Present Deformation Field of Silent Strand of Western NAFZ

Haluk OZENER, Asli DOGRU and Bulent TURGUT, Turkey

Key words: Crustal deformation monitoring, North Anatolian Fault Zone, GPS

SUMMARY

North Anatolian Fault Zone (NAFZ), where the Anatolian and Eurasian plates meet, is one of the largest active strike-slip fault zones in the world. The western part of NAFZ has a seismic past and many scientists have focused on this region. The study of monitoring horizontal crustal movements on the western part of NAFZ has started by Geodesy Department of KOERI, Bogazici University in 1990. Three geodetic control networks were established in Iznik, Sapanca, and Akyazi regions in order to monitor crustal displacements. The first period observations were performed by using terrestrial methods and these observations were repeated annually until 1993 by using total-station and electromagnetic distance-meter instruments. Since 1994 GPS measurements have been carried out at the temporary and permanent points in the area and the crustal movements are being monitored. In this study, the results obtained from these GPS observations performed at Iznik-Mekece segment are presented. A present-day deformation field is also investigated by GPS velocities. Iznik-Mekece segment of the NAF was identified as a seismic gap and the results of the study seem to be more confusing than clarifying. There has been no significant horizontal movements were detected by terrestrial methods but 14-year GPS data that evaluated gave us a significant idea about slip rate and deformation on that segment of NAFZ.

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1. IZNIK-MEKECE FAULT SEGMENT

The North Anatolian Fault (NAF), which is one of the most seismically active fault of the world, runs along the northern part of Turkey about 1500 km, from the Karliova to the North Aegean. NAFZ branches from 30.6º E westward into three active fault zones. The middle strand is called Iznik-Mekece fault zone (Figure 1-1). The middle branch extends westward via the southern coast of Lake Iznik to the Marmara Sea. Iznik-Mekece fault zone is known seismically low active than the other northern and southern fault zones. From the knowledge of historical events and trench studies, the recurrence interval of large earthquakes for middle strand is probably in the vicinity of 2000 years or more. Furthermore, there is only a micro-earthquake activity in the Gemlik area for the last 15 years (Barka, 1997). In spite of geologic evidence indicative of recent activity of the Iznik-Mekece fault, the middle and eastern part of the fault is virtually inactive seismically (Ucer et al., 1985; Tsukuda et al., 1988; Lio et al., 1989). Presence of seismic gaps in the area implies potential sites for future large earthquakes.

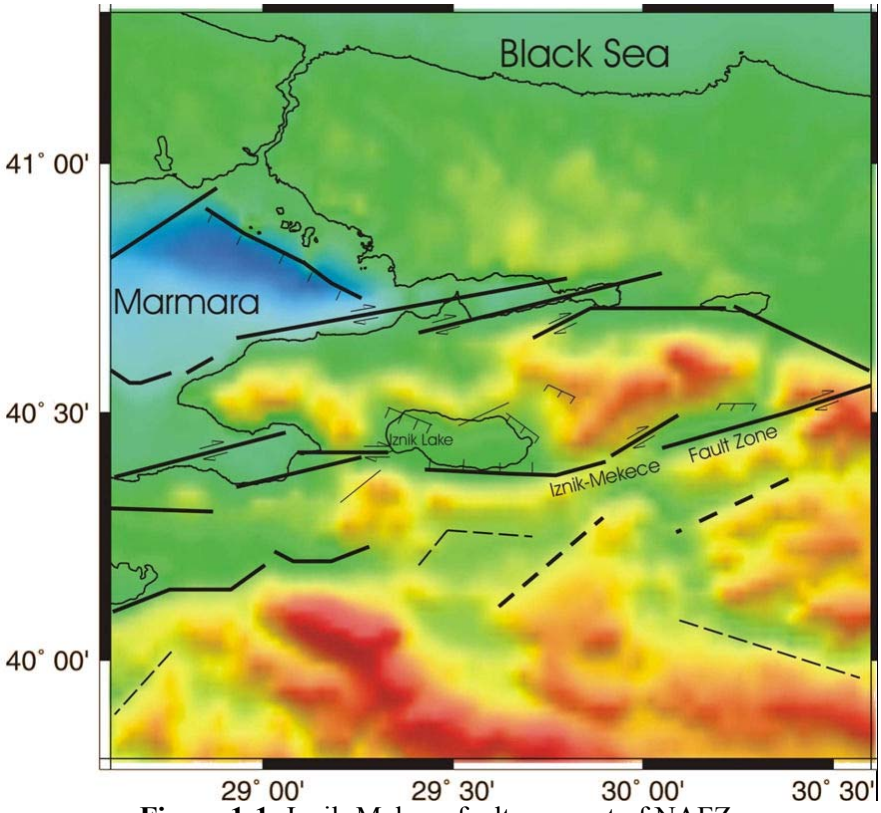

Figure 1-1: Iznik-Mekece fault segment of NAFZ.

