

**INTERNATIONAL WORKSHOP ON COMPARATIVE STUDIES
OF THE NORTH ANATOLIAN FAULT (NORTHWEST TURKEY)
AND THE SAN ANDREAS FAULT (SOUTHERN CALIFORNIA)**

ISTANBUL TECHNICAL UNIVERSITY
AUGUST 14-18, 2006



AGENDA

The North Anatolian Fault in Turkey and the San Andreas Fault in California are two major continental transform faults that share many characteristics. Both fault systems are right-lateral transforms that slip at rates of 20-35 mm/yr and endanger metropolitan areas with huge populations: Istanbul (13 million) and Los Angeles (17 million).

This international workshop has the following objectives:

- Initiate comparative studies of the North Anatolian Fault and the San Andreas Fault;
- Formalize collaborations between the Southern California Earthquake Center and a consortium of research institutions in Turkey;
- Plan multinational projects designed to improve seismic hazard assessments in southern California and northwest Turkey.

Keynote presentations will highlight issues that are not well understood, identify gaps in data or theory, suggest how comparative studies could help address these issues, and outline possible investigative strategies. Panel-led discussions will facilitate the exchange of ideas during the workshop, and participants are encouraged to prepare posters. In the afternoon, participants will break into sub-groups and be tasked with addressing specific issues and discussing investigative strategies that could address these issues. Posters will be displayed on the walls of the broad halls and common areas, grouped by relevant themes to facilitate discussions in breakout groups. On the third day, the task will be to delineate possible multinational projects. Keynote speakers will present emerging techniques and approaches that could be applied to earthquake sciences, and

breakout groups will focus on various themes and projects. By the end of the workshop, it is anticipated that each breakout groups will provide a 1-2 page document outlining strategies for future projects. These will be compiled in the workshop report.

Abstracts describing the participants' relevant research and a tentative strategy are posted onto the following site (to be mirrored at ITU):

<http://projects.crustal.ucsb.edu/NAF-SAF-2006>

Two 1-day field trips to the North Anatolian Fault will immediately follow the 3-day workshop. August 17 will be spent along the Izmit-Yalova segments on the North Anatolian Fault, and August 18 along the Ganos fault segment. Participants may join either one, or both field trips. Registration needs to be done separately for each of the field trips via email to Cenk Yaltirak (yaltirak@itu.edu.tr), with "Cc." to Marie-Helene Cormier (cormier@ldeo.columbia.edu) and Christopher Sorlien (chris@crustal.ucsb.edu).

Organizing Committee (alphabetical):

