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SEMI-ANNUAL REPORT TO: National Aeronautics and Space Administration
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TITLE: The Interpretation of Crustal Dynamics Data in Terms of Plate Interactions and Active Tectonics of the "Anatolian Plate" and Surrounding Regions in the Middle East

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INTRODUCTION

The long term objective of this project is to interpret NASA's Crustal Dynamics measurements (SLR) in the Eastern Mediterranean region in terms of relative plate motions and intraplate deformation. Our approach is to combine realistic modeling studies with analysis of available geophysical and geological observations to provide a framework for interpreting NASA's measurements. This semi-annual report concentrates on our recent results regarding the tectonics of Anatolia and surrounding regions from ground based observations. We also briefly report on our progress to use GPS measurements to densify SLR observations in the Eastern Mediterranean. Refer to the previous annual report for a discussion of our modeling results. Copies of preprints can be obtained from the authors.

I. STRIKE-SLIP FAULT GEOMETRY IN TURKEY AND ITS INFLUENCE ON EARTHQUAKE ACTIVITY (Barka et al., 1987; Barka and Kadinsky-Cade, 1987; Barka and Kadinsky-Cade, 1988a; Barka and Kadinsky-Cade, 1988b; Kadinsky-Cade and Barka, 1988; Barka et al., 1988a; Barka and Toksoz, 1988a; Barka and Toksoz, 1988b).

Analysis of Turkish strike-slip faults indicates that detailed fault geometry plays an important role in controlling earthquake rupture. Empirical relationships are used to estimate possible locations and sizes of future strike-slip events. These results have implications for earthquake activity on other strike-slip faults such as the San Andreas in California.

II. TECTONIC ESCAPE ORIGIN AND COMPLEX EVOLUTION OF THE ERZINCAN PULL-APART BASIN, EASTERN TURKEY (Barka and Gulen, 1988a)

A new tectonic model is presented for the pull-apart opening of the Erzincan basin in an effort to explain the relationship between continental block kinematics and basin formation. We propose a two stage pull-apart mechanism associated with the continental collision of the Arabian and Eurasian plates along the Bitlis Suture Zone in eastern Turkey. The first stage of westward pull-apart opening occurs between two divergent segments of the North Anatolian Fault Zone, accommodating westward tectonic escape of the Anatolian block. The second stage involves translational-rotational opening by the formation of the obliquely oriented, left-lateral Ovacik fault. This interpretation has implications for the detailed nature of plate interactions in this region.

III. TECTONIC PROCESSES OF THE CONTINENTAL COLLISION IN THE VICINITY OF THE MARAS TRIPLE JUNCTION, SOUTHERN TURKEY (Barka et al., 1988b)

Study of the geometry, kinematics and slip rates of the structures surrounding the Maras Triple Junction, formed by the collision between the Arabian, African and Eurasian plates in eastern Turkey, provides information on the continental collision process. Deformation is diffused over a region more than 500 km wide, from the Taurus to Caucosus Mountains within which several continental blocks escape from the maximum convergence zone. The collision initiated about 13 Ma ago and had two phases: the first caused thickening of the crust by thrusting, the second involved block escape. Our analysis suggests that 40% of the overall shortening is taken up by block escape along strike-slip

faults, and the remainder by thrusting and folding throughout the collision zone.

IV. GLOBAL POSITIONING SYSTEM (GPS) MEASUREMENTS OF FAULTING AND REGIONAL DEFORMATION IN THE EASTERN MEDITERRANEAN (Reilinger and Toksoz, 1988)

We are currently involved in a collaborative effort to use GPS technology to investigate relative plate motions and intraplate deformation in the Eastern Mediterranean region. At this point, the project involves MIT, Lamont-Doherty Geological Observatory, University of Colorado, WEGENER, and local participants from Greece and Turkey. Our major effort has been devoted to coordinating planned activities with the various participants and establishing a detailed field program for measurements in Turkey. Our primary objectives include:

(1) To monitor strain accumulation and release along the major fault systems in Turkey with special emphasis on the North Anatolian fault (NAF) and East Anatolian fault (EAF).