The Iznik-Mekece Fault that is located around west of Geyve, goes along approximately 15 km up to Sakarya as an right lateral fault (Barka, 1997) and then bounds the Geyve basin and then leaps over to the right side continuous through Mekece and Iznik Lake in W-SW

direction. Many researches were conducted along the fault for investigating seismic potential (Ambraseys and Finkel, 1991; Stein et al., 1997; Barka and Reilinger, 1997; Reilinger et al. 2000; Ayhan et al., 2002; Ergintav et al., 2002; Meade et al., 2002; Reilinger et al., 2006; Ergintav et al., 2007).

2. GEODETIC OBSERVATIONS

The study of monitoring horizontal crustal movements on the western part of NAFZ has started by Geodesy Department of Bogazici University in 1990. Iznik micro-geodetic network ($10km^2$ with 10 points) were constructed to investigate crustal deformation on the silent branch of the North Anatolian Fault Zone, then terrestrial methods were applied until 1994. After GPS observations started in 1994, space techniques have been applied (Gurkan et al., 1999; Ozener; 2000, Gurkan et al., 2001). The mean velocity of Iznik-Mekece segment was found 18mm/yr for the 1994-1998 periods (Ozener, 2000). The estimated GPS displacement during the first 298 post-seismic days after the Izmit Earthquake (17 August 1999, Mw 7.4) for IGAZ station around the fault (Ergintav et al., 2002) was approximately 85 mm in direction of southwest.

Another network in the region called the GCM-ITU (General Command of Mapping-Istanbul Technical University) network was originally implemented by GCM as constitution of nine pillars scattered around south and north of Iznik-Mekece fault and measured with conventional techniques in 1941, 1963 to 1981. In 1941 and 1963, the network observed with triangulation method by GCM. These observations actually conducted to connect the stations to the national triangulation network. In 1981, the network was re-observed by Geodesy Department of ITU applying angle and distance measurements. The slope distances were observed by tellurometer, and then reduced to sea level. Figure 2-1 shows the station points of two mentioned networks.