Naci Görür, Chair, Istanbul Technical University, Turkey

Sinan Akciz, University of California -Irvine, USA

Namik Çagatay, Istanbul Technical University, Turkey

Mehmet Celebi, US Geological Survey, USA

Marie-Helene Cormier, University of Missouri -Columbia, USA

Thomas Jordan, University of Southern California, USA

Geoffrey King, Institute of Physics of the Earth, Paris, France

Koji Okumura, Hiroshima University, Japan

Robert Reilinger, Massachusetts Institute of Technology, Cambridge, USA

Thomas Rockwell, San Diego State University, USA

Leonardo Seeber, Columbia University, NY, USA

Celal Sengör, Istanbul Technical University, Turkey

Christopher Sorlien, University of California -Santa Barbara, USA

Nafi Toksöz, Massachusetts Institute of Technology, Cambridge, USA

Cenk Yaltirak, Istanbul Technical University, Turkey

14 AUGUST 2006 MONDAY	
09.00-09.25	REGISTRATION
09.25-09.35	WELCOME
09.35-10.05	Naci GÖRÜR , Istanbul Technical University <i>Geological and geophysical studies on the North Anatolian Fault in the Sea of Marmara since the 1999 earthquakes</i>
10.05-10.35	Thomas JORDAN , University of Southern California & Southern California Earthquake Center (SCEC) <i>The SCEC's program of earthquake system science in southern California</i>
10.35-10.50	Coffee Break
SESSION-1	
THE NORTH ANATOLIAN AND SAN ANDREAS FAULT SYSTEMS	
10.50-11.20	A.M.Celal ŞENGÖR , Istanbul Technical University <i>The North Anatolian Fault</i>
11.20-11.50	James DOLAN , University of Southern California <i>Comparison of paleoseismological evidence for patterns of earthquake occurrence on the North Anatolian and San Andreas Faults: The importance of structural context</i>
11.50	LUNCH
SESSION-2	
EVOLUTION OF TRANSFORM SYSTEMS FROM DECADAL TO MILLION-YEAR TIMESCALES	
13.15-13.40	David BOWMAN , California State University, Fullerton <i>Slip partitioning and regional stress fields from geometrically irregular faults</i>
13.40-14.05	Aral OKAY , Istanbul Technical University <i>Evolution of transform basins and ridges with special references to the Marmara Sea</i>
14.05-14.30	Ismail KUSÇU , General Directorate of Mineral and Research and Exploration (MTA), Ankara <i>Stepover geometry in the Gemlik Bay on the southern strand of the North Anatolian Fault</i>
14.30-15.00	Panel-led discussion
15.00-15.15	COFFEE BREAK

SESSION-3	
FAULT KINEMATICS: HOLOCENE EARTHQUAKE CYCLES	
15.15-15.40	<p>Thomas ROCKWELL, San Diego State University <i>Paleoseismology of the 1912, 1944 and 1999 ruptures on the North Anatolian fault: Implications for late Holocene patterns of strain release</i></p>
15.40-16.05	<p>Elizabeth HEARN, University of British Columbia, Vancouver <i>Dynamics of the North Anatolian and San Andreas fault zones: Hypotheses, models, and open questions.</i></p>
16.05-16.30	<p>Robert REILINGER, Massachusetts Institute of Technology, Cambridge, & Semih ERGINTAV, Marmara Research Center, Gebze <i>Space geodetic constraints on the earthquake deformation cycle along the North Anatolian Fault</i></p>
DISCUSSIONS IN BREAKOUT GROUPS	
16.40-18.20	<p><i>Topics will be selected from following list or other suggestions:</i></p> <p>What factors account for time-varying behavior, why the differences between SAF and NAF? What drives vertical motions? Strain partitioning versus oblique motion Effects of pre-existing structures on the orientation and evolution of active ones Controversies: continued pull-apart extension, cessation of extreme extension, dipping faults? Fault bends, partially blind faults, slip partitioning, and oblique slip? Quantitative structural models for meaningful comparisons of the North Anatolian and San Andreas fault systems How is stress accommodated and transferred during the earthquake cycle? Vertical axis rotation and affect on displacement on domain-bounding faults. Discriminating loading determined from GPS on sub-parallel deeply-locked faults. Basin effects on GPS data (fluids, sediment compaction). GPS deformation modeled using 3D fault representations.</p>

15 AUGUST 2006, TUESDAY

09.00-09.45	Breakout groups reporting on discussion from previous day
SESSION-4	
FAULT RUPTURES: SEGMENTATION, TRIGGERING, CLUSTERING	
09.45-10.10	Susan HOUGH , US Geological Survey, Pasadena <i>Remotely triggered earthquakes</i>
10.10-10.35	Susana CUSTODIO , University of California Santa Barbara <i>The Parkfield section of the San Andreas Fault, California: Characteristic or complementary earthquake ruptures?</i>
10.35-10.50	COFFEE BREAK
SESSION-5	
DETAILED STRATIGRAPHIC STUDIES, FIELD STUDIES, AND SEISMOTECTONICS	
10.50-11.15	Namik ÇAGATAY , Istanbul Technical University <i>Late Quaternary stratigraphy and sedimentology of the Marmara Sea: Implications for tectonic studies</i>
11.15-11.40	Ali KOCYIGIT , Middle East technical University (METU), Ankara <i>The transition zone between the extensional and strike-slip neotectonic regimes in southern Marmara region: Bursa Graben</i>
11.40-12.05	Okan TÜYSÜZ , Istanbul Technical University <i>Morphotectonic features along the Tosya-Havza segment of the North Anatolian Fault</i>
12.05-12.30	Craig NICHOLSON , University of California – Santa Barbara <i>Combining high-resolution climate studies and tectonics: Imaging complex folding in 4 dimensions above active blind faults</i>
12.30-13.00	PANEL-LED DISCUSSION
13.00	LUNCH

