Geodesy, vol. 93, pp. 1171–1195, 8 Aug. 2019.
- H. Ozener, E. Arpat, S. Ergintav, A. Dogru, R. Cakmak, B. Turgut, ve U. Doğan, "Kinematics of the eastern part of the north anatolian fault zone," Journal of Geodynamics, vol. 49, pp. 141–150, 3–4 Apr. 2010.
- H. Ozener, A. Dogru, ve B. Turgut, "quantifying aseismic creep on the ismetpasa segment of the north anatolian fault zone (turkey) by 6 years of gps observations," Journal of Geodynamics, vol. 67, pp. 72–77, 2013.
- H. Yavaşoğlu, E. Tari, O. Tüysüz, Z. Çakir, ve S. Ergintav, "Determining and modeling tectonic movements along the central part of the north anatolian fault (turkey) using geodetic measurements," Journal of Geodynamics, vol. 51, pp. 339–343, 5 May 2011.
- E. Hussain, A. Hooper, T. J. Wright, R. J. Walters, ve D. P. Bekaert, "Interseismic strain accumulation across the central north anatolian fault from iteratively unwrapped insar measurements," Journal of Geophysical Research: Solid Earth, vol. 121, pp. 9000–9019, 12 Dec. 2016.
- K. Wang, R. Wells, S. Mazzotti, R. D. Hyndman, ve T. Sagiya, "A revised dislocation model of interseismic deformation of the cascadia subduction zone," Journal of Geophysical Research: Solid Earth, vol. 108, B1 Jan. 2003.