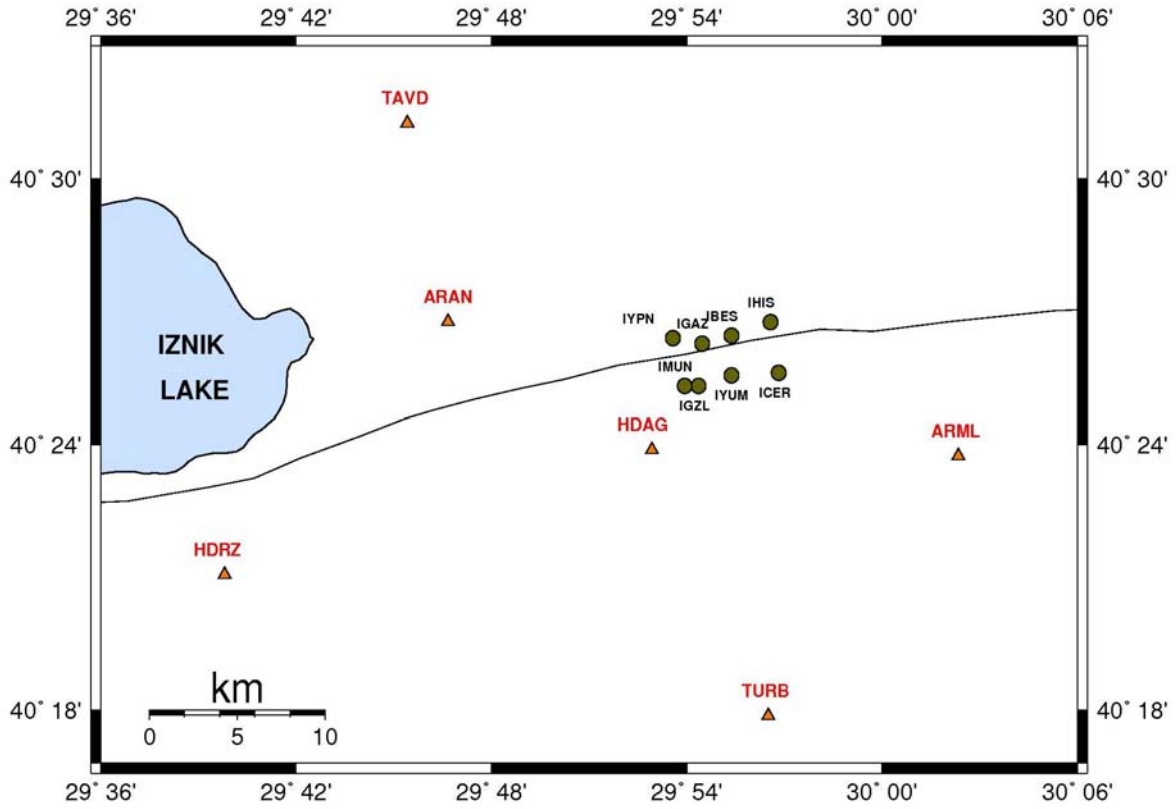

Figure 2-1: The constellation of Iznik network (stations shown by the circles) and GCM_ITU network (stations shown by the triangles).

After twenty years the network became part of the micro-geodetic networks of Geodesy Department of KOERI. It was designated to monitor crustal deformation around the western part of NAFZ. In 2004 and 2007 two GPS campaigns were performed on the network. The results are shown in Figure 2-2.

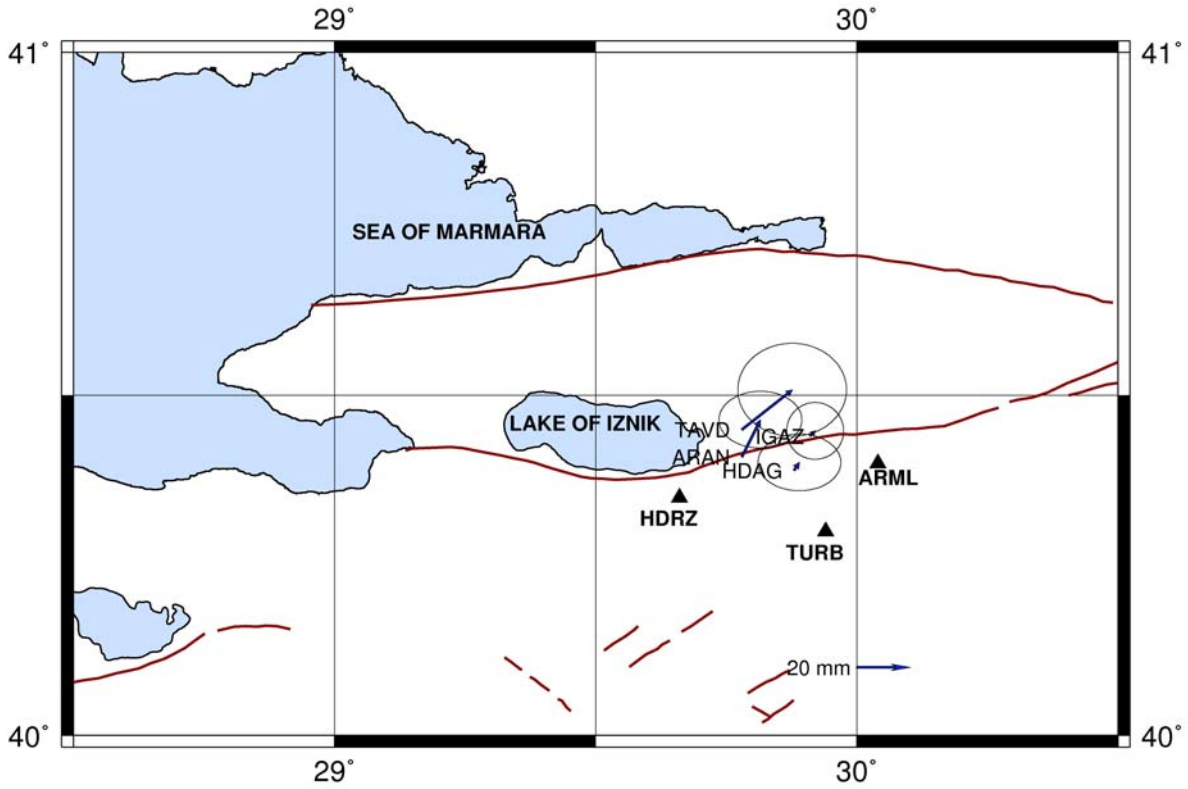

Figure 2-2: The amount of displacements between 2004 and 2007 on the study area. The displacements of TAVD, ARAN, HDAG, and IGAZ stations were estimated relative to the fixed stations (TURB, HDRZ, and ARML) located in Anatolian plate.