SESSION-6
EARTHQUAKE HAZARDS

14.15-14.40	Mustafa ERDIK , Kandilli Observatory and Earthquake Research Institute, Istanbul <i>Assessment of earthquake hazard in Marmara Region, Turkey</i>
14.40-15.05	Kim OLSEN , San Diego State University <i>TeraShake: Large-scale simulation of ground motion in Los Angeles for a M7.7 earthquake on the southern San Andreas Fault</i>
15.05-15.30	Sinan OZEREN , Istanbul Technical University <i>A semi-spectral approach for the mathematical modeling for the underwater landslide tsunami scenarios in the Sea of Marmara</i>
15.30-15.45	COFFEE BREAK

SESSION-7
POSTERS & DISCUSSIONS

15.45-17.15	<i>Poster titles listed on following pages</i>
17.15-18.30	<p style="text-align: center;">DISCUSSIONS IN BREAKOUT GROUPS</p> <p><i>Topics to be selected from following list or other suggestions made during the workshop:</i></p> <p>Stress loading and earthquake clustering. Complex fault geometries, rock type, rupture patterns, and dynamics of fault rupture Microseismicity and fault zone properties The need for quality stratigraphy to characterize tectonic evolution and deformation rates Dual use of high-resolution seismic data and cores for paleoclimate and paleoseismology Fluid flow along fault zones, and its impact on earthquakes Does shallow velocity structure near fault affect ground motions at distant site? Assessing tsunami and landslide hazards</p>

16 AUGUST 2006, WEDNESDAY

09.00-09.45	Reports from the breakout groups from previous day
<p>SESSION-9</p> <p>STRATEGIES FOR MULTINATIONAL AND MULTIDISCIPLINARY INVESTIGATIONS</p>	
09.45-10.05	Thomas JORDAN <i>Laboratory for the Study of Earthquake Predictability</i>
10.05-10.25	Naci GÖRÜR <i>Strategies for future investigations of the North Anatolian Fault</i>
10.25-10.40	COFFEE BREAK
<p>SESSION-10</p> <p>EMERGING TECHNOLOGIES FOR FAULT IMAGING AND MONITORING</p>	
10.40-11.00	David CHADWELL , Scripps Oceanographic Institution, San Diego <i>Underwater geodetic monitoring</i>
11.00-11.20	Mike JACKSON , UNAVCO (University NAVstar Consortium), Boulder <i>The EarthScope Plate Boundary Observatory</i>
11.20-11.40	Roland PERSON , Ifremer, Brest <i>ESONET: The European Seafloor Observatory NETwork</i>
11.40-12.15	PANEL-LED DISCUSSION
12.15-13.30	LUNCH

SESSION-11 RECENT, ON-GOING, OR UPCOMING INVESTIGATIONS ALONG THE NORTH ANATOLIAN FAULT AND THE SAN ANDREAS FAULT	
13.30	Pierre HENRY , College de France, Aix-en-Provence Cold seeps along the main Marmara Fault: Context and perspectives for monitoring
13.45	Emin DEMIRBAG , Istanbul Technical University Michael STECKLER , Lamont-Doherty Earth Observatory, Palisades <i>Seismic reflection surveys in the Marmara Sea</i>
14.00	Ömer EMRE , General Directorate of Mineral Research and Exploration (MTA), Ankara Sinan AKCIZ , University of California, Irvine <i>Status of paleoseismological studies along SAF & NAF</i>
14.15	Gülşen UÇARKUS , Istanbul Technical University (Tentative) <i>The RELIEF project along the North Anatolian Fault (RELIable Information on Earthquake Faulting)</i>
14.30	Hayrullah KARABULUT , Bogazici University, Istanbul <i>Status of seismometer networks, including OBS, in NW Turkey</i>
14.45	Semih ERGINTAV , Marmara Research Center (MAM) <i>GPS monitoring of the North Anatolian Fault</i>
15.00	Christopher SORLIEN , University of California, Santa Barbara <i>Community fault, stratigraphic, and 3D seismic velocity models for southern California and Northwest Turkey</i>
15.15	PANEL-LED DISCUSSION
15.45	COFFEE BREAK AND POSTERS

16.30-18.00

DISCUSSION IN BREAKOUT GROUPS

Topics to be selected from the following list and other suggestions made during the workshop:

Strategies for quantitative comparison between North Anatolian and San Andreas fault systems.