(2) To measure directly internal deformations of the Anatolian plate wedged between the Arabian, African, and Eurasian plates. These measurements include: a) Westward "escape" of the Anatolian plate; b) Eastward "escape" of the Northeast Anatolian block; c) North-south compression in Eastern Anatolia; and d) North-south extension in Western Anatolia.

(3) To determine present-day relative movements of the African, Arabian, Anatolian, and Eurasian plates. This objective is an extension of the NASA/WEGENER Geodynamics Project to measure relative plate movements in the Eastern Mediterranean with Satellite Laser Ranging (SLR) observations.

While our participation in this project is being supported primarily by NSF, we report on it here because: a) it is directly relevant to interpretation of the SLR measurements in the eastern Mediterranean, b) NASA (Ted Flinn) has played a major role in coordinating the various groups involved, and c) NASA will likely provide logistical and data support for this field effort.

PUBLICATIONS

Barka, A., and L. Gulen, Tectonic escape origin and complex evolution of the Erzincan pull-apart basin, eastern Turkey, *J. Struct. Geol.*, in press, 1988a.

Barka, A., and K. Kadinsky-Cade, Strike-slip fault geometry in Turkey and its influence on earthquake activity, *Tectonics*, *7*, 663-684, 1988a.

Barka, A., M.N. Toksoz, K. Kadinsky-Cade, and L. Gulen, The segmentation, seismicity and earthquake potential of the eastern part of the North Anatolian fault zone, *Special Publication of Hacettepe Univ.*, Ankara, Turkey, in press, 1988a.

Barka, A., and K. Kadinsky-Cade, Strike-slip fault geometry and earthquake activity in Turkey, *EOS, Trans. Am. Geophys. Union*, *68*, 362, 1987.

Barka, A., K. Kadinsky-Cade, and M.N. Toksoz, North Anatolian fault geometry and earthquake activity, *Seismol. Res. Lett.*,*58*, 31-32, 1987.

Barka,A.A., Gulen, L. and Toksoz, M.N., Tectonic processes of the continental collision in the vicinity of the Maras triple junction, southern Turkey,

Tectonophysics, submitted, 1988b.

Kadinsky-Cade, K. and Barka, A.A., Relationship between restraining bends and earthquake magnitude: large earthquakes in strike-slip fault zones, *USGS Open File Report, Proceedings of Conference on Fault Segmentation and Controls of Rupture Initiation and Termination*, in press, 1988.

Barka, A. A. and Kadinsky-Cade, K., Effects of restraining stepovers on earthquake rupture. *USGS Open File Report, Proceedings of Conference on Fault Segmentation and Controls of Rupture Initiation and Termination*, in press, 1988b.

Barka, A. A. and Toksoz, M. N., Seismotectonics and seismic gaps of the eastern part of the North Anatolian fault zone, *Bull.Seismo. Soc.Amer.*, submitted, 1988a.

Barka, A. A. and Toksoz M.N., Segmentation, tectonics and seismic gaps of the North Anatolian fault zone in the Marmara and Aegean regions, *Tectonophysics*, submitted, 1988b.

Barka, A. A. and Gulen, L., New constraints on age and total offset of the North Anatolian fault zone: Implications for tectonics of the Eastern Mediterranean region, (In), *Melih Tokay Geology Symposium*, Spec. Publ. Middle East Tech. Uni. Ankara, Turkey, in press, 1988b.

Reilinger, R., and M.N. Toksoz, Global positioning system measurements of faulting and regional deformation in Turkey: Densification of the WEGENER SLR network, (in) S.Zerbini, ed., *Proceedings of the Third WEGENER/MEDLAS Conference*, Bologna, Italy, in press, 1988.