3. CONCLUSIONS

Geodetic observations have been performed for monitoring both local and regional crustal movements by establishing micro-geodetic networks along plate boundaries on the western part of NAFZ in Marmara region over three decades. Geodesy provides facilities to investigate the Earth's crust movements if geodetic networks are established to be capable for detecting variations in time and crustal movements. The various sources of geodetic data can be used to observe crustal deformation. Crustal deformation studies are based on the analysis of repeated geodetic measurements. The Iznik network of Geodesy Department of Bogazici University has a long observation period. And a geodetic database has been created from the studies of monitoring crustal movements. For significant geometrical and geophysical analysis and interpretation of the deformation on the western part of NAFZ periodical geodetic observations need to be continued.

The overall results show that no significant horizontal displacements have been detected in the Iznik network and no significant movement between the northern and the southern part of the Iznik-Mekece fault has been detected. This leads us to suggest there will not be any possible tectonic activity in a short time. Therefore, this fault is still inactive as claimed in Barka's earlier studies (such as Barka and Reilinger, 1997).

REFERENCES

Ambraseys, N. N., Finkel C. F., 1991: Long-term Seismicity of Istanbul and of the Marmara Sea Region, Terra Nova, 3, 527–539.

Ayhan, M. E., Demir, C., Lenk, O., Kilicoglu, A., Altiner, Y., Barka, A. A., Ergintav, S., Ozener, H., 2002: Interseismic Strain Accumulation in the Marmara Sea Region, B. Seismol. Soc. Am., 92, 216-229; doi: 10.1785/0120000818.

Barka A. A., 1997: Neotectonics of the Marmara Sea Region, in Active Tectonics of Northwestern Anotolia - The MARMARA Poly-Project, edited by Schindler C. and Pfister, M., pp. 55- 87, vdf Hochschulverlag AG an der ETH Zurich.

Barka, A. and Reilinger R, 1997: Active Tectonics of the Eastern Mediterranean Region: Deduced From GPS, Neotectonic and Seismicity Data, Ann. Geofis., XL.

Ergintav, S.; Burgmann, R.; McClusky, S.; Cakmak, R.; Reilinger, R.; Lenk, O.; Barka, A.; Ozener, H., 2002: Postseismic Deformation Near the Izmit Earthquake (17 August 1999, M 7.5) Rupture Zone. B. Seismol. Soc. Am., 92, 194-207.

Ergintav, S., Dogan, U., Gerstenecker C., Cakmak, R., Belgen, A., Demirel, H., Aydın, C., Reilinger, R., 2007: A Snapshot (2003–2005) of the 3D Postseismic Deformation for the 1999, Mw = 7.4 Izmit Earthquake in the Marmara Region, Turkey, by First Results of Joint Gravity and GPS Monitoring, J. Geodyn., 44, 1-18, doi: 10.1016/j.jog.2006.12.005.

Gurkan, O., Igdir, I., Ozener, H., Sakalli, Y., Turgut, B., Yilmaz, O., 1999: Results of GPS Measurements for Networks Designed for Terrestrial Observations, in the Western Part of NAFZ, in: Proceedings of the Third Turkish-German Joint Geodetic Days, Istanbul, Turkey, 1-4 June 1999, 932-935.

Gurkan O., Ozener, H., Yilmaz, O., Turgut, B., 2001: Results of Post Seismic GPS Measurements Related to Izmit Earthquake (August 17, 1999), in: Proceedings of the Fourth Turkish-German Joint Geodetic Days, Berlin, Germany, 3-6 April 2001, 77-83.

Lio, Y., K. Nishigami, Gurbuz, C., Ucer, S. B., 1989: Microseismic Activity Around the Western Extension of the 1967 Mudurnu Earthquake Fault, in Multidisciplinary Research on Fault Activity in the Western Part of the North Anatolian Fault Zone (2), edited by Honkura, Y.and Isikara, A.M., Tokyo Inst. Technology, pp.57-66.

Meade, B. J., Hager, B. H., McClusky, S. C., Reilinger, R. E., Ergintav, S., Lenk, O., Barka, A., Ozener, H., 2002: Estimates of Seismic Potential in the Marmara Sea Region From Block Models of Secular Deformation Constrained by Global Positioning System Measurements, B. Seismol. Soc. Am., 92, 208–215.