Potential for quantitative comparison using similar community fault models

Underwater monitoring of fault activity: seafloor observatories

SCEC-like effort on paleoseismology (includes lakes and sea)

Data distribution and archiving: building an open source and free access database for the NAF

Many of the themes will be delineated by participants during the workshop.

Some probable themes follow.

- Implementation of a unified fault, stratigraphic, and seismic velocity representation of the several strands and fault blocks of the North Anatolian Fault zone, with initial focus on northwest Turkey, including seismicity information and GPS data.
- Submarine observatory to monitor activities along the North Anatolian Fault beneath the Marmara Sea. A seafloor observatory would not only provide new insight into submerged continental transform faults, it might also provide critical warnings should anomalous activities be detected.
- Expanding a comprehensive, permanent onshore/offshore geodetic array in Turkey.
- Extending investigations to the region surrounding the North Anatolian Fault: Aegean Sea and Southwest Turkey.
- Strategies for producing a high quality stratigraphy (offshore and onshore) for quantifying long-term tectonic rates; Possible role for EMCOL (Eastern Mediterranean Centre of Oceanography and Limnology) and IODP in addressing tectonic evolution of Marmara Sea.

19.00:

BOSPHORUS DINNER CRUISE !!

**FIELD TRIP TO THE NORTH ANATOLIAN FAULT SYSTEM
BETWEEN IZMIT AND YALOVA**

THURSDAY, AUGUST 17

Field Trip Leaders: Omer Emre, Volkan Ozaksoy and Namik Cagatay

The northern strand of the North Anatolian Fault System passes through Sea of Marmara. The 17 August 1999 Izmit earthquake (Mw 7.4) was originated from eastern section of the northern strand of the North Anatolian Fault System. The earthquake produced 150 km-long multi-segment surface rupture between Yalova and Duzce basin. The whole surface rupture is subdivided into six geometric segments. Western part of the Izmit rupture extends in the Gulf of Izmit in E-W direction. However, some part of the rupture zone observed onshore around the area of Golcuk and Hersek promontory in the east of Yalova. Several surveys were performed both in the Sea of Marmara including Izmit bay and on land to understand the structural geometry of the North Anatolian fault zone. The objective of this trip is to exhibit characteristics of the western segments of the 1999 Izmit rupture and related tectonic deformations in a broad zone along the NAF on land.

FIELD TRIP PROGRAM

Departure:

08.00 am/ front of Faculty of Mines Building of ITU

08 00: -10 00

Transportation from ITU to Golcuk town

10.00-11.00

Stop 1: Ford Otosan Factory-Kavaklı District/Golcuk Town

Normal faulting associated with the 1999 Izmit earthquake in Golcuk releasing stepover between Tepetarla and Golcuk segments. Also lateral spreading and submerged coastal zone along the Hisardere delta on the northern block of the normal fault.

11.15. 11.45

Stop 2:Yuzbasilar District/Golcuk Town

A 4.30 m of right lateral displacement on a road and the stone-wall on the eastern section of Golcuk segment of the 1999 Izmit rupture in town of Golcuk

12.30-13.00

Stop 3: Kaytazdere/ East of Altinova town

Uplifted Tyrrhenian Terrace on the southern coast of Izmit bay

13.00-14.00

Lunch Break/Altinova

14.30: 16.30

Stop 4: Hersek promontory/North of Altınova town

Hersek ridge, uplifted Late Holocene paleoshorelines due to thrust faulting on the Hersek restraining bend between Yalova and Golcuk segments of the 1999 Izmit rupture.