Ozener, H., 2000: Monitoring Regional Horizontal Crustal Movements by Individual Microgeodetic Networks Established Along Plate Boundaries, Ph.D. Thesis, Bogazici University, Istanbul, Turkey.

Reilinger, R. E., Ergintav, S., Burgmann, R., McClusky S., Lenk O., Barka A., Gurkan O., Hearn L., Feigl K. L., Cakmak R., Aktug B., Ozener H., Toksoz M. N., 2000: Coseismic and Postseismic Fault Slip for the 17 August, 1999, M= 7.5, Izmit, Turkey Earthquake, Science 289, 1519–1524.

Reilinger, R., McClusky, S., Vernant, P., Lawrance S., Ergintav, S., Cakmak, R., Ozener, H., Kadirov, F., Guliev, I., Stepanyan, R., Nadariya M., Hahubia, G., Mahmoud, S., Sakr, K., ArRajehi, A., Paradissis, D., Al-Aydrus, A., Prilepin, M., Guseva, T., Evren, E.,

Dmitrotsa, A., Filikov, S. V., Gomez, F., Al-Ghazzi R., Karam, G., 2006: GPS Constraints on Continental Deformation in the Africa-Arabia-Eurasia Continental Collision Zone and Implications for the Dynamics of Plate Interactions, J. Geophys. Res., 111, B05411, doi: 10.1029/2005JB004051.

Stein, R. S., Barka, A. A., Dieterich, J. H., 1997: Progressive Failure on the North Anatolian Fault Since 1939 by Earthquake Stress Triggering, Geophys. J. Int, 128, 594–604.

Tsukuda, E., Herece, E., Kuscu, I., 1988: Some Geological Evidence on Activity of the Western North Anatolian Fault, Geyve, Iznik, Gemlik Area, ITIT project 8513, 68-91.

Ucer, S. B., Crampin, S., Evans, R., Kafadar, N., 1985: The MARNET Radio Linked Seismometer Network Spanning the Marmara Sea and the Seismicity of Western Turkey, Geophys. J. Astr. Soc., 83, 17-30.

BIOGRAPHICAL NOTES

Associate Professor **Haluk Ozener** was born in 1967. He received the B.S. degree (1988) in Geodesy and Photogrammetry Engineering from Istanbul Technical University, and the M.Sc. (1992) and Ph.D. (2000) degrees in Geodesy from the University of Bogazici. He is currently working in the Surveying Technique Division of the Department of Geodesy and Photogrammetry Engineering of ITU in Turkey.

Dr. **Asli Dogru** was born in 1976. She received the B.S. degree (1999), and the M.Sc. (2002) in Geodesy and Photogrammetry Engineering from Istanbul Technical University and Ph.D. (2008) degree in Geomatic Engineering from the same university. She is currently working in the Geodesy Department of Kandilli Observatory and Earthquake Research Institute, University of Bogazici in Turkey.

Mr. **Bulent Turgut** was born in 1966. He received the B.S. degree (1988) in Geodesy and Photogrammetry Engineering from Istanbul Technical University. He is currently working in the Geodesy Department of Kandilli Observatory and Earthquake Research Institute, University of Bogazici in Turkey.

CONTACTS

Assoc. Prof. Haluk Ozener
Istanbul Technical University
Department of Geodesy and Photogrammetry Engineering
Surveying Technique Division
34469, Maslak
Istanbul
TURKEY
Tel. + 90 212 2853819
Fax + 90 216 3320241
Email: haluk.ozener@itu.edu.tr
Web site: http://www.koeri.boun.edu.tr/jeodezi/eng/staff/ozener.htm

Dr. Asli Dogru
Bogazici University
Kandilli Observatory and Earthquake Research Institute
Geodesy Department
34680, Cengelkoy
Istanbul
TURKEY
Tel. + 90 216 5163377
Fax + 90 216 3320241
Email: asli.dogru@boun.edu.tr
Web site: http://www.koeri.boun.edu.tr/jeodezi/eng/staff/asli_eng.htm

Mr. Bulent Turgut
Bogazici University
Kandilli Observatory and Earthquake Research Institute
Geodesy Department
34680, Cengelkoy
Istanbul
TURKEY
Tel. + 90 216 5163352
Fax + 90 216 3320241
Email: turgut@boun.edu.tr
Web site: http://www.koeri.boun.edu.tr/jeodezi/personel/turgut.htm