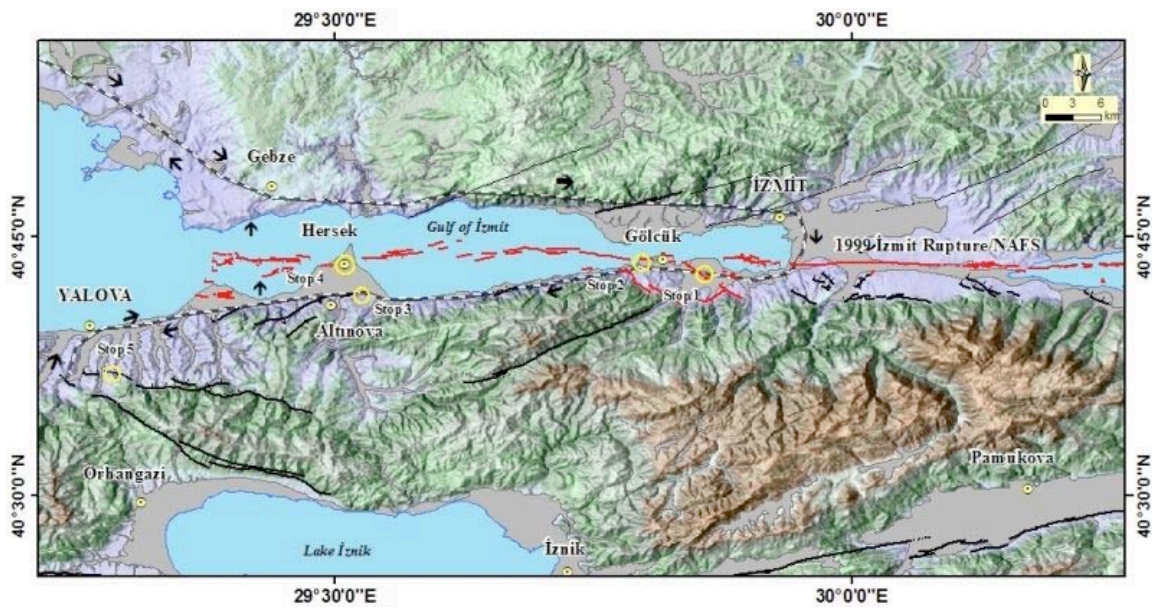
17.00-17.30

Stop 5: South of Yalova

Çukurköy normal fault on the northern margin of the Armutlu peninsula

18.20: Return to Istanbul

Estimated Arrival time to Faculty of Mines-ITU at 20.30



The map showing route and stops of the 17 August 2006 the North Anatolian Fault Trip between Yalova and İzmit.

**FIELD TRIP TO THE NORTH ANATOLIAN FAULT SYSTEM IN THRACE:
THE GANOS FAULT SEGMENT**

FRIDAY, AUGUST 18

Field trip leaders: Aral Okay, Cenk Yaltrak and Nano Seeber

Maximum number of participants: 35

Transportation by one or two minibusses

The Ganos fault is the 45-km long segment of the North Anatolian Fault between the Marmara and Aegean seas. Recent apatite fission track data indicate that it has a history going back at least to the Oligocene. The aim of the excursion is to study the structures and morphology associated with the eastern part of the Ganos fault zone. In the Marmara Sea the North Anatolian fault (NAF) forms a 17° bend between the Central Marmara and Ganos fault segments. The bend is associated with the formation of the 1100-m-deep Tekirdağ basin and the adjoining 924-m-high Ganos mountain. Structurally the Ganos mountain forms a crustal scale monocline with its steep limb abutting against the Ganos fault. The Ganos mountain is made up of Eocene turbidites deformed into recumbent kink-folds and cut by normal faults. A similar Eocene turbidite series, but with olistostrome horizons comprising blocks of blueschist, serpentinite, diabase and Eocene reefal limestone blocks, crops out south of the Ganos fault. This series is overlain through an angular unconformity by terrigenous to shallow marine Miocene sandstones and conglomerates. Marine terrace deposits are present both north and south of the Ganos fault suggesting that both sides of the fault are being uplifted with respect to the sea level.

Principal sights during the excursion:

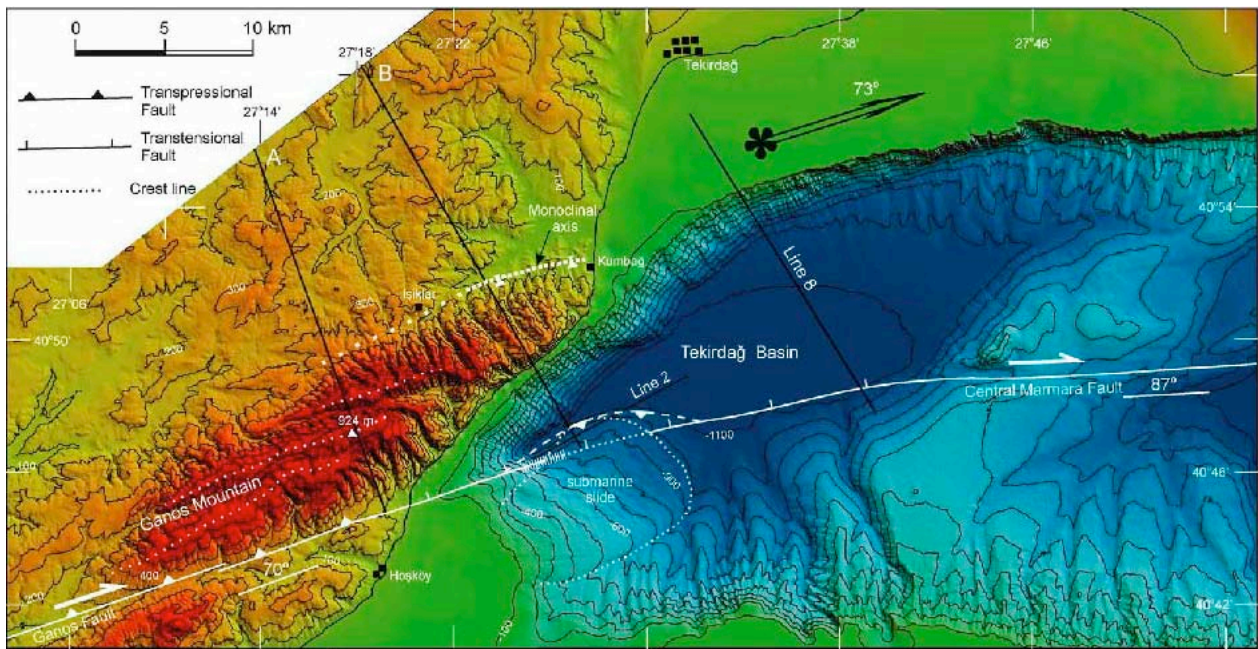
Marine terraces at Marmara Ereğlisi and Gazikoy, recumbent kink-folds and normal faults in the steep limb of the Ganos monocline, Ganos Fault zone at Gazikoy and at Golcuk, Miocene south of the Ganos fault, the unconformity between the Oligocene and the Miocene, olistostromal Eocene sequence south of the Ganos fault.

Provisional field trip itinerary for the 18th August:

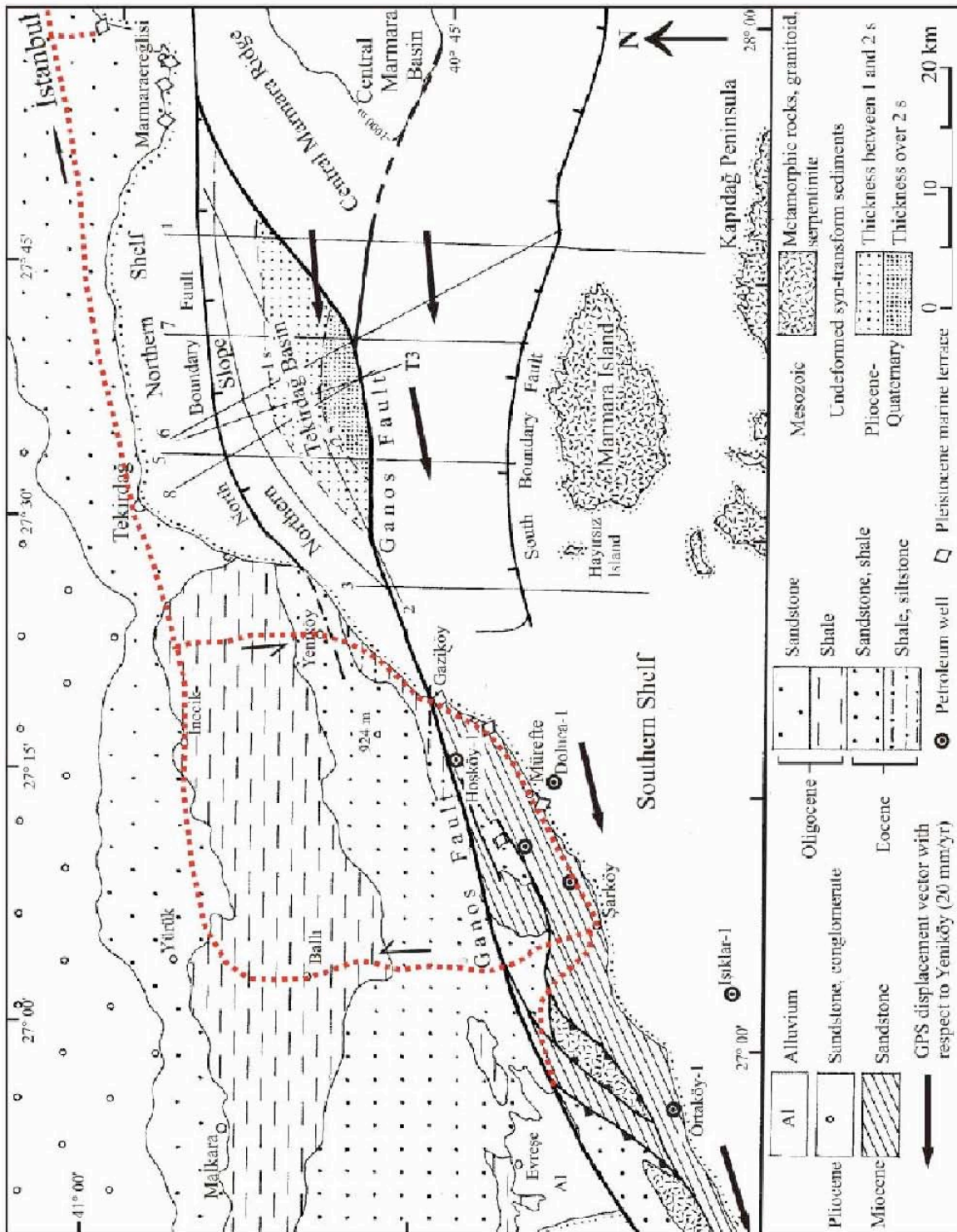
Leave Istanbul at 8.00 a.m. from the ITU campus, drive west towards Tekirdağ, possibly stop at the marine terrace deposits in Marmara Ereğlisi, gently folded Oligocene shales near Naip, cross-section across the steep limb of the Ganos monocline, recumbent kink folds and overturned bedding, picnic lunch on the Ganos mountain, normal faults on the coastal road south of the Ganos Mountain, Ganos fault zone at Gazikoy, marine terrace at Gazikoy, Miocene sequence south of the Ganos fault, angular unconformity between Oligocene and Miocene, olistostromal facies in the Eocene south of the Ganos fault in the Sarko region, Ganos fault at Golcuk, back to Istanbul.

Some recent relevant references:

- Armijo, R., Meyer, B., Hubert, A., and Barka, A., 1999, Westward propagation of the North Anatolian fault into the northern Aegean: Timing and kinematics. *Geology*, 27, 267-270.
- Okay, A.I., Tüysüz, O. & Kaya, Ş., 2004, From transpression to transtension: Changes in morphology and structure around a bend on the North Anatolian Fault in the Marmara region. *Tectonophysics*, 391, 259-282.
- Okay, A.I., Demirbağ, E., Kurt, H., Okay, N., Kuşçu, İ., 1999, An active, deep marine strike-slip basin along the North Anatolian fault in Turkey. *Tectonics*, 18, 129-148.
- Seeber, L., Emre, O., Cormier, M., Sorlien, C., McHugh, C., Polonia, A., 2004. Uplift and subsidence from oblique slip: the Ganos-Marmara bend of the North Anatolian Transform, western Turkey. *Tectonophysics*, 391, 239-258.
- Yaltırak C., Sakınc, M., Aksu, A.E., Hiscott, R.N., Galeb, B., Ulgen, U.B., 2002, Late Pleistocene uplift history along the southwestern Marmara Sea determined from raised coastal deposits and global sea-level variations, *Marine Geol.*, 190, 283-305.
- Yaltırak C., Sakınc, M., Oktay, F.Y., 2000, Westward propagation of North Anatolian fault into the northern Aegean: Timing and kinematics: Comment, *Geology*, 28, 187-188.
- Zattin, M., Okay, A.I., Cavazza, W., 2005. Fission-track evidence for late Oligocene and mid-Miocene activity along the North Anatolian Fault in south-western Thrace. *Terra Nova*, 17, 95-101.



Digital elevation model of the Ganos Mountain and the adjoining Tekirdağ Basin (Okay et al., 2004).



The red dotted line shows the itinerary of the Ganos field trip on the 18th August 2006.